DRAFT SUPPLEMENT ANALYSIS FOR LOCATION(S) TO DISPOSE OF DEPLETED URANIUM OXIDE CONVERSION PRODUCT GENERATED FROM DOE'S INVENTORY OF DEPLETED URANIUM HEXAFLUORIDE

(DOE/EIS-0359-SA1 AND DOE/EIS-0360-SA1)

March 2007

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TABLES

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NOTATION

The following is a list of acronyms and abbreviations, chemical names, and units of measure used in this document. Some acronyms used only in tables may be defined only in those tables.

GENERAL ACRONYMS AND ABBREVIATIONS

CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DUF_6	depleted uranium hexafluoride
EIS	environmental impact statement
ETTP	East Tennessee Technology Park
FR	*Federal Register*
ICRP	International Commission on Radiological Protection
INEEL	Idaho National Engineering and Environmental Laboratory
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
LLW	low-level radioactive waste
LLWPA	Low-Level Radioactive Waste Policy Act
MEI	maximally exposed individual
NEPA	National Environmental Policy Act of 1969
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
PEIS	programmatic environmental impact statement
P.L.	Public Law
ROD	Record of Decision

SA	Supplement Analysis
SRS	Savannah River Site
UAC	*Utah Administration Code*
UDEQ	Utah Department of Environmental Quality
UDS	Uranium Disposition Services, LLC
USC	*United States Code*
WAC	waste acceptance criteria
WM PEIS	Waste Management Programmatic Environmental Impact Statement
WCS	Waste Control Specialists

CHEMICALS

CaF_2	calcium fluoride
HF	hydrogen fluoride; hydrofluoric acid
Tc	technetium
U_3O_8	triuranium octaoxide
UF_6	uranium hexafluoride

UNITS OF MEASURE

ft	foot (feet)
ft^3	cubic foot (feet)
gal	gallon(s)
ha	hectare(s)
km	kilometer(s)
L	liter(s)
m	meter(s)
m^3	cubic meter(s)
mi	mile(s)
mrem	millirem(s)
m/s	meters per second
ppm	part(s) per million
rem	roentgen equivalent man
t	metric ton(s)
ton(s)	short ton(s)
yd^3	cubic yard(s)
yr	year(s)

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1 INTRODUCTION AND BACKGROUND

1.1 WHY DOE HAS PREPARED THIS DRAFT SUPPLEMENT ANALYSIS

Pursuant to the National Environmental Policy Act (NEPA), the Department of Energy (DOE or the Department) has prepared this Draft Supplement Analysis (SA) in order to determine whether it must supplement two site-specific Environmental Impact Statements (EISs), or prepare any new EISs, for depleted uranium hexafluoride (DUF_6) conversion facilities at Paducah, Kentucky, and Portsmouth, Ohio, in order to decide where it will dispose of the depleted uranium oxide product from these facilities. See, *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Paducah, Kentucky, Site*, DOE/EIS-0359 (June 2004**,** DOE 2004a) (Paducah Site-Specific EIS) and the *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at Portsmouth, Ohio, Site*, DOE/EIS-0360 (June 2004**,** DOE 2004b) (Portsmouth Site-Specific EIS).

In each of those site-specific reviews, DOE considered transportation and disposal of the oxide product (primarily depleted triuranium octaoxide [U_3O_8]) from converting DUF_6 and two concurrent waste streams (i.e., emptied cylinders, and a small amount of CaF_2 produced during normal conversion operations).[1] DOE's Nevada Test Site (NTS) and the Envirocare of Utah (Envirocare)[2] site near Clive, Utah, were the assumed destinations. DOE had intended to identify disposal locations in its Records of Decision (RODs). Prior to issuing the RODs, however, DOE discovered that it had inadvertently not formally provided copies of the draft and final EISs to

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[1] The Portsmouth and Paducah conversion facilities will generate respectively approximately 18 metric tons (t) (20 tons) and 24 t (26 tons) of CaF_2 annually as a result of normal DUF_6 conversion operations. These amounts are small compared to the 10,800 t (11,800 tons) and 14,300 t (15,800 tons) annually of depleted uranium oxide conversion product that will be produced respectively at the Portsmouth and Paducah facilities, and DOE plans to concurrently arrange for disposal of these small amounts of CaF_2 and the depleted uranium oxide conversion product. Similarly, emptied DUF_6 cylinders will be generated at both conversion facilities (1,980 t/yr [2,200 tons/yr] at Paducah and 1,177 t/yr [1,300 tons/yr] at Portsmouth). These emptied cylinders are expected to be used as containers for, and hence will be co-disposed with, the depleted uranium oxide conversion product. Hydrogen fluoride (HF) also will be produced as a conversion co-product. The HF will be sold for commercial use. A sales contract with Solvay Fluorides, a commercial vendor, was signed in May 2006. If for some unexpected reason, sale of the HF is not accomplished, DOE will undertake additional NEPA review, as necessary, to examine disposal options.

[2] On February 3, 2006, it was announced that Envirocare of Utah, Scientech D&D, and BNG America would join together and become Energy*Solutions* LLC. Notwithstanding, the names "Envirocare of Utah" or "Envirocare" are used throughout this report to refer to the Energy*Solutions* facility located at Clive, Utah, in order to maintain consistency with earlier documents discussed herein.

either Nevada or Utah, and DOE concluded that it was bound by the Council on Environmental Quality's (CEQ) regulations at 40 CFR 1502.19 to forego decisions on disposal location(s) until it had properly served these states. Accordingly, in its RODs, DOE did not include decisions with respect to specific disposal location(s), but instead informed the public that it would make the decisions later and that any supplemental NEPA analysis would be provided for review and comment. See 69 *Federal Register* (FR) at 44653 and 44658 (July 27, 2004).

DOE has now corrected its oversight, provided all appropriate stakeholders with documentation as required by the regulations, and is prepared to select NTS and/or Envirocare as disposal locations for both conversion facilities. The purpose of this Draft SA is to determine whether, in order to now make its decision on disposal locations, DOE can simply amend the existing RODs or must instead either supplement the existing site-specific EISs or prepare a new EIS.

Based on this Draft SA, DOE believes that existing NEPA documentation adequately supports its decision to dispose of the depleted uranium oxide conversion product from both DUF_6 conversion facilities, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations at the NTS and/or Envirocare. In other words, all of the impacts discussed in this Draft SA have been presented to the public in previous NEPA documents. The Draft SA identifies no significant new circumstances or information relevant to environmental concerns that bear on DOE's decision on disposal locations or the impacts of that decision. Hence, DOE believes that neither supplementing the site-specific EISs nor preparing any new EIS is required.[3]

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[3] Criteria for determining the need for a Supplemental EIS are set out in the CEQ regulations for implementing NEPA at Section 1502.9(c) of Title 40 in the *Code of Federal Regulations* (CFR) (40 CFR 1502.9(c)) and in the DOE NEPA regulations at 10 CFR 1021.314:

40 CFR 1502.9(c) Agencies:

(1) Shall prepare supplements to either draft or final environmental impact statements if:

(i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or

(ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

(2) May also prepare supplements when the agency determines that the purposes of the Act will be furthered by doing so.

(3) Shall adopt procedures for introducing a supplement into its formal administrative record, if such a record exists.

(4) Shall prepare, circulate, and file a supplement to a statement in the same fashion (exclusive of scoping) as a draft and final statement unless alternative procedures are approved by the Council.

10 CFR 1021.314 Supplemental environmental impact statements.

(a) DOE shall prepare a supplemental EIS if there are substantial changes to the proposal or significant new circumstances or information relevant to environmental concerns, as discussed in 40 CFR 1502.9(c)(1).

(b) DOE may supplement a draft EIS or final EIS at any time, to further the purposes of NEPA, in accordance with 40 CFR 1502.9(c)(2).

(c) When it is unclear whether or not an EIS supplement is required, DOE shall prepare a Supplement Analysis.

(1) The Supplement Analysis shall discuss the circumstances that are pertinent to deciding whether to prepare a supplemental EIS, pursuant to 40 CFR 1502.9(c).

(2) The Supplement Analysis shall contain sufficient information for DOE to determine whether:

1.2 BACKGROUND

The Department manages approximately 700,000 t (759,000 tons) of DUF_6 at DOE's former production sites (gaseous diffusion plants) located near Paducah, Kentucky and Portsmouth, Ohio. Consistent with the ROD for the Portsmouth DUF_6 conversion facility, all DUF_6 cylinders once stored at DOE's East Tennessee Technology Park (ETTP) have been shipped to Portsmouth for conversion. See 69 FR at 44653 (July 27, 2004). In order to allow safer and more secure disposition of the DUF_6, it will be converted to a more stable chemical form.

DOE has looked exhaustively at options for disposition of its DUF_6 inventory. In its *Final Programmatic Environmental Impact Statement* [PEIS] *for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride, DOE-EIS-0269* (DOE 1999), the Department assessed the potential impacts of alternative management strategies for DUF_6. In its August 10, 1999, programmatic ROD (64 FR 43358), DOE decided to convert the DUF_6 inventory to depleted uranium oxide, depleted uranium metal, or a combination of both. DOE stated that any proposal to proceed with siting, construction, and operation of a conversion facility or facilities would involve additional review under NEPA.

The incentive to act intensified when, on August 2, 2002, the President signed into law the *2002 Supplemental Appropriations Act for Further Recovery From and Response To Terrorist Attacks on the United States* (P.L. 107-206). Section 502 in that law required DOE, within thirty (30) days of the law's enactment, to award a contract for the design, construction, and operation of DUF_6 conversion plants at the Department's gaseous diffusion plant sites near Paducah, Kentucky and Portsmouth, Ohio. Accordingly, on August 29, 2002, DOE awarded a contract to Uranium Disposition Services, LLC (UDS) for such services.

Between 2002 and 2004, DOE reviewed the environmental consequences of building and operating the conversion facilities. On June 18, 2004, DOE issued two site-specific EISs for the construction and operation of the Paducah and Portsmouth DUF_6 conversion facilities (DOE 2004a, b). In the RODs for these facilities, DOE decided that it would build both facilities and

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(i) An existing EIS should be supplemented;
(ii) A new EIS should be prepared; or
(iii) No further NEPA documentation is required.

(3) DOE shall make the determination and the related Supplement Analysis available to the public for information. Copies of the determination and Supplement Analysis shall be provided upon written request. DOE shall make copies available for inspection in the appropriate DOE public reading room(s) or other appropriate location(s) for a reasonable time.

(d) DOE shall prepare, circulate, and file a supplement to a draft or final EIS in the same manner as any other draft and final EISs, except that scoping is optional for a supplement. If DOE decides to take action on a proposal covered by a supplemental EIS, DOE shall prepare a ROD in accordance with the provisions of § 1021.315 of this part.

(e) When applicable, DOE will incorporate an EIS supplement, or the determination and supporting Supplement Analysis made under paragraph (c) of this section, into any related formal administrative record on the action that is the subject of the EIS supplement or determination (40 CFR 1502.9(c)(3)).

convert DOE's inventory of DUF_6 to depleted uranium oxide (primarily depleted U_3O_8) and aqueous hydrogen fluoride (HF). The aqueous HF produced during conversion is projected to be sold for use in commercial applications in accordance with approved authorized release limits. The depleted uranium oxide conversion product will be reused to the extent possible or be disposed of as low-level waste (LLW) concurrently with emptied cylinders and the small amount of CaF_2 produced during normal conversion operations. As noted earlier, though the site-specific EISs considered the NTS and Envirocare as destinations for transportation and disposal of the these materials, DOE did not decide specific disposal location(s) due to its oversight in serving Nevada and Utah. See DOE 2004b at Section 1.6.2.4; *see also Id.* at Section S.2.3.4 and Table 2.2-2; *see also* 69 FR at 44653 and 69 FR at 44658 (July 27, 2004).

In determining whether supplements to the site specific EISs or any new EISs are needed, this Draft SA considers the PEIS, the site-specific EISs, and their respective RODs. The Draft SA also considers other relevant information, including the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE 1996a) and certain analyses and findings of the U.S. Nuclear Regulatory Commission (NRC). (NRC 2005a, b, c, d, and 2006a, b)

1.3 PROPOSED ACTIONS CONSIDERED IN THIS DRAFT SUPPLEMENT ANALYSIS

DOE proposes to amend the decision announced in the site-specific RODs (DOE 2004c,d) regarding specific location(s) for disposal. All other aspects of the DUF_6 conversion activities remain as described previously in site-specific EISs and RODs.

In the site-specific EISs it was estimated that the Portsmouth DUF_6 conversion facility would operate for 18 years while the Paducah facility would operate for 25 years. The longer assumed operating life of the Paducah facility is principally a result of the larger DUF_6 inventory that is located and will be converted at the Paducah site. The site-specific EISs further assumed that, during the operating life of each conversion facility, the depleted uranium oxide conversion product, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations would be transported from the facility to a disposal site. Hence, the impacts from such transportation, and impacts from transport of aqueous HF to a site for use were included in the EISs. For the purpose of analysis, the depleted uranium oxide conversion product was assumed to be depleted U_3O_8. Both truck and rail modes of transportation were evaluated. For the purpose of analyzing potential transportation impacts, two potential disposal sites were considered: Envirocare and the NTS.

The site-specific EISs assumed that the depleted uranium oxide conversion product would be packaged and transported in the emptied cylinders that have been used for DUF_6 storage. Alternatively, if not used as disposal containers for depleted uranium oxide product, the site-specific EISs assumed that the emptied cylinders would be crushed and shipped in 20-ft (6-m) cargo containers, approximately 10 to a container.

2 SUMMARY OF DUF$_6$ PROGRAMMATIC AND CONVERSION FACILITY NEPA ANALYSES

This section provides a brief summary of the actions considered in the site-specific conversion facility EISs. It also summarizes the generic NEPA analyses for disposal of depleted uranium oxide that were conducted for the PEIS. The information is presented in order to provide a basis for the decision as to whether additional NEPA analysis is required for deciding on specific disposal location(s).

2.1 CONVERSION

The site-specific EISs analyzed the impacts of converting 13,500 t/yr (15,000 tons/yr) of DUF$_6$ at the Portsmouth facility and 18,000 t/yr (20,000 tons/yr) at the Paducah facility. Construction, operation, maintenance, and decontamination and decommissioning were considered. The start of operations was assumed to be in 2006; the Portsmouth facility would operate for 18 years and the Paducah facility would operate for 25 years. Impacts in the areas of human health, air quality and noise, water and soil, socioeconomics, ecology, waste management, resource requirements, land use, cultural resources, and environmental justice were assessed. Impacts were compared with a no action alternative that considered the continued storage of the cylinders at their current storage locations (DOE 2004a, Section 1.6.2, page 1-17; DOE 2004b, Section 1.6.2, page 1-18).

The site specific EISs analyzed three areas at each site for locating the conversion facilities, locations A, B and C (DOE 2004a, Section 2.2.1, page 2-5; DOE 2004b, Section 2.2.1, page 2-6). DOE considered impacts for each alternative location. DOE identified construction and operation of the proposed DUF$_6$ conversion facilities at Location A at both sites as the preferred alternatives. Although no significant adverse impacts were estimated for the preferred alternatives at both sites, mitigation measures were identified to further minimize impacts.

2.2 TRANSPORTATION

Transportation risk associated with disposal were evaluated in the conversion facilities EISs (DOE 2004a, Section 5.2.3, page 5-73; DOE 2004b, Section 5.2.5, page 5-93). DOE used the collective population risk assessment as the primary means of comparing various transportation options in the site-specific EISs. The collective population risk, expressed as additional latent cancer fatalities (LCFs), additional deaths, or additional injuries (i.e., reversible or irreversible adverse effects) is a measure of the total risk posed to society as a whole from actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Collective population risks were calculated for both vehicle- and cargo-related causes for routine transportation and for accidents. Risks from vehicle-related causes are independent of the cargo in the shipment and include risks from vehicular exhaust emissions and traffic accidents (fatalities caused by physical trauma). Risks from cargo-related causes include radiological risks caused by ionizing radiation, and risks from human exposures that could occur after the release and dispersal of radioactive or chemical cargo components during an accident. In addition to estimating collective risks, DOE also estimated risks to maximally exposed individuals (MEIs) of the public and to crew members. A detailed discussion of the methodologies, assumptions, and models used to estimate transportation impacts are provided in DOE 2004a (Appendix F, page F-21) and DOE 2004b (Appendix F, page F-21). The results of the assessments are presented in DOE 2004a (Section 5.2.3, page 5-73) and DOE 2004b (Section 5.2.5, page 5-93).

2.2.1 Impacts of Transport from Portsmouth to Disposal Locations

For the Portsmouth site, the transportation assessment analyzed the annual transport of 10,800 metric tons uranium oxide/yr (11,800 tons/yr), 18 t/yr (20 tons/yr) of CaF_2, and 1,177 t/yr (1,300 tons/yr) of unused emptied cylinders from Portsmouth to both the Envirocare facility and NTS. The operational period was assumed to be 18 years. If U_3O_8 were disposed of in emptied cylinders, there would be a total of approximately 4,200 railcar shipments or up to 21,000 truck shipments. If bulk bags (large capacity, strong, flexible bags) were used as disposal containers, there would be a total of about 2,200 shipments for railcars or 8,800 shipments for trucks (DOE 2004b, Section 2.4.2.3, page 2-35).

The results of the transportation assessment to Envirocare or NTS are presented in Section 5.2.5 of the Portsmouth EIS (DOE 2004b, page 5-93). A brief summary of the results follows:

- For the entire 18 year shipping campaign, cargo-related radiological impacts to crew members and the general public would result in less than 1 LCF for shipments to either Envirocare or NTS.

- Health risks from cardiovascular and pulmonary diseases have been linked to incremental increases in particulate concentrations in air, such as those produced by vehicle exhaust emissions. In the Portsmouth site-specific EIS, health risks from vehicle emissions were calculated by multiplying the total distances shipped over the duration of the campaign by health risk factors presented in Biwer and Butler (1999). Because estimating health risks associated with vehicle emissions is subject to a great deal of uncertainty, the risk factors used in the EIS (from Biwer and Butler 1999) purposely provide an overestimate of the actual risk (referred to as a "conservative" estimate). Therefore, the emissions-related health impacts presented in the Portsmouth site-specific EIS should be considered an upper bound estimate of potential impacts, with the actual impacts expected to be much less. For the 18-year shipping campaign, the transportation assessment results for vehicle-related emission fatalities for truck shipments were estimated to be about 8 for shipment to Envirocare and 9 for shipment to NTS using bulk bags; no emission fatalities would be expected for railcar shipments. If the emptied cylinders were used as disposal containers, the estimated emission fatalities would be similar but could vary depending on the number of cylinders per truck or railcar shipment. As discussed in the Portsmouth site-specific EIS, the emission risks are believed to overestimate actual emission impacts by at least a factor of 30 (see DOE 2004b, page 5-100).

- Truck accidents (non-cargo-related) for the life of the project were estimated to result in about 1 fatality for transportation to either Envirocare or NTS, whereas rail accidents would be expected to result in less than 1 fatality based on state-specific accident statistics for average fatalities per kilometer driven for interstate-registered heavy combination trucks and average fatalities per kilometer traveled per railcar, respectively.

Severe transportation accidents could also result in a release of radioactive material or chemicals from a shipment. The consequences of such a release would depend on the material released, location of the accident, and atmospheric conditions at the time. Potential consequences would be greatest in urban areas and under stable atmospheric conditions (calm/stagnant weather conditions with low wind speeds [approximately 1 to 2 m/s] such as at nighttime).

In the following paragraphs, results of the transportation assessment are presented in greater detail, with accompanying tables taken from the Portsmouth site-specific EIS (DOE 2004b).

2.2.1.1 Collective Population Risk

As stated above, both truck and rail options were considered for shipments to both Envirocare and NTS. For analyzing an all-rail transport option to NTS, it was assumed that a rail line would be available for the entire distance. Currently, however, the nearest rail terminal to NTS is about 70 mi (113 km) from the site. Accordingly, if NTS were to be selected as the disposal location a rail spur would have to be constructed connecting the existing rail line to the site in order to realize the all-rail option. Alternatively, railcar shipments would have to go to a terminal from which trucks could carry the shipment contents the rest of the way. The Portsmouth site-specific EIS (DOE 2004b, Section 5.2.5.1, page 5-94) indicated that if a rail spur to NTS were built, additional NEPA review would need to be conducted to evaluate the impacts resulting from such construction. The Portsmouth site-specific EIS also indicated that, if shipments of depleted uranium oxide conversion product from Portsmouth to NTS were made instead through intermodal transfers from rail to trucks, the impacts would be slightly greater than for the all-rail option, but less than for the all-truck option (DOE 2004b, Section 5.2.5.1, page 5-94).

Estimates of the collective population risks for shipment to Envirocare of the depleted U_3O_8, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations over the entire 18-year operational period are presented in Table 2.2-1, assuming that the U_3O_8 is shipped in bulk bags. As an option, risks for the shipment of these materials to NTS are provided in Table 2.2-2. No radiological LCFs, traffic fatalities, or emission fatalities are expected for rail transport under either option. If the truck option was used, about 1 traffic fatality would occur and up to 7 fatalities from vehicle emissions might occur over the project period (see discussion in Section 2.2.1 [page 6] related to the “conservative” nature of the emission fatality estimates). No LCFs are expected.

If the emptied DUF_6 cylinders were refilled with the conversion product and used to transport the product to the disposal location(s), as preferred, the risks shown in Tables 2.2-1 and 2.2-2 for transportation of emptied cylinders would not be applicable, and for this scenario, the risks associated with transportation of CaF_2 would be unchanged. The risks of transporting the conversion product in cylinders (Table 2.2-3) would be about the same as the sum of the risks for transporting the product in bulk bags and the risk of shipping the crushed cylinders for the truck option (compare with Tables 2.2-1 and 2.2-2), assuming two refilled cylinders per truck. If one cylinder per truck were shipped, routine risks to the crew and vehicle-related risks would approximately double because the number of shipments would double. If the rail option was used, the risks would be slightly higher for the cylinder refill option, primarily because the quantity of U_3O_8 shipped in a single railcar would be less under the cylinder refill option than under the bulk bag option, and the number of shipments would be proportionally higher.

2.2.1.2 Maximally Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals may be exposed to radiation in the vicinity of a shipment. The RISKIND code (a computer-based risk assessment program) was used to estimate the risk to these individuals for a number of hypothetical exposure-causing events (Yuan et al. 1995). The receptors include transportation crew members, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living near an origin or a destination site. The assumptions about exposure are given in Biwer et al. (2001). The scenarios for exposure are not intended to be exhaustive; they were selected to provide a range of representative potential exposures. Doses were assessed and are presented in Table 2.2-4 on a per-event basis for the shipments of all radioactive materials (DOE 2004b, Section 5.2.5.2, page 5-101).

As discussed above, the assessment of potential impacts to individuals considered a number of hypothetical exposure scenarios from which exposures and risks were estimated. As presented in Table 2.2-4, the highest potential routine radiological exposure to an MEI, with an LCF risk of 2×10^{-7} per event, would be for a “Person in Traffic.” For calculational purposes, the “Person in Traffic” was assumed to be stopped in traffic near a railcar for 30 minutes at a distance of 3 ft (1 m). This is a conservative exposure scenario in that it is not likely that a person in traffic would be exposed in such close proximity (i.e., 1 m [3 ft]) to the depleted uranium oxide conversion product for as long as 30 minutes. There is also the possibility for multiple exposures. For example, if an individual lived near the Portsmouth site or the disposal location and all shipments of U_3O_8 were made by rail in bulk bags, the resident could receive a combined dose of approximately 2.4×10^{-5} rem if present for all shipments (calculated as the product of about 2,200 shipments and an estimated exposure per shipment of 1.1×10^{-8} rem). The individual dose would increase by a factor of approximately 2 if the U_3O_8 were shipped in refilled cylinders. This dose is more than 6,000 times lower than the individual average annual exposure of 0.3 rem from natural background radiation (DOE 2004b, Section 5.2.5.2, page 5-101).

TABLE 2.2-1 Collective Population Transportation Risks for Shipments from Portsmouth, Assuming Envirocare is the Primary Disposal Location and U_3O_8 is Disposed of in Bulk Bags

	U_3O_8		Emptied Cylinders				CaF_2[d]	
	Portsmouth to Envirocare		Portsmouth to Envirocare[b]		Portsmouth to NTS[c]		Portsmouth to Envirocare	
Mode	Truck (option)	Rail (proposed)[a]	Truck (option)	Rail (proposed)[a]	Truck (proposed)	Rail (option)[a]	Truck (option)	Rail (proposed)[a]
Shipment summary								
Number of shipments	8,846	2,212	2,007	1,004	2,232	558	15	4
Total distance (km)	25,860,000	7,315,000	5,866,000	3,320,000	7,504,000	2,240,000	43,850	13,230
Cargo-related[e]								
Radiological impacts								
Dose risk (person-rem)								
Routine crew	150	350	35	88	79	170	NA[f]	NA
Routine public								
Off-link	2.6	12	0.7	2.9	1.2	3.9	NA	NA
On-link	7.2	0.31	1.9	0.077	3.0	0.12	NA	NA
Stops	60	5.4	16	1.3	23	2.7	NA	NA
Total	70	17	19	4.3	27	6.6	NA	NA
Accident[g]	28	9.3	0.24	0.075	0.02	0.0062	NA	NA
Latent cancer fatalities[h]								
Crew fatalities	0.06	0.1	0.01	0.04	0.03	0.07	NA	NA
Public fatalities	0.05	0.01	0.009	0.002	0.01	0.003	NA	NA
Chemical impacts								
Adverse effects	0.0009	0.0003	NA	NA	NA	NA	NA	NA
Irreversible adverse effects	0.0001	0.00009	NA	NA	NA	NA	NA	NA
Vehicle-related[i]								
Emission fatalities	5	0.2	1	0.1	2	0.05	0.008	0.0005
Accident fatalities	0.53	0.24	0.12	0.11	0.13	0.061	0.0009	0.00043

[a] Risks are presented on a railcar basis. One shipment is equivalent to one railcar. For assessment purposes, it was assumed that all-rail access to NTS would be available in the future.

Footnotes continued on next page.

TABLE 2.2-1 (Cont.)

[b] Emptied cylinders are crushed and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

[c] Cylinders assumed not to meet waste acceptance criteria (WAC) for Envirocare. Shipped “as-is,” 1 per truck or 4 per railcar.

[d] Assuming HF can be sold for beneficial use and is not converted to CaF_2 for disposal.

[e] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[f] NA = not applicable.

[g] Dose risk is a societal risk and is the product of accident probability and accident consequence.

[h] Latent cancer fatalities were calculated by multiplying the dose by the International Commission on Radiological Commission (ICRP) Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for members of the public (ICRP 1991).

[i] Vehicle-related impacts are impacts independent of the cargo in the shipment.

Source: DOE 2004b, Table 5.2.26, page 5-98.

TABLE 2.2-2 Collective Population Transportation Risks for Shipments from Portsmouth, Assuming NTS is the Primary Disposal Location and U_3O_8 is Disposed of in Bulk Bags

	U_3O_8		Emptied Cylinders				CaF_2[d]	
	Portsmouth to NTS		Portsmouth to NTS[a]		Portsmouth to NTS[c]		Portsmouth to NTS	
Mode	Truck (option)	Rail (option)[a]	Truck (option)	Rail (option)[a]	Truck (option)	Rail (option)[a]	Truck (option)	Rail (option)[a]
Shipment summary								
Number of shipments	8,846	2,212	2,007	1,004	2,232	558	15	4
Total distance (km)	29,740,000	8,879,000	6,748,000	4,030,000	7,504,000	2,240,000	50,430	16,060
Cargo-related[e]								
Radiological impacts								
Dose risk (person-rem)								
Routine crew	180	410	41	100	79	170	NA[f]	NA
Routine public								
Off-link	3.6	9.2	0.96	2.3	1.2	3.9	NA	NA
On-link	9.0	0.28	2.4	0.069	3.0	0.12	NA	NA
Stops	69	6.4	18	1.6	23	2.7	NA	NA
Total	82	16	22	3.9	27	6.6	NA	NA
Accident[g]	20	7.5	0.18	0.053	0.02	0.0062	NA	NA
Latent cancer fatalities[h]								
Crew fatalities	0.07	0.2	0.02	0.04	0.03	0.07	NA	NA
Public fatalities	0.05	0.01	0.01	0.002	0.01	0.003	NA	NA
Chemical impacts								
Adverse effects	0.001	0.0004	NA	NA	NA	NA	NA	NA
Irreversible adverse effects	0.0002	0.0001	NA	NA	NA	NA	NA	NA
Vehicle-related[i]								
Emission fatalities	6	0.2	1	0.09	2	0.05	0.01	0.0004
Accident fatalities	0.53	0.24	0.12	0.11	0.13	0.061	0.0009	0.0004

[a] Risks are presented on a railcar basis. One shipment is equivalent to one railcar. For assessment purposes, it was assumed that all-rail access to NTS would be available in the future.

[b] Cylinders are crushed and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

Footnotes continued on next page.

TABLE 2.2-2 (Cont.)

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[c] Cylinders assumed not to meet WAC for Envirocare. Shipped "as-is," 1 per truck or 4 per railcar.

[d] Assuming HF can be sold for beneficial use and is not converted to CaF_2 for disposal.

[e] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[f] NA = not applicable.

[g] Dose risk is a societal risk and is the product of accident probability and accident consequence.

[h] Latent cancer fatalities were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for members of the public (ICRP 1991).

[i] Vehicle-related impacts are impacts independent of the cargo in the shipment.

Source: DOE 2004b, Table 5.2-27, page 5-99.

TABLE 2.2-3 Collective Population Transportation Risks for Shipment of Depleted U_3O_8 from Portsmouth in Emptied Cylinders

	Portsmouth to Envirocare (proposed)			Portsmouth to NTS (option)		
	Truck (option)		Rail (proposed)	Truck (option)		Rail[a] (option)
Mode	1 cylinder	2 cylinders		1 cylinder	2 cylinders	
Shipment summary						
Number of shipments	21,000	10,500	4,200	21,000	10,500	4,200
Total distance (km)	61,380,000	30,690,000	13,890,000	70,600,000	35,300,000	16,860,000
Cargo-related[b]						
Radiological impacts						
Dose risk (person-rem)						
Routine crew	330	180	520	390	210	600
Routine public						
Off-link	4.5	4.5	19	6.1	6.2	15
On-link	12	12	0.52	15	15	0.46
Stops	100	100	8.8	120	120	10
Total	120	120	29	140	140	26
Accident	31	31	10	21	21	8
Latent cancer fatalities						
Crew fatalities	0.1	0.07	0.2	0.2	0.08	0.2
Public fatalities	0.07	0.08	0.02	0.08	0.08	0.02
Chemical impacts						
Adverse effects	0.0008	0.0008	0.0004	0.0009	0.0009	0.0005
Irreversible adverse effects	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Vehicle-related[c]						
Emission fatalities	10	5	0.5	10	7	0.4
Accident fatalities	1.3	0.63	0.45	1.3	0.63	0.46

[a] For assessment purposes, it was assumed that all-rail access to NTS would be available in the future.

[b] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

Source: DOE 2004b, Table 5.2-28, page 5-100.

TABLE 2.2-4 Estimated Radiological Impacts to the MEI from Routine Shipment of Radioactive Materials from Portsmouth

Material	Mode	Inspector	Resident	Person in Traffic	Person at Gas Station	Person near Rail Stop
Routine Radiological Dose from a Single Shipment (rem)						
Depleted U_3O_8 (in bulk bags)[a]	Truck	4.0×10^{-5}	3.1×10^{-9}	1.6×10^{-4}	4.4×10^{-6}	NA[b]
	Rail	9.3×10^{-5}	1.1×10^{-8}	2.7×10^{-4}	NA	6.9×10^{-7}
Crushed, emptied DUF_6 cylinders[c]	Truck	5.3×10^{-5}	5.7×10^{-9}	1.6×10^{-4}	7.7×10^{-6}	NA
	Rail	6.6×10^{-5}	9.4×10^{-9}	1.7×10^{-4}	NA	6.1×10^{-7}
Emptied DUF_6 cylinders[d]	Truck	6.8×10^{-5}	5.4×10^{-9}	2.7×10^{-4}	7.5×10^{-6}	NA
	Rail	1.5×10^{-4}	2.0×10^{-8}	4.0×10^{-4}	NA	1.3×10^{-6}
Routine Radiological Risk from a Single Shipment (lifetime risk of a LCF)[e]						
Depleted U_3O_8 (in bulk bags)[a]	Truck	2×10^{-8}	2×10^{-12}	8×10^{-8}	2×10^{-9}	NA
	Rail	5×10^{-8}	6×10^{-12}	1×10^{-7}	NA	4×10^{-10}
Crushed emptied DUF_6 cylinders[c]	Truck	3×10^{-8}	3×10^{-12}	8×10^{-8}	4×10^{-9}	NA
	Rail	3×10^{-8}	5×10^{-12}	8×10^{-8}	NA	3×10^{-10}
Emptied DUF_6 cylinders[d]	Truck	3×10^{-8}	3×10^{-12}	1×10^{-7}	4×10^{-9}	NA
	Rail	7×10^{-8}	1×10^{-11}	2×10^{-7}	NA	6×10^{-10}

[a] Per-shipment doses and LCFs would be approximately the same for the cylinder refill option.

[b] Not applicable.

[c] Crushed, emptied DUF_6 cylinders are shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

[d] Cylinders assumed not to meet WAC for Envirocare. Shipped "as-is," 1 per truck or 4 per railcar.

[e] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for members of the public (ICRP 1991).

Source: DOE 2004b, Table 5.2-31, page 5-103.

2.2.1.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts and in terms of adverse effects and irreversible adverse effects for chemical impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Tables 2.2-5 and 2.2-6 present the radiological and chemical consequences, respectively, to the population from severe accidents involving shipment of depleted U_3O_8 and emptied DUF_6 cylinders (DOE 2004b, Section 5.2.3, page 5-102).

No LCFs are expected for accidents involving emptied DUF6 cylinders. However, the calculations indicate that 3 LCFs might occur from radiation exposure, and chemical exposure might cause 103 adverse effects (i.e., mild and temporary effects, such as respiratory irritation or temporary decrease in kidney function) and 38 irreversible adverse effects (such as lung damage or kidney damage) if one assumed that a severe rail accident involving a railcar of depleted U_3O_8 occurred in an urban area under stable atmospheric conditions (calm/stagnant weather conditions with low wind speeds [approximately 1 to 2 m/s] such as at nighttime), with about 3 million people being exposed to the uranium that would be dispersed by the wind (DOE 2004b, Section 5.2.3, page 5-102). As indicated in Tables 2.2.5 and 2.2.6, these consequences would be considerably less if the same accident occurred in a rural or suburban environment under unstable daytime atmospheric conditions or if it involved a truck carrying depleted U_3O_8. Also, the probability that a severe rail accident would occur in an urban area under the stable atmospheric conditions assumed (i.e., nighttime) is expected to be considerably lower than the probability that such an accident would occur in other locations and under other atmospheric conditions, yielding lower consequences (DOE 2004b, Section 5.2.3, page 5 102). For comparison, the number of cancer fatalities from all other causes in a population of 3 million people, is expected to be approximately 700,000.

Conservative estimates meant to over predict any actual doses that can potentially be received by an individual were also made. For these estimates, the MEI was assumed to be located 100 ft (30 m) away from the accident site along the transportation route for shipment of depleted U_3O_8 and emptied DUF_6 cylinders (assuming they are not used as containers for depleted U_3O_8). The results for radiological impacts are shown in Table 2.2-7. If the person was located at a distance of 100 ft (30 m) and if the accident occurred under the most severe conditions described above, the individual could suffer acute and potentially lethal consequences from both radiation exposure and the chemical effects of uranium. At 328 ft (100 m) or farther from the accident, the MEI would not be expected to suffer acute effects. However, the chance of the MEI developing a latent cancer would increase by about 10% for the train accident and about 3% for the truck accident under those conditions (DOE 2004b, Section 5.2.3, page 5-102).

The consequences of severe accidents can be reduced or mitigated through design (e.g., by limiting the quantity of material per vehicle), operational procedures (e.g., by judicious selection of routes and times of travel, increased protection and tracking of transport vehicles), and emergency response actions (e.g., by sheltering, evacuation, and interdiction of contaminated food materials following an accident) (DOE 2004b, Section 5.2.3, page 5-102).

TABLE 2.2-5 Potential Radiological Consequences to the Population from Severe Transportation Accidents Due to Shipments from Portsmouth[a]

		Neutral Meteorological Conditions			Stable Meteorological Conditions		
Material	Mode	Rural	Suburban	Urban[b]	Rural	Suburban	Urban[b]
Radiological Dose (person-rem)							
Depleted U_3O_8 (in bulk bags)	Truck	250	250	550	630	610	1,400
	Rail	1,000	990	2,200	2,500	2,400	5,400
Depleted U_3O_8 (1 cylinder)	Truck	120	110	250	280	280	620
	Rail	290	280	630	710	690	1,500
Depleted U_3O_8 (2 cylinders)	Truck	230	230	500	570	550	1,200
	Rail	580	560	1,300	1,400	1,400	3,100
Crushed, emptied DUF_6 cylinders[c]	Truck	2.5	0.67	1.5	4.4	1.2	2.6
	Rail	5.0	1.3	3.0	8.7	2.3	5.2
Emptied DUF_6 cylinders[d]	Truck	0.25	0.067	0.15	0.44	0.12	0.26
	Rail	1.0	0.27	0.60	1.7	0.47	1.0
Radiological Risk (LCF)[e]							
Depleted U_3O_8 (in bulk bags)	Truck	0.1	0.1	0.3	0.3	0.3	0.7
	Rail	0.5	0.5	1	1	1	3
Depleted U_3O_8 (1 cylinder)	Truck	0.06	0.06	0.1	0.1	0.1	0.3
	Rail	0.1	0.1	0.3	0.4	0.3	0.8
Depleted U_3O_8 (2 cylinders)	Truck	0.1	0.1	0.3	0.3	0.3	0.6
	Rail	0.3	0.3	0.6	0.7	0.7	2
Crushed, emptied DUF_6 cylinders[c]	Truck	0.001	0.0003	0.0007	0.002	0.0006	0.001
	Rail	0.002	0.0007	0.001	0.004	0.001	0.003
Emptied DUF_6 cylinders[d]	Truck	0.0001	3×10^{-5}	7×10^{-5}	0.0002	6×10^{-5}	0.0001
	Rail	0.0005	0.0001	0.0003	0.0009	0.0002	0.0005

[a] National average population densities were used for the accident consequence assessment, corresponding to densities of 6 persons/km^2, 719 persons/km^2, and 1,600 persons/km^2 for rural, suburban, and urban zones, respectively. Potential impacts were estimated for the population within a 50-mi (80-km) radius, assuming a uniform population density for each zone.

[b] It is important to note that the urban population density generally applies to a relatively small urbanized area — very few, if any, urban areas have a population density as high as 1,600 persons/km^2 extending as far as 50 mi (80 km). The urban population density corresponds to approximately 32 million people within the 50-mi (80-km) radius, well in excess of the total populations along the routes considered in this assessment.

[c] Crushed, emptied DUF_6 cylinders are shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

[d] Cylinders assumed not to meet WAC for Envirocare. Shipped "as-is," 1 per truck or 4 per railcar.

[e] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for members of the public (ICRP 1991).

Source: DOE 2004b, Table 5.2-32, page 5-105.

TABLE 2.2-6 Potential Chemical Consequences to the Population from Severe Transportation Accidents Due to Shipments from Portsmouth[a]

		Neutral Meteorological Conditions			Stable Meteorological Conditions		
Chemical Effect	Mode	Rural	Suburban	Urban[b]	Rural	Suburban	Urban[b]
Number of Persons with the Potential for Adverse Health Effects							
Depleted U_3O_8 (in bulk bags)	Truck	0	1	1	0	12	28
	Rail	0	3	9	0	47	103
Depleted U_3O_8 (in cylinders)	Truck (1 cylinder)	0	0	1	0	6	13
	Truck (2 cylinders)	0	1	1	0	11	26
	Rail	0	2	5	0	27	58
Number of Persons with the Potential for Irreversible Adverse Health Effects							
Depleted U_3O_8 (in bulk bags)	Truck	0	0	0	0	5	10
	Rail	0	0	0	0	17	38
Depleted U_3O_8 (in cylinders)	Truck (1 cylinder)	0	0	0	0	2	5
	Truck (2 cylinders)	0	0	0	0	4	8
	Rail	0	1	1	0	10	22

[a] National average population densities were used for the accident consequence assessment, corresponding to densities of 6 persons/km^2, 719 persons/km^2, and 1,600 persons/km^2 for rural, suburban, and urban zones, respectively. Potential impacts were estimated for the population within a 50-mi (80-km) radius, assuming a uniform population density for each zone.

[b] It is important to note that the urban population density generally applies to a relatively small urbanized area — very few, if any, urban areas have a population density as high as 1,600 persons/km^2 extending as far as 50 mi (80 km). The urban population density corresponds to approximately 32 million people within the 50-mi (80-km) radius, well in excess of the total populations along the routes considered in this assessment.

Source: DOE 2004b, Table 5.2-33, page 5-106.

2.2.1.4 Intentional Destructive Acts

The releases caused by intentional destructive acts (such as terrorism) during the transportation of depleted uranium oxide conversion product from the conversion facility to a disposal location were not expressly calculated in the site-specific EIS (DOE 2004b). However, should an intentional destructive act occur, the consequences of the accident scenarios considered in the site-specific EISs and presented therein would either bound or be comparable to the consequences from the act. As discussed in the EIS, releases for and the consequences from severe transportation accidents involving the depleted uranium oxide conversion product were derived using highly conservative assumptions. Therefore any releases caused by and the

TABLE 2.2-7 Potential Radiological Consequences to the MEI from Severe Transportation Accidents Involving Shipment of Radioactive Materials from Portsmouth

	Neutral Meteorological Conditions		Stable Meteorological Conditions	
Mode	Dose (rem)	Radiological Risk (LCF)[a]	Dose (rem)	Radiological Risk (LCF)[a]
Depleted U_3O_8 (in bulk bags)				
Truck	11	0.005	170[b]	0.08
Rail	42	0.02	670[b]	0.3
Depleted U_3O_8 (1 cylinder)				
Truck	4.8	0.002	76	0.04
Rail	12	0.006	190	0.09
Depleted U_3O_8 (2 cylinders)				
Truck	9.6	0.005	150[b]	0.08
Rail	24	0.01	380[b]	0.2
Crushed, emptied DUF_6 cylinders[c]				
Truck	0.28	0.0001	0.63	0.0003
Rail	0.55	0.0003	1.3	0.0006
Emptied DUF_6 cylinders[d]				
Truck	0.028	1×10^{-5}	0.063	3×10^{-5}
Rail	0.11	6×10^{-5}	0.25	0.0001

[a] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

[b] See text for discussion. Because of the conservative assumptions made in deriving the numbers in this table, the MEI is likely to receive a dose that is less than that shown here. However, if the doses were as high as those shown in the table, the MEI could develop acute radiation effects. The individual might also suffer from chemical effects due to uranium intake.

[c] Crushed, emptied DUF_6 cylinders are shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

[d] Shipped "as is," 1 cylinder per truck or 4 cylinders per railcar.

Source: DOE 2004b, Table 5.2-34, page 5-109.

consequences from any potential intentional events during transportation of the depleted uranium oxide conversion product would either be bounded by or be comparable to the releases and consequences presented in the EIS for severe accidents.

2.2.2 Impacts of Transport from Paducah to Disposal Locations

For the Paducah site, the transportation assessment analyzed the annual transport of 14,300 metric tons uranium oxide/yr (15,800 tons/yr), 24 t/yr (26 tons/yr) of CaF_2, and 1,980 t/yr (2,200 tons/yr) of unused emptied DUF_6 cylinders from Paducah to both the Envirocare facility and NTS. The operational period was assumed to be 25 years. If U_3O_8 was disposed of in emptied DUF_6 cylinders, there would be a total of approximately 7,240 railcar shipments or up to 36,200 truck shipments. If bulk bags were used as disposal containers, there would be a total of about 4,100 shipments for railcars or 16,400 shipments for trucks (DOE 2004a, Section 5.2.3, page 5-73).

The results of the transportation assessment to Envirocare or NTS are presented in Section 5.2.3 of the Paducah EIS (DOE 2004a). A brief summary follows:

- For the entire shipment campaign (25 years), cargo-related radiological impacts to crew members and the general public would result in less than 1 LCF for disposal either at Envirocare or NTS.

- Health risks from cardiovascular and pulmonary diseases have been linked to incremental increases in particulate concentrations in air, such as those produced by vehicle exhaust emissions. In the Paducah site-specific EIS, health risks from vehicle emissions were calculated by multiplying the total distances shipped over the duration of the campaign by health risk factors presented in Biwer and Butler (1999). Because estimating the health risks associated with vehicle emissions is subject to a great deal of uncertainty, the risk factors used in the EIS (from Biwer and Butler 1999) purposely overestimate the actual risk (referred to as a “conservative” estimate). Therefore, the emissions-related health impacts presented in the Paducah site-specific EIS should be considered an upper bound estimate of potential impacts, with the actual impacts expected to be much less. For the 25-year shipping campaign, the transportation assessment results for vehicle related emissions fatalities for truck shipments were estimated to be about 12 for shipment to Envirocare and 13 for shipment to NTS using bulk bags; no emission fatalities would be expected for railcar shipments. If the emptied cylinders were used as disposal containers, the estimated emission fatalities would be similar but could vary depending on the number of cylinders per truck or railcar shipment. As discussed in the Paducah site-specific EIS, the emission risks are believed to overestimate actual emission impacts by at least a factor of 30 (see DOE 2004a, page 5-80).

- Truck accidents (non-cargo-related) for the life of the project were estimated to result in 1 to 2 additional fatalities for transportation to either Envirocare or NTS, whereas rail accidents would be expected to result in less than 1 fatality (based on state-specific accident statistics).

- Severe transportation accidents could also result in a release of radioactive material or chemicals from a shipment. The consequences of such a release would depend on the material released, location of the accident, and atmospheric conditions at the time. Potential consequences would be greatest in urban areas and under stable atmospheric conditions (calm/stagnant weather conditions with low wind speeds [approximately 1 to 2 m/s] such as at nighttime).

In the following paragraphs, the results of the transportation assessment are presented in greater detail, with accompanying tables taken from the Paducah site-specific EIS (DOE 2004a). The types of materials shipped, methods, and assumptions used in the assessment were the same as described previously for the Portsmouth site-specific EIS.

2.2.2.1 Collective Population Risk

As stated previously, both truck and rail options were considered for shipments to both Envirocare and NTS. For analyzing an all-rail transport option to NTS, it was assumed that a rail line would be available for the entire distance. Currently, however, the nearest rail terminal to NTS is about 70 mi (113 km) from the site. Accordingly, if NTS were to be selected as the disposal location, a rail spur would have to be constructed connecting the existing rail line to the site in order to realize the all-rail option. Alternatively, railcar shipments would have to go to a terminal from which trucks could carry the load the rest of the way. The Paducah site-specific EIS (DOE 2004a, Section 5.2.3.1, page 5-75) indicated that if a rail spur to NTS were built, additional NEPA review would need to be conducted to evaluate the impacts resulting from such construction. The Paducah site-specific EIS also indicated that, if shipments from Paducah to NTS were made instead through intermodal transfers from rail to trucks, the impacts would be slightly greater than for the all-rail option, but less than for the all-truck option (DOE 2004a, Section 5.2.3.1, page 5-75).

Estimates of the collective population risks for shipment to Envirocare of the depleted U_3O_8, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations over the entire 25-year operational period are presented in Table 2.2-8, assuming the U_3O_8 was shipped in bulk bags. As an option, risks for the shipment of these materials to NTS are provided in Table 2.2-9. No radiological LCFs, traffic fatalities, or emission fatalities are expected for rail transport under either option. No radiological LCFs would be expected for the truck option either. However, approximately 1 traffic fatality might occur, and up to 11 fatalities from vehicle emissions might occur over the project period if the truck option was used (see discussion in Section 2.2.2 [page 19] related to the "conservative" nature of the emission fatality estimates).

If the emptied DUF_6 cylinders were refilled with the U_3O_8 conversion product and used to transport it to the disposal location(s), as proposed, the risks shown in Tables 2.2-8 and 2.2-9 for transportation of emptied cylinders would not be applicable, and for this scenario, the risks associated with transportation of CaF_2 would be unchanged. The risks of transporting the U_3O_8 in cylinders (Table 2.2-10) would be about the same as the sum of the risks for transporting the U_3O_8 in bulk bags and the risk of shipping the crushed cylinders for the truck option (compare with Tables 2.2-8 and 2.2-9), assuming two refilled cylinders per truck. If one cylinder per truck was shipped, routine risks to the crew and vehicle-related risks would be approximately double, because the number of shipments would double. If the rail option was used, the risks would be slightly higher for the cylinder refill option primarily because the quantity of U_3O_8 shipped in a single railcar would be less under the cylinder refill option than under the use of the bulk bag option, and the number of shipments would be proportionally higher.

2.2.2.2 Maximally Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals may be exposed to radiation in the vicinity of a shipment. The doses and risks to the MEI for a number of hypothetical exposure scenarios during routine shipments from Paducah are presented in Table 2.2-11 on a per-event basis for the shipment of all radioactive materials. As described for Portsmouth shipments, the highest potential routine radiological exposure to an MEI, with an LCF risk of 2×10^{-7} per event, would be for a "Person in Traffic," assumed for assessment purposes to be a person stopped in traffic near a railcar of emptied DUF_6 cylinders for 30 minutes at a distance of 3 ft (1 m). There is also the possibility for multiple exposures. For example, if an individual lived near the Paducah site or the disposal location and all shipments of U_3O_8 were made by rail in bulk bags, the resident could receive a combined dose of approximately 4.5×10^{-5} rem if present for all shipments (calculated as the product of 4,105 shipments and an estimated exposure per shipment of 1.1×10^{-8} rem). The individual's dose would increase by approximately a factor of 2 if the U_3O_8 were shipped in refilled cylinders. This dose is more than 3,000 times lower than the individual average annual exposure of 0.3 rem from natural background radiation (DOE 2004a, Section 5.2.3.2, page 5-82).

2.2.2.3 Accident Consequence Assessment

Because the same materials would be shipped and the consequences were determined on a per-shipment basis, the results of the Paducah accident consequence assessment are the same as those discussed in section 2.2.1.3 for Portsmouth.

TABLE 2.2-8 Collective Population Transportation Risks for Shipments from Paducah, Assuming Envirocare is the Primary Disposal Locations and U_3O_8 is Disposed of in Bulk Bags

	U_3O_8		Emptied Cylinders				CaF_2[d]	
	Paducah to Envirocare		Paducah to Envirocare[b]		Paducah to NTS[c]		Paducah to Envirocare	
Mode	Truck (option)	Rail (proposed)[a]	Truck (option)	Rail (proposed)[a]	Truck (proposed)	Rail (option)[a]	Truck (option)	Rail (proposed)[a]
Shipment summary								
Number of shipments	16,420	4,105	3,715	1,858	4,150	1,038	28	7
Total distance (km)	41,710,000	11,010,000	9,436,000	4,985,000	11,690,000	3,559,000	71,120	18,780
Cargo-related[e]								
Radiological impacts								
Dose risk (person-rem)								
Routine crew	240	560	55	140	120	270	NA[f]	NA
Routine public								
Off-link	4.3	11	1.1	2.7	1.7	4.6	NA	NA
On-link	12	0.35	3.1	0.085	4.4	0.16	NA	NA
Stops	97	9.5	26	2.3	36	4.6	NA	NA
Total	110	21	30	5.1	42	9.4	NA	NA
Accident[g]	35	9.9	0.35	0.076	0.02	0.0085	NA	NA
Latent cancer fatalities[h]								
Crew fatalities	0.1	0.2	0.02	0.06	0.05	0.1	NA	NA
Public fatalities	0.07	0.02	0.02	0.003	0.02	0.005	NA	NA
Chemical impacts								
Adverse effects	0.002	0.0004	NA	NA	NA	NA	NA	NA
Irreversible adverse effects	0.0002	0.0001	NA	NA	NA	NA	NA	NA
Vehicle-related[i]								
Emission fatalities	8	0.2	2	0.1	2	0.06	0.01	0.0004
Accident fatalities	1.0	0.24	0.23	0.11	0.27	0.08	0.0018	0.00041

[a] Risks are presented on a railcar basis. One shipment is equivalent to one railcar. For assessment purposes, it was assumed that all-rail access to NTS would be available in the future.

[b] Emptied cylinders are crushed and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

[c] Cylinders assumed not to meet the WAC for Envirocare. Shipped "as is," 1 per truck or 4 per railcar.

Footnotes continued on next page.

TABLE 2.2-8 (Cont.)

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[d] Assuming HF can be sold for beneficial use and is not converted to CaF_2 for disposal.

[e] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[f] NA = not applicable.

[g] Dose risk is a societal risk and is the product of accident probability and accident consequence.

[h] Latent cancer fatalities were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for members of the public (ICRP 1991).

[i] Vehicle-related impacts are impacts independent of the cargo in the shipment.

Source: DOE 2004a, Table 5.2-21, page 5-76.

TABLE 2.2-9 Collective Population Transportation Risks for Shipments from Paducah, Assuming NTS is the Primary Disposal Location and U_3O_8 is Disposed of in Bulk Bags

	U_3O_8		Emptied Cylinders				CaF_2[d]	
	Paducah to NTS		Paducah to NTS[b]		Paducah to NTS[b]		Paducah to NTS	
Mode	Truck (option)	Rail (option)[a]	Truck (option)	Rail (option)[a]	Truck (option)	Rail (option)[a]	Truck (option)	Rail (option)[a]
Shipment summary								
Number of shipments	16,420	4,105	3,715	1,858	4,150	1,038	28	7
Total distance (km)	46,240,000	14,080,000	10,460,000	6,371,000	11,690,000	3,559,000	78,850	24,000
Cargo-related[e]								
Radiological impacts								
Dose risk (person-rem)								
Routine crew	270	670	61	170	120	270	NA[f]	NA
Routine public								
Off-link	5.2	11	1.4	2.7	1.7	4.6	NA	NA
On-link	13	0.39	3.6	0.094	4.4	0.16	NA	NA
Stops	110	11	29	2.7	36	4.6	NA	NA
Total	130	22	34	5.4	42	9.4	NA	NA
Accident[g]	14	9.9	0.18	0.076	0.02	0.0085	NA	NA
Latent cancer fatalities[h]								
Crew fatalities	0.1	0.3	0.02	0.07	0.05	0.1	NA	NA
Public fatalities	0.07	0.02	0.02	0.003	0.02	0.005	NA	NA
Chemical impacts								
Adverse effects	0.002	0.0006	NA	NA	NA	NA	NA	NA
Irreversible adverse effects	0.0002	0.0002	NA	NA	NA	NA	NA	NA
Vehicle-related[i]								
Emission fatalities	9	0.2	2	0.1	2	0.06	0.02	0.0004
Accident fatalities	1.1	0.32	0.24	0.14	0.27	0.08	0.0018	0.0005

[a] Risks are presented on a railcar basis. One shipment is equivalent to one railcar. For assessment purposes, it was assumed that all-rail access to NTS would be available in the future.

[b] Emptied cylinders are crushed and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

Footnotes continued on next page.

TABLE 2.2-9 (Cont.)

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[c] Cylinders shipped “as is,” 1 cylinder per truck or 4 cylinders per railcar.

[d] Assuming HF can be sold for beneficial use and is not converted to CaF_2 for disposal.

[e] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[f] NA = not applicable.

[g] Dose risk is a societal risk and is the product of accident probability and accident consequence.

[h] Latent cancer fatalities were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

[i] Vehicle-related impacts are impacts independent of the cargo in the shipment.

Source: DOE 2004a, Table 5.2-22, page 5-78.

TABLE 2.2-10 Collective Population Transportation Risks for Shipment of Depleted U_3O_8 from Paducah in Emptied Cylinders

	Paducah to Envirocare (proposed)			Paducah to NTS (option)		
	Truck (option)			Truck (option)		
Mode	1 Cylinder	2 Cylinders	Rail (proposed)	1 Cylinder	2 Cylinders	Rail (option)[a]
Shipment summary						
Number of shipments	36,200	18,100	7,240	36,200	18,100	7,240
Total distance (km)	91,950,000	45,970,000	19,420,000	101,900,000	50,970,000	24,830,000
Cargo-related[b]						
Radiological impacts						
Dose risk (person-rem)						
Routine crew	490	260	770	540	290	930
Routine public						
Off-link	6.8	6.9	17	8.1	8.3	17
On-link	18	18	0.53	21	21	0.59
Stops	150	150	14	170	170	17
Total	180	180	31	200	200	34
Accident	35	35	9.8	14	14	9.8
Latent cancer fatalities						
Crew fatalities	0.2	0.1	0.3	0.2	0.1	0.4
Public fatalities	0.1	0.1	0.02	0.1	0.1	0.02
Chemical impacts						
Adverse effects	0.001	0.001	0.0005	0.001	0.001	0.0007
Irreversible adverse effects	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Vehicle-related[c]						
Emission fatalities	20	8	0.4	20	10	0.4
Accident fatalities	2.3	1.1	0.42	2.4	1.2	0.56

[a] For assessment purposes, it was assumed that all-rail access to NTS would be available in the future.

[b] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

Source: DOE 2004a, Table 5.2-23, page 5-80.

TABLE 2.2-11 Estimated Radiological Impacts to the MEI from Routine Shipment of Radioactive Materials from Paducah

Material	Mode	Inspector	Resident	Person in Traffic	Person at Gas Station	Person near Rail Stop
Routine Radiological Dose from a Single Shipment (rem)						
Depleted U_3O_8 (in bulk bags)[a]	Truck	4.0×10^{-5}	3.1×10^{-9}	1.6×10^{-4}	4.4×10^{-6}	NA[b]
	Rail	9.3×10^{-5}	1.1×10^{-8}	2.7×10^{-4}	NA	6.9×10^{-7}
Crushed, emptied DUF_6 cylinders[c]	Truck	5.3×10^{-5}	5.7×10^{-9}	1.6×10^{-4}	7.7×10^{-6}	NA
	Rail	6.6×10^{-5}	9.4×10^{-9}	1.7×10^{-4}	NA	6.1×10^{-7}
Emptied DUF_6 cylinders[d]	Truck	6.8×10^{-5}	5.4×10^{-9}	2.7×10^{-4}	7.5×10^{-6}	NA
	Rail	1.5×10^{-4}	2.0×10^{-8}	4.0×10^{-4}	NA	1.3×10^{-6}
Routine Radiological Risk from a Single Shipment (lifetime risk of a LCF)[e]						
Depleted U_3O_8 (in bulk bags)	Truck	2×10^{-8}	2×10^{-12}	8×10^{-8}	2×10^{-9}	NA
	Rail	5×10^{-8}	6×10^{-12}	1×10^{-7}	NA	4×10^{-10}
Crushed, emptied DUF_6 cylinders[c]	Truck	3×10^{-8}	3×10^{-12}	8×10^{-8}	4×10^{-9}	NA
	Rail	3×10^{-8}	5×10^{-12}	8×10^{-8}	NA	3×10^{-10}
Emptied DUF_6 cylinders[d]	Truck	3×10^{-8}	3×10^{-12}	1×10^{-7}	4×10^{-9}	NA
	Rail	7×10^{-8}	1×10^{-11}	2×10^{-7}	NA	6×10^{-10}

[a] Per-shipment doses and LCFs would be approximately the same as for the cylinder refill option.

[b] NA = not applicable.

[c] Crushed, emptied DUF_6 cylinders are shipped 10 cylinders per cargo container, with 1 container per truck or 2 containers per railcar.

[d] Shipped “as is,” 1 cylinder per truck or 4 cylinders per railcar.

[e] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for members of the public (ICRP 1991).

Source: DOE 2004a, Table 5.2-26, page 5-83.

2.2.2.4 Intentional Destructive Acts

The releases caused by intentional destructive acts (such as terrorism) during the transportation of depleted uranium oxide conversion product from the conversion facility to a disposal location were not expressly calculated in the site-specific EIS (DOE 2004a). However, should an intentional destructive act occur, the consequences of the accident scenariosconsidered in the site-specific EISs and presented therein would either bound or be comparable to the consequences from the act. As discussed in the EIS, releases for and the consequences from severe transportation accidents involving the depleted uranium oxide conversion product were derived using highly conservative assumptions. Therefore any releases caused by and the consequences from any potential intentional events during transportation of the depleted uranium oxide conversion product would either be bounded by or be comparable to the releases and consequences presented in the EIS for severe accidents.

2.3 DISPOSAL

2.3.1 Background

The DUF_6 PEIS (DOE 1999) considered the environmental impacts of six alternative strategies for long-term management of DOE's DUF_6 inventory. The alternative strategies included options for continued storage of DUF_6 in cylinders at the three, then current, storage sites; long-term storage as UF_6 at a consolidated site; conversion of the DUF_6 to an oxide followed by long-term storage; conversion to an oxide or depleted uranium metal followed by use; conversion to an oxide followed by disposal; and the No Action alternative (DOE 1999, Section 2.2, page 2-5). The analyses of the long-term storage and disposal alternatives included the transportation of the converted depleted uranium product to a generic storage or disposal site located 155 mi (250 km), 620 mi (1,000 km), or 3,100 mi (5,000 km) from the conversion facilities. Analyses for the impacts of converted depleted uranium disposal, which are further described in Section 2.3.2 below, were completed using generic assumptions about disposal site characteristics, rather than actual characteristics for any particular disposal site (DOE 1999, Section 2.2.6, page 2-17).

The conversion facility site-specific EISs stated that disposal location(s) would be (1) selected in a manner consistent with DOE policies and orders, and (2) authorized or licensed to receive the depleted uranium oxide conversion product, emptied cylinders, and CaF_2 produced during normal conversion operations by DOE (in conformance with DOE orders), the NRC (in conformance with NRC regulations), or an NRC agreement state agency (in conformance with state laws and regulations determined to be equivalent to NRC regulations) (DOE 2004a, Section 1.6.2.4, page 1-19; DOE 2004b, Section 1.6.2.4, page 1-20).

2.3.2 Programmatic EIS Disposal Analyses

2.3.2.1 Summary of PEIS Disposal Analyses

The DUF_6 PEIS included a generic assessment of disposal of depleted uranium oxide (as U_3O_8 or UO_2) in either ungrouted or grouted form, in a wet or dry environment. The results of the disposal assessment are presented in Appendix I of the PEIS (DOE 1999), with additional detailed information provided in Tomasko (1997). Assessment of impacts for disposal in shallow earthen structures, vaults, or mines was included. The operational phase (time during which waste would be actively placed in the disposal units) and the post-closure phase were considered separately. Post-closure impacts were estimated for the 1,000-year period after the disposal facility was assumed to fail (i.e., slowly release depleted uranium compounds to the subsurface through leaching). The impact assessment concluded the following for U_3O_8 (DOE 1999, Appendix I.1, page I-4):

- Potential impacts during the operational phase would be much less than regulatory limits.

- The maximum dose to an individual assumed to live at the edge of a disposal site within 1,000 years after failure of a disposal facility in a wet setting and using the contaminated ground water was estimated to be about 110 mrem/yr, which would exceed the 25 mrem/yr limit specified in 10 CFR 61 and Directive DOE M 435.1-1 (DOE 2001) for protection of the general public from releases of radioactivity from LLW disposal facilities.

- Essentially no impacts to human health or groundwater would be expected in a dry setting for more than 1,000 years because of the low water infiltration rate and greater depth to the water table.

- Possible exposures on the order of 10 rem/yr could occur if the cover material of shallow earthen structures or vaults was to be disturbed (e.g., by digging) or were to erode and expose the uranium material. However, sufficient erosion would not occur until several thousand years post-closure, and the exposure could be eliminated by adding new cover material to the top of the waste area.

- During the operational phase, disposal of grouted waste would have larger environmental impacts than ungrouted waste because (1) grouting increases the volume of waste requiring disposal (by 50%) and (2) grouting results in small emissions of uranium material to air and water. The increased volume from grouting results in greater land requirements for disposal and associated impacts. In addition, although grouting might reduce the leaching of uranium into the groundwater in the first several hundred years after failure, over longer periods the grouted form would be expected to deteriorate, at which time the performance of grouted and ungrouted waste would be essentially the same. Consequently, the PEIS did not identify environmental advantages associated with grouting.

- Shallow earthen structures would not be expected to fail (i.e., they would contain the waste) for at least several hundred years.

2.3.2.2 Detailed Results of PEIS Disposal Analyses

The results of the PEIS's generic disposal assessment for U_3O_8 are presented here in greater detail, with accompanying tables (See Appendix I in DOE 1999). This detailed discussion is presented to support the PEIS conclusion that disposal of depleted uranium oxide conversion product in either shallow earthen structures, vaults, or in mines is adequately protective of human health and the environment over the time period considered, as long as the disposal facility is located in a dry environment and appropriately engineered (e.g., the cover material is maintained).

The PEIS considered two physical waste forms: ungrouted and grouted. Ungrouted waste refers to uranium oxide in the powder form produced during the conversion process. DOE assumed this bulk material would be disposed of in 55-gal (208-L) drums. 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 the structural strength and stability of the waste, and reduce the leaching rate of the waste in water. However, because cement is added to the uranium oxide, grouting would increase the total volume requiring disposal by up to 50%. Grouting of waste was assumed to occur at the disposal facility.

Generic disposal facilities were assumed to be stand-alone, single-purpose facilities consisting of a central receiving building/warehouse ("wasteform facility") and several disposal units. Depending on the option, the disposal units would be a series of shallow earthen structures, vaults, or underground mine tunnels ("drifts"). Activities at the disposal facility would include receiving containers of depleted uranium oxide by truck or railcar, inspecting the containers, grouting the material if necessary, and placing containers into the disposal units. The disposal unit would then be backfilled with soil, sand, gravel, or other material and covered with multiple layers of natural material, such as clay, designed to minimize infiltration of water for long periods of time. The disposal facilities would be designed to protect the waste from the environment and prevent potential releases of material to the environment. Following disposal of the last containers, the disposal facility would be closed and then monitored and maintained for a period of time consistent with regulatory and license requirements. (DOE 1999, Appendix I.2, page I-24)

Potential impacts during the operational phase, which would include construction activities and the handling of waste containers as they were placed into disposal units, would primarily affect workers. In addition, some potential impacts to the public could occur from air emissions during grouting of the waste. The potential impacts during the post-closure phase would affect only the public and would follow the eventual release of material from the disposal facility to the environment. For assessment purposes, all disposal facilities were assumed to fail, or release waste to the environment, at the end of an institutional control period (failure was assumed to occur around 100 years after site closure). Because of the infiltration of water, uranium could ultimately migrate through the soil, eventually contaminating the groundwater and potentially exposing members of the public. Post-closure impacts were estimated at 1,000 years after the disposal facilities were assumed to fail.

For assessment purposes, two generic environmental settings were defined, a generic dry setting and a generic wet setting. The conditions of the dry setting would be typical of a site in the arid western United States (e.g., depth to water table of 500 ft [160 m], infiltration velocity of 0.1 in./yr), and the conditions of the wet setting would be typical of a site in the eastern United States (e.g., depth to water table of 30 ft [9 m], infiltration velocity of 20 in./yr) (DOE 1999, Section 3.4.4, page 3-60). The estimated impacts associated with the disposal options are subject to a great deal of uncertainty, especially for the post-closure period because disposal impacts consider an extremely long period of time and depend on predicting the behavior of the waste material as it interacts with soil and water in a complex and changing environment. Consequently, the estimated disposal impacts depend upon the assumptions made for the assessment, including such key factors as soil characteristics, water infiltration rates, depth to underlying groundwater table, chemistry of different uranium compounds, and locations of future human receptors. These factors could vary widely, depending on site-specific conditions. Therefore, a range of these factors was selected for analysis to represent the range of actual conditions that could occur. (see Appendix I in DOE 1999, and Tomasko 1997).

The design of the shallow earthen structures (also called engineered trenches) was assumed to include a clay liner. The trenches were assumed to be about 26 ft (8 m) deep. The waste containers were assumed to be tightly stacked, and any open space between containers would be filled with earth, sand, gravel, or other similar material as each layer of containers was placed. Each engineered trench would be capped with a 6 ft (2 m) compacted clay and soil cap after it was filled. The cap would be mounded and sloped to minimize the potential for water infiltration. Disposal of ungrouted and grouted U_3O_8 in this type of shallow earthen structure would require about 42 acres (17 ha) and 76 acres (31 ha), respectively. (DOE 1999, Appendix I.2.1, page I-25)

For vaults, it was assumed that the floors and walls would be constructed of reinforced concrete. Once a vault was full, any open space between containers would be filled with earth, sand, gravel, or other similar material. A permanent roof slab of reinforced concrete that would completely cover the vault would be installed after it was full. A cap of engineered fill soil and clay would be placed on top of the concrete cover and compacted. The cap would be mounded above the local grade and sloped to minimize the potential for water infiltration. Disposal of ungrouted and grouted U_3O_8 in such vaults would require about 71 and 140 acres (28 and 56 ha), respectively. (DOE 1999, Appendix I.2.2, page I-26)

A mined disposal facility for permanent, deep geological disposal could possibly use a previously existing mine or be constructed for the sole purpose of waste disposal. A newly constructed mine facility would likely include surface facilities for waste receiving and inspection, and shafts and ramps for access to and ventilation of the underground portion of the repository. In the PEIS, the drifts used for waste disposal were assumed to have a width of 21 ft

(6 m). It was assumed that waste containers would be placed in drifts and backfilled. Disposal of ungrouted and grouted U_3O_8 would require about 228 acres (91 ha) and 462 acres (185 ha), respectively. The relatively large land use requirement for mines results from the engineering design assumed for the mine (including characteristics such as drift width and required spacing between drifts) and the need to dispose of excavated material. (DOE 1999, Appendix I.2.3, page I-26)

The PEIS and supporting documents provide more details about the characteristics assumed for the disposal facilities, such as facility layouts; resource requirements; and estimates of land use requirements, effluents, wastes, and emissions (see Appendix I in DOE 1999).

Tables 2.3-1 and 2.3-2 provide summaries of the operational phase impacts for grouted and ungrouted U_3O_8, respectively. As the tables show, there are slightly higher involved worker doses for the grouted options due to the larger amount of handling required. Increased labor requirements for construction of vaults and mines would also lead to somewhat higher worker injury estimates. The amount of land required for disposal of grouted U_3O_8 versus ungrouted U_3O_8 would essentially double for each disposal option (i.e., shallow earthen structures, vaults, and mines). Also, the land area required for vaults would be about double that required for shallow earthen structures, and the area required for mines would be about 10 times that required for shallow earthen structures. This large land area for mines includes land required for disposal of excavated soils, which might not be needed if an existing mine was used. (DOE 1999, Appendix I.3, page I-27)

Table 2.3-3 summarizes the post-closure impacts in a wet environment for both grouted and ungrouted U_3O_8. Impacts for the post-closure phase were calculated for a time period of 1,000 years after each disposal facility was assumed to fail. Regardless of the disposal option selected in a wet setting, the doses from groundwater use would exceed the DOE limit of 25 mrem/yr at some time in the future. However, no impacts would be expected within 1,000 years in a dry setting (primarily because the infiltration rate in a dry setting would be so low that depleted uranium would not reach a deep water table within that time period). (DOE 1999, Appendix I.4, page I-68)

TABLE 2.3-1 Summary of Disposal Option Impacts for U_3O_8 during the Operational Phase ¾ Generic Assessment ¾ Grouted U_3O_8[a,b,c]

Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Grouted U_3O_8 in Vaults	Impacts from Disposal as Grouted U_3O_8 in Mines
Human Health ¾ Normal Operations: Radiological		
Involved Workers Total collective dose: 480 person-rem Total number of LCFs: 0.2	**Involved Workers** Total collective dose: 520 person-rem Total number of LCFs: 0.2	**Involved Workers** Total collective dose: 720 person-rem Total number of LCFs: 0.3
Noninvolved Workers Annual dose to MEI: 0.0021 – 0.0088 mrem/yr Annual cancer risk to MEI: $8 \times 10^{-4} \times 10^{-9}$ per year Total collective dose: 0.00054 – 0.0035 person-rem Total number of LCFs: $2 \times 10^{-7} – 1 \times 10^{-6}$	**Noninvolved Workers** Annual dose to MEI: 0.0021 – 0.0088 mrem/yr Annual cancer risk to MEI: $8 \times 10\text{-}10 – 4 \times 10^{-9}$ per year Total collective dose: 0.00059–0.0038 person-rem Total number of LCFs: $2 \times 10^{-7} – 2 \times 10^{-6}$	**Noninvolved Workers** Annual dose to MEI: 0.00084 – 0.0085 mrem/yr Annual cancer risk to MEI: $3 \times 10^{-10} – 3 \times 10^{-9}$ per year Total collective dose: 0.00057 – 0.0036 person-rem Total number of LCFs: $2 \times 10^{-7} – 1 \times 10^{-6}$
General Public Annual dose to MEI: 0.0061 – 0.026 mrem/yr Annual cancer risk to MEI: $3 \times 10^{-9} – 1 \times 10^{-10}$ per year Total collective dose to population within 50 mi (80 km): 0.037 – 0.11 person-rem Total number of LCFs in population within 50 mi (80 km): $2 \times 10^{-5} – 6 \times 10^{-5}$	**General Public** Annual dose to MEI: 0.0060 – 0.020 mrem/yr Annual cancer risk to MEI: $3 \times 10^{-9} – 1 \times 10^{-8}$ per year Total collective dose to population within 50 mi (80 km): 0.037 – 0.11 person-rem Total number of LCFs in population within 50 mi (80 km): $2 \times 10^{-5} – 6 \times 10^{-5}$	**General Public** Annual dose to MEI: 0.0061 – 0.026 mrem/yr Annual cancer risk to MEI: $3 \times 10^{-9} – 1 \times 10^{-8}$ per year Total collective dose to population within 50 mi (80 km): 0.037 – 0.11 person-rem Total number of LCFs in population within 50 mi (80 km): $2 \times 10^{-5} – 6 \times 10^{-5}$
Human Health ¾ Normal Operations: Chemical		
Noninvolved Workers No impacts **General Public** No impacts	**Noninvolved Workers** No impacts **General Public** No impacts	**Noninvolved Workers** No impacts **General Public** No impacts
Human Health ¾ Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Dose to MEI: 140 rem Risk of LCF to MEI: 0.06 Collective dose: 6.1 person-rem Number of LCFs: 0.002 **General Public** Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 mi (80 km): 1.5 person-rem Number of LCFs in population within 50 mi (80 km): 0.0007	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Dose to MEI: 140 rem Risk of LCF to MEI: 0.06 Collective dose: 6.1 person-rem Number of LCFs: 0.002 **General Public** Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 mi (80 km): 1.5 person-rem Number of LCFs in population within 50 mi (80 km): 0.0007	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Dose to MEI: 140 rem Risk of LCF to MEI: 0.06 Collective dose: 6.1 person-rem Number of LCFs: 0.002 **General Public** Bounding accident consequences (per occurrence): Dose to MEI: 1.1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 mi (80 km): 1.5 person-rem Number of LCFs in population within 50 mi (80 km): 0.0007

TABLE 2.3-1 (Cont.)

Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Grouted U_3O_8 in Vaults	Impacts from Disposal as Grouted U_3O_8 in Mines
Human Health ¾ Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 1 Number of persons with potential for irreversible adverse effects: 1 **General Public** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 Number of persons with potential for irreversible adverse effects: 0	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 1 Number of persons with potential for irreversible adverse effects: 1 **General Public** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 Number of persons with potential for irreversible adverse effects: 0	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 1 Number of persons with potential for irreversible adverse effects: 1 **General Public** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 Number of persons with potential for irreversible adverse effects: 0
Human Health ¾ Accidents: Physical Hazards		
Construction and Operations **All Workers** Less than 1 (0.26) fatality, approximately 210 injuries	**Construction and Operations** **All Workers** Less than 1 (0.44) fatality, approximately 300 injuries	**Construction and Operations** **All Workers** Approximately 1 fatality, approximately 450 injuries
Air Quality		
Construction Annual NO_x concentration potentially as large as 3% of standard; other criteria pollutant concentrations between 0.2 and 2% of respective standards **Operations** Annual NO_x concentration potentially as large as 7% of standard; other criteria pollutant concentrations between 0.3 and 3% of respective standards	**Construction** Annual NO_x concentration potentially as large as 13% of standard; other criteria pollutant concentrations between 0.3 and 4% of respective standards **Operations** Annual NO_x concentration potentially as large as 37% of standard; other criteria pollutant concentrations between 0.8 and 10% of respective standards	**Construction** All pollutant concentrations below 0.1% of respective standards **Operations** All pollutant concentrations below 0.02% of respective standards
Water[d]		
Construction Negligible impacts to surface water and groundwater **Operations** None to negligible impacts to surface water and groundwater	**Construction** Negligible impacts to surface water and groundwater **Operations** None to negligible impacts to surface water and groundwater	**Construction** Negligible impacts to surface water and groundwater **Operations** None to negligible impacts to surface water and groundwater
Soil[d]		
Construction Negligible, but temporary, impacts **Operations** No impacts	**Construction** Moderate to large, but temporary, impacts **Operations** No impacts	**Construction** Moderate to large, but temporary, impacts **Operations** No impacts

TABLE 2.3-1 (Cont.)

Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Grouted U_3O_8 in Vaults	Impacts from Disposal as Grouted U_3O_8 in Mines
	Socioeconomics	
Construction Potential moderate impacts on employment and income **Operations** Potential moderate impacts on employment and income	**Construction** Potential moderate impacts on employment and income **Operations** Potential moderate impacts on employment and income	**Construction** Potential moderate impacts on employment and income **Operations** Potential moderate impacts on employment and income
	Ecology	
Construction Potential moderate impacts to vegetation and wildlife **Operations** Potential adverse impacts to aquatic biota	**Construction** Potential large impacts to vegetation and wildlife **Operations** Potential adverse impacts to aquatic biota	**Construction** Potential large impacts to vegetation and wildlife **Operations** Potential adverse impacts to aquatic biota
	Waste Management	
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
	Land Use	
Use of approximately 85 acres (34 ha); potential moderate impacts	Use of approximately 149 acres (60 ha); potential moderate impacts	Use of approximately 471 acres (191 ha); potential large impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction

[a] Impacts presented in the table are for a generic wet setting (typical of the eastern United States). Potential impacts during the operational phase would be similar for a generic dry setting (typical of the western United States).

[b] Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; NO_x = nitrogen oxides.

[c] As used and presented in the PEIS (DOE 1999), the terms “Negligible to Low,” “Moderate,” and “Large” are used within this table to summarize the level of impact. These terms are defined in detail for each area of impact (e.g., human health, air, water, etc.) in Table 4.2, page 4-9 of the PEIS.

[d] Impacts are based on a site that would be large compared with the area of the facility, with a nearby river having a minimum flow that would be large compared with water use and discharge requirements.

Source: DOE 1999, Table I.2, page I-5.

TABLE 2.3-2 Summary of Disposal Option Impacts for U_3O_8 during the Operational Phase ¾ Generic Assessment ¾ Ungrouted U_3O_8[a,b]

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in Mines
Human Health ¾ Normal Operations: Radiological		
Involved Workers Total collective dose: 280 person-rem Total number of LCFs: 0.1	**Involved Workers** Total collective dose: 300 person-rem Total number of LCFs: 0.1	**Involved Workers** Total collective dose: 360 person-rem Total number of LCFs: 0.1
Noninvolved Workers No impacts **General Public** No impacts	**Noninvolved Workers** No impacts **General Public** No impacts	**Noninvolved Workers** No impacts **General Public** No impacts
Human Health ¾ Normal Operations: Chemical		
Noninvolved Workers No impacts **General Public** No impacts	**Noninvolved Workers** No impacts **General Public** No impacts	**Noninvolved Workers** No impacts **General Public** No impacts
Human Health ¾ Accidents: Radiological		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Dose to MEI: 130 rem Risk of LCF to MEI: 0.05 Collective dose: 5.6 person-rem Number of LCFs: 0.002 **General Public** Bounding accident consequences (per occurrence): Dose to MEI: 1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 mi (80 km): 1.3 person-rem Number of LCFs in population within 50 mi (80 km): 0.0007	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Dose to MEI: 130 rem Risk of LCF to MEI: 0.05 Collective dose: 5.6 person-rem Number of LCFs: 0.002 **General Public** Bounding accident consequences (per occurrence): Dose to MEI: 1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 mi (80 km): 1.3 person-rem Number of LCFs in population within 50 mi l (80 km): 0.0007	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Dose to MEI: 130 rem Risk of LCF to MEI: 0.05 Collective dose: 5.6 person-rem Number of LCFs: 0.002 **General Public** Bounding accident consequences (per occurrence): Dose to MEI: 1 rem Risk of LCF to MEI: 5×10^{-4} Collective dose to population within 50 mi (80 km): 1.3 person-rem Number of LCFs in population within 50 mi (80 km): 0.0007

TABLE 2.3-2 (Cont.)

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in Mines
Human Health ¾ Accidents: Chemical		
Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 1 Number of persons with potential for irreversible adverse effects: 1 **General Public** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 Number of persons with potential for irreversible adverse effects: 0	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 1 Number of persons with potential for irreversible adverse effects: 1 **General Public** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 Number of persons with potential for irreversible adverse effects: 0	Bounding accident frequency: 1 in 100 years to 1 in 10,000 years **Noninvolved Workers** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 1 Number of persons with potential for irreversible adverse effects: 1 **General Public** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 0 Number of persons with potential for irreversible adverse effects: 0
Human Health ¾ Accidents: Physical Hazards		
Construction and Operations **All Workers** Less than 1 (0.13) fatality, approximately 90 injuries	**Construction and Operations** **All Workers** Less than 1 (0.22) fatality, approximately 140 injuries	**Construction and Operations** **All Workers** Approximately 1 (0.53) fatality, approximately 240 injuries
Air Quality		
Construction Annual NO_x concentration potentially as large as 1.3% of standard; all other criteria pollutant concentrations between 0.07 and 0.6% of respective standards **Operations** Annual NO_x concentration potentially as large as 2.3% of standard; all other criteria pollutant concentrations between 0.1 and 1% of respective standards	**Construction** Annual NO_x concentration potentially as large as 3.5% of standard; all other criteria pollutant concentrations between 0.1 and 1% of respective standards **Operations** Annual NO_x concentration potentially as large as 10% of standard; all other criteria pollutant concentrations between 0.3 and 3% of respective standards	**Construction** All pollutant concentrations below 0.1% of respective standards **Operations** All pollutant concentrations below 0.02% of respective standards
Water[d]		
Construction Negligible impacts to surface water and groundwater **Operations** None to negligible impacts to surface water and groundwater	**Construction** Negligible impacts to surface water and groundwater **Operations** None to negligible impacts to surface water and groundwater	**Construction** Negligible impacts to surface water and groundwater **Operations** None to negligible impacts to surface water and groundwater
Soil[d]		
Construction Negligible, but temporary, impacts **Operations** No impacts	**Construction** Moderate to large, but temporary, impacts **Operations** No impacts	**Construction** Moderate to large, but temporary, impacts **Operations** No impacts

TABLE 2.3-2 (Cont.)

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in Mines
	Socioeconomics	
Construction Potential moderate impacts on employment and income **Operations** Potential moderate impacts on employment and income	**Construction** Potential moderate impacts on employment and income **Operations** Potential moderate impacts on employment and income	**Construction** Potential moderate impacts on employment and income **Operations** Potential moderate impacts on employment and income
	Ecology	
Construction Potential moderate impacts to vegetation and wildlife **Operations** Negligible impacts	**Construction** Potential moderate impacts to vegetation and wildlife **Operations** Negligible impacts	**Construction** Potential large impacts to vegetation and wildlife **Operations** Negligible impacts
	Waste Management	
Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations	Negligible to low impacts on national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements on the local or national scale are expected; impacts of electrical requirements for mine excavation depend on site location
	Land Use	
Use of approximately 46 acres (19 ha), negligible impacts	Use of approximately 75 acres (30 ha); potential moderate impacts	Use of approximately 232 acres (94 ha); potential large impacts, including impacts from disposal of excavated material and potential off-site traffic impacts during construction

[a] Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; NO_x = nitrogen oxides.

[b] Impacts presented in the table are for a generic wet setting (typical of the eastern United States). Potential impacts during the operational phase would be similar for a generic dry setting (typical of the western United States).

[c] As used and presented in the PEIS (DOE 1999), the terms “Negligible to Low,” “Moderate,” and “Large” are used within this table to summarize the level of impact. These terms are defined in detail for each area of impact (e.g., human health, air, water, etc.) in Table 4.2, page 4-9 of the PEIS.

[d] Impacts are based on a site that would be large compared with the area of the facility, with a nearby river having a minimum flow that would be large compared with water use and discharge requirements.

Source: DOE 1999, Table I.2, page I-5.

TABLE 2.3-3 Summary of Post-Closure Phase Impacts for U_3O_8 Disposal in a Wet Environment[a,b,c]

Grouted		
Impacts from Disposal as Grouted U_3O_8 in Shallow Earthen Structures[d]	Impacts from Disposal as Grouted U_3O_8 in Vaults[d]	Impacts from Disposal as Grouted U_3O_8 in Mines[d]
	Human Health ¾ Radiological	
General Public Annual dose to MEI: 49 – 72 mrem/yr Annual cancer risk to MEI: 2×10^{-5} – 4×10^{-5} per year Collective dose to population within 50 mi (80 km): not determined Number of LCFs in population within 50 mi (80 km): not determined	**General Public** Annual dose to MEI: 57 – 84 mrem/yr Annual cancer risk to MEI: 3×10^{-5} – 4×10^{-5} per year Collective dose to population within 50 mi (80 km): not determined Number of LCFs in population within 50 mi (80 km): not determined	**General Public** Annual dose to MEI: 1 – 110 mrem/yr Annual cancer risk to MEI: 4×10^{-7} – 5×10^{-5} per year Collective dose to population within 50 mi (80 km): not determined Number of LCFs in population within 50 mi (80 km): not determined
	Human Health ¾ Chemical	
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater
	Water	
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
	Ecology	
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination
Ungrouted		
Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in a Mine
	Human Health ¾ Radiological	
General Public Annual dose to MEI: 41 – 60 mrem/yr Annual cancer risk to MEI: 2×10^{-5} – 3×10^{-5} per year Collective dose to population within 50 mi (80 km): not determined Number of LCFs in population within 50 mi (80 km): not determined	**General Public** Annual dose to MEI: 48 – 70 mrem/yr Annual cancer risk to MEI: 2×10^{-5} – 4×10^{-5} per year Collective dose to population within 50 mi (80 km): not determined Number of LCFs in population within 50 mi (80 km): not determined	**General Public** Annual dose to MEI: 1 – 93 mrem/yr Annual cancer risk to MEI: 4×10^{-7} – 5×10^{-5} per year Collective dose to population within 50 mi (80 km): not determined Number of LCFs in population within 50 mi (80 km): not determined
	Human Health ¾ Chemical	
Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater	Potential impacts to MEI of the general public from groundwater

TABLE 2.3-3 (Cont.)

Impacts from Disposal as Ungrouted U_3O_8 in Shallow Earthen Structures	Impacts from Disposal as Ungrouted U_3O_8 in Vaults	Impacts from Disposal as Ungrouted U_3O_8 in Mines
	Water	
Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination	Potential large impact to groundwater quality from uranium contamination
	Ecology	
Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination	Potential moderate impacts to wetlands and aquatic biota from surface water and groundwater contamination

[a] Notation: LCF = latent cancer fatality; MEI = maximally exposed individual.

[b] Impacts for the post-closure phase were calculated for a time 1,000 years after each disposal facility was assumed to fail. Impacts are presented for a generic wet setting; no impacts would be expected within 1,000 years in a dry setting.

[c] As used and presented in the PEIS (DOE 1999), the terms “Negligible to Low,” “Moderate,” and “Large” are used within this table to summarize the level of impact. These terms are defined in detail for each area of impact (e.g., human health, air, water, etc.) in Table 4.2, page 4-9 of the PEIS.

[d] All disposal facilities would be designed to contain the waste material for at least hundreds of years. Shallow earthen structures would be expected to last several hundred years before failure; vaults and mines would be expected to last several hundreds to thousands of years before failure.

Source: DOE 1999, Table I.4, page I-20.

3 NEED FOR ADDITIONAL NEPA ANALYSES

The purpose of this section is to evaluate the impacts reported in existing NEPA documentation to determine whether a Supplemental EIS is needed to support a decision on disposal location(s). The criteria to be used for this evaluation are described in Section 1.1 of this Draft SA.

Based on the analysis set forth in this Draft SA, the Department believes that the existing NEPA coverage is sufficient to make its decision on disposal location(s). The site-specific EISs identified both of the alternative disposal sites, NTS and Envirocare, and identified the impacts of packaging, handling, and transporting the depleted uranium oxide conversion product, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations from the conversion facilities to each location.[4] As indicated in Sections 3.1 through 3.3 of this Draft SA, existing NEPA documentation also adequately addresses the impacts of disposal at the NTS and Envirocare sites.

3.1 ALTERNATIVE DISPOSAL SITES

In DOE's Final Waste Management Programmatic EIS (WM PEIS), issued in May 1997 (DOE 1997), 54 DOE sites that generate or store substantial quantities of radioactive or hazardous waste were evaluated.[5] By considering factors, including which sites had the largest waste volumes, where existing facilities were located, and where transportation requirements would be minimized; DOE narrowed the potential candidate disposal sites for DOE wastes to 16 DOE sites. On December 10, 1999, DOE published a Notice of Preferred Alternatives (64 FR 69241) announcing its preferred LLW and mixed LLW disposal sites. For LLW disposal, DOE identified its preferred alternative to be disposal at the Hanford Site and NTS. In addition, to the extent practicable and consistent with current practice, DOE indicated it would continue disposal of on-site LLW at Idaho National Engineering and Environmental Laboratory (INEEL) (now Idaho National Laboratory), Los Alamos National Laboratory (LANL), Oak Ridge Reservation (ORR), and the Savannah River Site (SRS). INEEL and SRS also would continue to dispose of LLW generated by the Naval Nuclear Propulsion Program. On February 25, 2000, DOE published its ROD to implement its preferred alternative for LLW disposal (65 FR 10061). The ROD indicated that the decision would not preclude DOE's use of commercial disposal facilities, consistent with DOE policies and directives.

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[4] The reason DOE did not make its disposal decision at the time it issued its site specific RODs is that it discovered that it had inadvertently not formally provided copies of the draft and final EISs to either Nevada or Utah, and DOE concluded that it was bound by the CEQ's regulations at 40 CFR 1502.19 to forego decisions on disposal location(s) until it had properly served these states. DOE has now corrected its oversight and provided all appropriate stakeholders with documentation as required by the regulations.

[5] The WM PEIS analyzes the potential environmental impacts of broad alternatives for DOE's waste management program, and was designed to provide part of the basis for DOE decisions on programmatic configurations of sites for waste management activities. Four RODs have been issued under the WM PEIS.

During 1999, Argonne National Laboratory completed an investigation of the feasibility of depleted uranium disposal, which, among other things, identified six then operating potential LLW disposal facilities for DOE's depleted uranium stockpile (Biwer et al. 1999). The six facilities included the two DOE facilities identified in the WM PEIS as preferred LLW regional disposal facilities (Hanford Site and NTS) and four commercial LLW disposal facilities (Barnwell located near Barnwell, South Carolina; Envirocare of Utah, Inc. located near Clive, Utah; U.S. Ecology located near Richland, Washington; and Waste Control Specialists [WCS] located in Texas near the Texas-New Mexico border). Attributes investigated for each facility were Waste Acceptance Criteria, available capacity, and disposal cost.

U.S. Ecology was eliminated from consideration because it can only accept wastes from states in the Northwest LLW Compact. In 1980, Congress enacted the Low-Level Radioactive Waste Policy Act (LLWPA) (Public Law 96-573; *United States Code* Title 42, Sections 2021b et seq. [42 USC §§ 2021b et seq.]), which authorized states to form regional compacts for the purpose of providing for disposal of LLW generated within the boundaries of member states. Upon approval by Congress, each compact was allowed, beginning in 1993, to restrict the import of LLW from states located outside the compact into its LLW disposal facilities. In 1986, Congress passed the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLWPAA) (P.L. 99-240; 99 Stat. 1842; 42 USC §§ 2021b – 2021i), which amended the LLWPA by giving the states with existing disposal sites (i.e., Washington and South Carolina) the power to add surcharges to disposal costs on wastes from other states if the other states did not meet specified deadlines. Further, the states with existing disposal sites were empowered to eventually exclude waste shipments from those states which failed to meet deadlines. The State of Washington is a member of the Northwest LLW Compact. Other members are Alaska, Idaho, Montana, Oregon, Utah, and Wyoming.

In 1999, WCS applied for but was denied a LLW disposal permit by the State of Texas (an NRC agreement state) because the facility is not located on state or federal land, a licensing requirement in 10 CFR 61.59. This situation was noted in the Biwer et al. (1999) investigation report as a potentially significant barrier to the viability of WCS as a disposal alternative for DOE's DUF_6 inventory. If the WCS facility is granted a license for LLW disposal, it may become a reasonable alternative for disposal of the DOE depleted uranium oxide conversion product in the future. However, in the past and for the purpose of this Draft SA, its unlicensed status has eliminated it from further consideration. Should the WCS disposal facility become a reasonable alternative, appropriate NEPA analysis to support its use would be conducted at that time.

The Biwer et al. (1999) investigation report concluded that disposal of depleted uranium in the U_3O_8 form would be acceptable under the WAC at the NTS, Envirocare, and Barnwell LLW disposal sites, and that at Hanford, disposal of U_3O_8 might require additional packaging. Of these four facilities, NTS, Hanford, and Envirocare were found to have sufficient available capacity. The Barnwell facility's capacity was determined to be insufficient to meet DOE's needs for disposal of either grouted or ungrouted U_3O_8 that would result from the conversion of the DOE DUF_6 inventory. With respect to cost, Hanford and NTS had the lowest estimated costs, but Envirocare was also potentially competitive. Accordingly, the Barnwell facility has been eliminated from further consideration as an alternative for disposal of the depleted uranium oxide conversion product, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations because of its lack of capacity.

Studies conducted by Oak Ridge National Laboratory (ORNL) for DOE during the year 2000 further investigated the reasonableness of the NTS, Hanford, and Envirocare sites for disposal of depleted uranium conversion product (Croff et al. 2000a,b). These studies verified that both NTS and Envirocare potentially would have enough capacity to accept the total expected volume of depleted uranium conversion product from both DUF_6 conversion plants, and would have WAC that would allow for disposal of untreated depleted uranium conversion product (Croff et al. 2000a). However, for Hanford, it was stated that the WAC limits on the radiological concentration of uranium in waste materials would preclude the disposal of unconsolidated depleted uranium in the 200 Area Low-Level Waste Burial Grounds (i.e., the waste form would have to be grouted).

In accordance with a Settlement Agreement between DOE and the State of Washington, DOE is currently evaluating receipt of off-site waste that could potentially go to Hanford for disposal in the Tank Closure and Waste Management EIS (DOE 2006). This EIS will evaluate waste streams from the DOE Portsmouth and Paducah sites for potential disposal at Hanford, although depleted uranium oxide conversion product is not currently one of the streams. As stated in the Settlement Agreement, pending finalization of the Tank Closure and Waste Management EIS and publication of the appropriate ROD, DOE will not import off-site low level waste, mixed LLW or transuranic waste to the Hanford site, except as permitted in the existing stipulations that have been agreed upon and entered as orders of the court.

Based on the current Settlement Agreement at Hanford, Hanford is not considered further in this Draft SA. Notwithstanding, if in the future the Hanford facility becomes a reasonable alternative, appropriate NEPA analysis to support disposal at Hanford would be conducted at that time.

Newer information verifies that NTS has adequate disposal capacity for the depleted uranium oxide conversion product, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations (DOE 2002a). The total volume of the depleted uranium oxide conversion product will be between 205,000 and 230,000 m^3 (7.2 and 8.1 million ft^3). The NTS has an estimated total disposal capacity of 3.7 million m^3 (130 million ft^3). The DOE analysis of demand for LLW disposal at NTS through 2070 projects a need for about 1.1 million m^3 (39 million ft^3 or 30%) of total NTS disposal capacity, making the reserve capacity at NTS about 2.6 million m^3 (92 million ft^3) (DOE 2002a). Thus, the depleted uranium oxide conversion product would occupy about 6% of the total NTS available volume, or about 9% of the reserve capacity.

The Utah Department of Environmental Quality (UDEQ), Division of Radiation Control amended Envirocare's Radioactive Materials License in 2000. Under the amendment, Envirocare was allowed to accept depleted uranium products for disposal in a then-to-be-constructed Class A cell (construction has since been completed), because activity limits do not apply to depleted uranium in that cell. The capacity of the Class A disposal cell is approximately 3.1 million m^3 (109.5 million ft^3) (Croff et al. 2000b). In 2005, Envirocare's license was again amended to allow construction of a second disposal cell dedicated to Class A waste (the Class A North cell). The capacity of the Class A North cell, which also could accept depleted uranium oxide waste, is estimated to be approximately 2.3 million m^3 (81.2 million ft^3). Thus, Envirocare's total currently licensed Class A waste disposal capacity is about 5.4 million m^3 (190.6 million ft^3).[6] Over the life of the depleted UF_6 conversion project, if all of the depleted uranium oxide wastes were sent to Envirocare, such wastes could occupy up to 4% of the total currently licensed Class A waste disposal volume at the facility.[7] In a letter to UDS in 2001, Envirocare confirmed its ability to accept 14,200 m^3 (500,000 ft^3) per year of depleted uranium oxide conversion product (Envirocare 2001).

DOE's Radioactive Waste Management Manual (DOE 2001) specifies that DOE LLW shall be disposed of at the site where it was generated, or at another DOE facility, unless doing so is not practical or cost-effective. Therefore, in order to select a commercial disposal facility rather than NTS, DOE would need to approve an exemption detailing the better practicality and/or cost-effectiveness of the commercial facility. Under such exemptions, the Envirocare of Utah facility has accepted LLW from DOE facilities in the past, including shipments of depleted uranium. On the basis of this, the Envirocare facility is considered to be a reasonable LLW disposal alternative to NTS.

3.2 DISPOSAL AT NTS

The DUF_6 Programmatic EIS describes the impacts of depleted uranium oxide conversion product disposal in a generic dry environmental setting similar to that of NTS for up to 1,000 years after the failure of the disposal facility (DOE 1999, Appendix I, Table I.2, pages I-5 through I-11). These impacts, summarized in Section 2.3.2.2, above, sufficiently bound the

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[6] The capacity of the Class A North cell was estimated by (1) determining the cell's length (710 m [2,329 ft]) and width (310 m [1,017 ft]) from the longitude and latitude coordinates of its corners, as presented in the Envirocare Radioactive Materials License, Amendment 22C (UDEQ 2006a) and (2) assuming that its waste depth would be the same as the waste depth in the Class A cell (10.3 m [33.8 ft]). The waste depth in the Class A cell was calculated by (1) determining the cell's length (700 m [2,297 ft]) and width (430 m [1,411 ft]) from the longitude and latitude coordinates of its corners, as presented in the Envirocare Radioactive Materials License, Amendment 22C (UDEQ 2006a) and (2) calculating the depth by dividing its approximate capacity of 3.1 million m^3 (Croff et al. 2000b) by its surface area (301,000 m^2 [3.24 million ft^2]). Envirocare's total Class A disposal capacity (5.4 million m^3 [109.5 million ft^3]) was determined by summing the estimated capacities of the Class A North and Class A cells. This estimate is believed to be conservative because, in September 2006, the Utah Division of Radiation Control issued a notice that Envirocare has requested a license amendment to allow redesign and merging of the existing Class A and Class A North Cells into a single Class A Combined cell (UDEQ 2006b). This pending request is estimated to increase the life of Class A disposal at the facility by 10 years (UDEQ 2006c).

[7] In the licensing proceeding for a commercial uranium enrichment facility, the NRC has confirmed that depleted uranium oxide requiring disposal should be classified as LLW (NRC 2005a). As a result of issues regarding classification of waste raised in the same licensing proceeding, the NRC staff is reviewing the LLW classification regulations in 10 CFR 61.55 (NRC 2005b). The NRC Staff's investigation of this issue seems likely to take several years and the outcome is uncertain. An NRC Atomic Safety and Licensing Board recently noted that, in the interim, depleted uranium is Class A waste under 10 CFR 61.55(a) as currently in force (NRC 2006a).

impacts that would be expected to result from the handling and disposal of the depleted uranium oxide conversion product at NTS.

A June 2000 report examining depleted uranium disposal options found that disposal at NTS was generally feasible pending acceptance of the uranium oxide waste stream following the waste profile approval process (Croff et al. 2000a).

The NTS sitewide EIS (DOE 1996a) did not analyze impacts from disposal at the NTS of the depleted uranium oxide conversion product from the DUF_6 project. However, a 2002 NTS SA considering the need for a supplemental site-wide EIS at the NTS (DOE 2002b)[8] did account for disposal between 2002 and 2011 of 60,000 m^3 (2.1 million ft^3) of depleted uranium oxide conversion product, which equates approximately to between 6 and 7 years of operation for the two DUF_6 conversion facilities. The 2002 NTS SA concluded that no detailed analysis was required for the areas of occupational safety and health, noise, traffic and transportation, geology and soils, land use, visual resources, biological resources, groundwater, socioeconomics, environmental justice, cultural resources, and American Indian resources. For the areas of radiological impacts (normal operations), accident analysis, air resources, waste management, and cumulative impacts, the 2002 NTS SA reported that a detailed consequence analysis was conducted which concluded that “the environmental consequences for each of these technical discipline areas are within the impact analysis of the 1996 NTS EIS” (DOE 2002b). Overall, the 2002 NTS SA concluded that neither changes from actions foreseen in 1996 nor new and modified proposals and projects (including the disposal of 60,000 m^3 (2.1 million ft^3) of depleted uranium oxide conversion product) presented a seriously different picture of the likely consequences of continued operation of the NTS than was presented in the 1996 NTS EIS. Therefore, no supplemental EIS for the 1996 NTS EIS was deemed to be needed.

Based on the information above and in section 3.1, it is concluded that while the NTS disposal capacity (i.e., 3.7 million m^3 [130 million ft^3]) is more than sufficient to accommodate the output from the conversion of DOE’s entire existing DUF_6 inventory (i.e., between 205,000 and 230,000 m^3 [7.2 million and 8.1 million ft^3] of depleted uranium oxide conversion product) as well as emptied cylinders and the small amount of CaF_2 produced during normal conversion operations, adequate NTS-specific NEPA coverage extends only to disposal of 60,000 m^3 (2.1 million ft^3) of depleted uranium oxide conversion product. Additional site-specific NEPA analyses would be necessary to support any future decision by DOE to dispose at the NTS the remaining volume (i.e., between 145,000 and 170,000 m^3 [5.1 million to 6.0 million ft^3]). Accordingly, disposal of the total volume of depleted uranium oxide conversion product to be generated by the DUF_6 conversion project will be addressed as part of the upcoming review and evaluation of the NTS site-wide EIS. Further analyses and documentation (i.e., SA, supplemental EIS or new site-wide EIS) will be prepared, as necessary, based on the results of that review. The depleted uranium oxide conversion product not acceptable for disposal at NTS, if any, would be disposed at Envirocare, or another disposal facility determined to be acceptable at that time, following appropriate NEPA review.

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[8] DOE regulations require that site-wide NEPA documents for DOE facilities be evaluated every five years to determine whether the existing content remains adequate (10 CFR 1021.330).

3.3 DISPOSAL AT ENVIROCARE

This section provides information to show that (1) Envirocare has confirmed its ability to accept the annual amount of depleted uranium oxide conversion product that will be produced by the two DUF_6 conversion facilities for the next 25 years; (2) DOE's proposed waste load would be a small part of Envirocare's throughput, and (3) analyses performed by the Utah Division of Radiation Control and the NRC indicate that the Envirocare facility would operate well within its established standards. This section also explains how such information supports a conclusion that additional NEPA coverage of on-site handling and disposal impacts is not needed to support a decision concerning disposal at Envirocare.

As a commercial radioactive waste disposal facility, Envirocare conducts its Class A LLW disposal activities under a radioactive material license issued by the Utah Division of Radiation Control. The process followed by the UDEQ in issuing a license for land disposal of radioactive waste requires demonstration and verification that the applicant's facility will present no unreasonable risk to public health and safety and will comply with radiation protection performance standards. Envirocare was first granted a radioactive materials license by the UDEQ in 1988. Since then, its license was renewed on October 22, 1998, and has been amended several times.[9] The steps in the licensing process followed in issuing the 1998 license renewal are briefly summarized below.

- *Application to receive, possess, and dispose of radioactive wastes (UAC [Utah Administrative Code] R313-25-7 through R313-25-10, R313-25-19, and R313-25-20).* A person proposing to construct or operate a commercial radioactive waste disposal facility must file an application with the UDEQ. Among other things, the application must describe the radiation safety program for control and monitoring of radioactive effluents to ensure that the annual dose received by the general population from releases of radioactivity does not exceed 25 mrem and that no member of the public will receive a dose of more than 4 mrem from groundwater. Also, the application must demonstrate a reasonable assurance that adequate barriers to inadvertent intrusion will be provided.

- *Issuance of a license (UAC R313-25-11).* The UDEQ will issue a license for receipt, possession, and disposal of waste containing radioactive material once it determines that the applicant is qualified to operate the facility; radiation protection performance standards will be met; equipment facilities and procedures are adequate; there is reasonable assurance that continued

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[9] The 1998 version of Envirocare's Radioactive Material License (UT2300249) has an expiration date of October 22, 2003. On July 2, 2003, Envirocare filed a renewal application with the Utah Division of Radiation Control. In a letter dated July 8, 2003, the Utah Radiation Control Board notified Envirocare that, by filing a renewal application at least 90 days before the license expiration date, the timely renewal requirements of R313-25-13(3) were met and the license will not expire until final action is taken on the renewal application (UDEQ 2003).

maintenance of the site after closure will not be needed; there is reasonable assurance that institutional controls will be provided for the required length of time; financial and surety arrangements meet requirements; and the facility will not constitute an unreasonable risk to the health and safety of the public.

- *Public participation (UAC R313-17).* The UDEQ must provide public notice of its intention to issue a license for land disposal of radioactive waste. The public is given 30 days to comment and request a public hearing. The UDEQ must hold a public hearing if requests indicate a significant degree of public interest in the proposed facility.

According to DOE guidance for use of already licensed commercial vendor facilities given in *NEPA Lessons Learned* (DOE 1996b), "[NEPA] analysis should be guided by the "sliding scale" principle described in *Recommendations for the Preparation of Environmental Impact Statements and Environmental Assessments* [DOE 2004e], i.e., the level of detail should be commensurate with the importance of the impacts or issues related to the impacts. If DOE's proposed waste load would be a small part of the facility's throughput and the facility would operate well within its established standards, then the vendor's part of DOE's proposal would be low on the scale, and a statement of this context could adequately characterize the impacts."

In the case of Envirocare, the facility has confirmed its ability to accept the annual amount of depleted uranium oxide conversion product that will be produced by the two DOE conversion facilities for the next 25 years (Envirocare 2001). Over the life of the depleted UF_6 conversion project, the total amount of depleted uranium oxide conversion product sent to Envirocare would constitute about 4% of the total capacity currently licensed for disposal of Class A waste (see Section 3.1) and about 2% of the total of all currently licensed disposal capacity at the facility. In any given year, however, the depleted uranium oxide conversion product could constitute somewhat more or less than 2% of all waste placed at the Envirocare facility during that year. This information supports a conclusion that DOE's proposed waste load would be a small part of the Envirocare facility's throughput and the facility would operate well within its established standards upon receipt of the depleted uranium oxide conversion product, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations.

DOE's DUF_6 Programmatic EIS analysis of impacts of depleted uranium oxide conversion product disposal in a generic dry environmental setting suggests that disposal impacts at Envirocare, which is located in a dry environment, would not exceed regulatory standards for protection of human health and the environment. This proposition has been corroborated by an NRC EIS prepared to support licensing of a commercial uranium enrichment facility. In that EIS, the NRC staff made the following statements about disposal of depleted uranium oxide conversion product at the Envirocare site (NRC 2005c):

> The environmental impacts at the shallow disposal sites considered for disposition of LLW would have been assessed at the time of the initial license approvals of these disposal facilities or as a part of any subsequent amendments to the license. For example, under its Radioactive Materials License issued by the State of Utah, the Envirocare disposal facility is authorized to accept depleted uranium for

> disposal with no volume restrictions [citation omitted]. Several site-specific factors contribute to the acceptability of depleted uranium disposal at the Envirocare site, including highly saline groundwater that makes it unsuitable for use in irrigation and for human or animal consumption, saline soils unsuitable for agriculture, and low annual precipitation [citation omitted]. As Utah is an NRC Agreement State and Envirocare has met Utah's LLW licensing requirements, which are compatible with 10 CFR Part 61,[10] the impacts from the disposal of depleted uranium generated by the proposed [National Enrichment Facility] at the Envirocare facility would be SMALL. [emphasis in original]

The NRC staff's analysis leading to the conclusion quoted above was based on information provided by the Utah Division of Radiation Control (NRC 2005d) and has been supplemented and upheld by an Atomic Safety and Licensing Board decision (NRC 2006a) and an NRC Commissioners' Memorandum and Order (NRC 2006b).[11]

Additional assurance that the impacts of disposal at Envirocare of depleted uranium oxide conversion product from DOE's conversion facilities, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations would be acceptable is provided by the requirements in Directive DOE M 435.1-1 (DOE 2001). According to this directive, before a non-DOE commercial facility is used for disposal of LLW generated by a DOE facility, an exemption from DOE's policy of using only DOE disposal facilities to manage DOE radioactive wastes must be obtained. To obtain the exemption, it must be shown that the commercial disposal facility complies with applicable federal, state, and local requirements, and has the necessary permits, licenses, and approvals for the specific wastes to be disposed of. In addition, the exemption for use of the commercial facility must be documented to be cost-effective and in DOE's best interest, including consideration of alternatives for on-site disposal at the location of generation, an alternative DOE site, and any other available non-DOE facilities. Consideration of life-cycle cost, potential liability, and protection of public health and the environment must be included. DOE headquarters, host states, and state LLW compacts must be consulted prior to approval of an exemption, and notified prior to shipments being made.

Such exemptions have been successfully obtained in past DOE disposal actions at Envirocare; for example, in 2000, about a dozen exemptions existed that were granted by the DOE Oak Ridge Operations Office for disposal of various LLW streams at Envirocare.

In conclusion, because (1) Envirocare has confirmed its ability to accept the annual amount of depleted uranium oxide that will be produced by the two DOE conversion facilities for the next 25 years; (2) DOE's proposed waste load would be a small part of Envirocare's

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[10] Because Utah is an NRC Agreement State, its LLW disposal regulations must be compatible with 10 CFR Part 61 to receive, in the first instance, and maintain its Agreement State status.

[11] According to the Memorandum and Order, the NRC Commissioners reviewed the potential impacts of depleted uranium disposal at a "reference" near-surface disposal facility, which was the Envirocare facility. The Commissioners concluded that Envirocare "appears to be a suitable location" for near-surface disposal of depleted uranium and "may be a plausible option for disposal of National Enrichment Facility depleted uranium" (NRC 2006b).

throughput, and (3) analyses performed by the Utah Division of Radiation Control and the NRC indicate that the Envirocare facility would operate well within its established standards, DOE believes that Envirocare's part of the impacts from construction and operation of the DUF_6 conversion facilities would be low. Accordingly, additional NEPA coverage of on-site handling and disposal impacts is not needed to support a DOE decision concerning disposal at Envirocare. If DOE decides to dispose of the depleted uranium oxide conversion product, emptied cylinders, and small amount of CaF_2 produced during normal conversion operations at Envirocare, the Department would need to approve an exemption from its policy of using only DOE disposal facilities to manage DOE radioactive wastes. No depleted uranium oxide conversion product, emptied cylinders, or CaF_2 produced during normal conversion operations will be sent to Envirocare for disposal until required exemptions are granted.

3.4 TRANSPORTATION TO NTS AND ENVIROCARE

The site-specific EISs analyzed transport of the depleted uranium oxide conversion product (assumed to be U_3O_8), emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations to NTS and Envirocare. These analyses are discussed in detail in Section 2.2 of this report. The EIS analyses assumed 4 cylinders refilled with depleted uranium oxide per railcar shipment and 1 or 2 refilled cylinders per truck shipment (DOE 2004a, Tables 5.2-22, -26, -27, and -29; DOE 2004b, Tables 5.2-26, -27, -31, -32, and -34). For rail transport (the preferred option), 233 railcars per year from Portsmouth (DOE 2004b, Section 2.4.2.3, page 2-35) and 290 railcars per year from Paducah were estimated (DOE 2004a, Section 2.4.2.3, page 2-32). UDS is planning railcar shipment with 6 to 8 cylinders per railcar, so it is estimated that only about 150 railcar shipments per year from Portsmouth and 200 railcar shipments per year from Paducah will be required (UDS 2005).

Because under current UDS plans the number of railcar shipments required to transport the depleted uranium disposal product would be lower than that assessed in the site-specific EISs, the vehicle-related risks would be correspondingly lower under UDS plans. Although the per-shipment cargo-related risk under normal operations would increase somewhat because of the increased number of cylinders per shipment, this increase would be offset by the decrease in number of shipments, and the total campaign cargo-related risk estimates given in Section 2.2 would not change.

The consequences from an accidental release of uranium oxide during transportation are determined by the amount of oxide released and available for transport in the environment (DOE 2004a, Section 5.2.3.3, pages 5-83 to 5-87; DOE 2004b, Section 5.2.5.3, pages 5-102 to 5-109). Because of the high density of uranium compounds, the majority of released material would settle out of the air near the release point, rather than being available for long-range transport or for inhalation. Therefore, even with a somewhat higher amount of uranium oxide per shipment, the amount of uranium oxide dispersion and exposure after an accidental release during transportation (assuming cleanup of the accident site) would be slightly higher than what was assumed in the site-specific EIS transportation analyses. Therefore, because of the reduction in the total number of shipments, the overall risks from severe transportation accidents would be expected to be about the same under the current UDS shipment plans as they were in the site-specific EISs.

A small number of truck shipments to NTS (less than 5 per year) are included in the UDS plans; these shipments would include 1 cylinder per truck (UDS 2005). Risks from these shipments were included in the site-specific EIS transportation analyses (DOE 2004a, Sections 5.2.3.1 to 5.2.3.3, pages 5-73 to 5-87; DOE 2004b, Sections 5.2.5.1 to 5.2.5.3, pages 5-93 to 5-109).

The doses and risks to a resident living near the exit from the Paducah and Portsmouth sites or the entrance to the disposal facility (either Envirocare or NTS) were presented in Sections 2.2.1.2 and 2.2.2.2 of this analysis. A person living near the disposal site would be exposed to shipments from both the Paducah and Portsmouth sites. On a per-shipment basis, the individual's dose and risk would be the same as shown in Tables 2.2-5 and 2.2-13. However, cumulatively, the individual's dose would be approximately 0.07 mrem if all shipments of uranium oxide were made by rail in bulk bags. The individual's dose would increase by about a factor of 2 to approximately 0.14 mrem if the uranium oxide were shipped in refilled cylinders. Considering the possibility of some crushed emptied cylinders being disposed of at either disposal site, the total dose to the resident living near the entrance to the disposal facility from all the DUF_6-related activities is estimated to be less than 0.2 mrem. The individual's risk would be less than 10^{-7}.

Collective population risks to people living near the transportation routes, sharing the roads with the conveyance vehicles, and the transportation crew due to shipments of depleted uranium oxide conversion product, emptied DUF_6 cylinders, and the small quantity of CaF_2 from Portsmouth and Paducah are discussed in Sections 2.2.1.1 and 2.2.2.1, respectively. Both truck and rail options were considered for shipments to both Envirocare and NTS. Considering all the shipments from both the Portsmouth and Paducah sites over the entire 18-year operational period assumed for the Portsmouth site and the 25-year period assumed for the Paducah site, at most one radiological LCF would be expected under any transportation mode to either disposal site. Depending on the number of cylinders per truck or rail car and whether the depleted uranium oxide conversion product is shipped in bulk bags or emptied cylinders, the total number of traffic fatalities is estimated to be 4 or less for the truck option for shipments to either Envirocare or NTS. The rail option would result in one traffic fatality for either site. Similarly, depending on the number of cylinders per truck or rail car and whether the bulk bags or the emptied cylinders are used for shipment of the depleted uranium conversion product, the total number of emission fatalities would be estimated to be 1 or less for the rail option, and 30 or less for the truck option.[12] The results of the transportation analysis indicate that the largest impact during normal transportation conditions from the Portsmouth and Paducah sites would be associated with vehicle exhaust and fugitive dust emissions (unrelated to the cargo). The uncertainty and conservatism associated with the methods and assumptions used to estimate the impacts from air emissions are discussed in Section 2.2.1.1.

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[12] Estimating the health risks associated with vehicle emissions is subject to a great deal of uncertainty. The estimates presented in the Portsmouth site-specific EIS were based on very conservative health risk factors presented in Biwer and Butler (1999) and should be considered an upper bound.

For analyzing an all-rail transport option to NTS, DOE assumed that a rail line would be available for the entire distance. Currently, however, the nearest rail terminal to NTS is about 70 mi (113 km) from the site. Accordingly, if NTS were to be selected as the disposal site, a rail spur would have to be constructed connecting the existing rail line to the site in order to realize the all-rail option. Alternatively, railcar shipments would have to go to a terminal from which trucks could carry the load the rest of the way. The site-specific EISs indicated that if a rail spur to NTS were built, additional NEPA review would need to be conducted to evaluate the impacts resulting from such construction. The site-specific EISs also indicated that, if shipments of depleted uranium oxide conversion product, emptied cylinders, and CaF_2 produced during normal conversion operations from Portsmouth and/or Paducah to NTS were made instead through intermodal transfers from rail to trucks, the impacts would be slightly greater than for the all-rail option, but less than for the all-truck option. (DOE 2004a, Section 5.2.3.1, page 5-75; DOE 2004b, Section 5.2.5.1.3, pages 5-96 to 5-97).

Cumulative impacts associated with transportation of all types of radioactive wastes, both DOE-origin and non-DOE origin, were addressed in DOE's WM PEIS (DOE 1997). The analysis of cumulative impacts in the WM PEIS (Vol. I, Section 11.20, page 11-114) indicated that the potential cumulative transportation-related radiological collective doses over the 93-year period from 1943 through about 2035 would be about 343,000 person-rem to occupational workers and about 347,000 to the general population. The total number of radiation-related cancer fatalities was estimated to be 315 from the occupational and general public exposures combined. Even though the analyses were performed assuming that DOE wastes would all be disposed of at DOE disposal sites, they would not change if some DOE wastes were disposed of in commercial facilities such as Envirocare. In comparison to the above estimates, the added effects of transporting depleted uranium conversion product, emptied cylinders, and the CaF_2 produced during normal conversion operations would be relatively small (less than 1%).

The WM PEIS also assessed the cumulative impacts to individuals along the transportation routes. For example, the dose received by a resident who lives near the entrance to NTS and is exposed to approximately 70,000 LLW shipments over his lifetime, was estimated to be about 1.1 mrem (WM PEIS, Vol. IV, Appendix E, Table E-18, page E-68). The dose received by a resident near any other disposal site, including Envirocare, would be similar for the same number of shipments. As indicated in Section 2 (Tables 2.2-3 and 2.2-11) of this Draft SA, the number of shipments of depleted uranium oxide to either NTS or Envirocare by truck, assuming 2 cylinders per truck, would be about 29,000 (10,500 from Portsmouth and 18,100 from Paducah). And as discussed above, the total dose received by a resident near the entrance to the disposal site from these shipments would be less than 0.2 mrem. For perspective, the dose received by the same individual from natural background radiation, including radon, would be about 360 mrem.

On the basis of the above assessment, if either NTS or Envirocare is selected as a disposal location, the transportation impacts have been adequately addressed by the site-specific EIS analyses, which looked at impacts for transportation of U_3O_8, CaF_2, and emptied cylinders to both sites using rail, truck, and intermodal methods.

3.5 ISSUES ASSOCIATED WITH DUF$_6$ CYLINDER CONTAMINATION

As discussed in the site-specific EISs, there is a potential for a small but unknown number of cylinders in DOE's inventory to be contaminated with transuranic isotopes and technetium-99 (Tc-99) on the inside and for a larger but still unknown number of cylinders to be contaminated with polychlorinated biphenyls (PCBs) on the outside.[13] The transuranics and Tc-99 in the cylinders are believed to have resulted from the prior use of the DUF$_6$ cylinders to transport the previously processed UF$_6$ for re-enrichment in DOE's gaseous diffusion plants and the same cylinders being refilled with DUF$_6$ without being cleaned in between. The likelihood that some or all of the transuranics and Tc-99 in the cylinders would be transferred during conversion into the depleted uranium oxide product was discussed in Appendix B of the site-specific EISs (DOE 2004a,b). It was stated that the transuranics and Tc-99 would not be expected to transfer from the cylinders to the oxide product in sufficient quantities to be of concern due to the fact that transuranics or Tc-99 contaminants would principally exist in the form of nonvolatile fluorides and would be contained in small heels of material adhered to the cylinders (Brumburgh et al.2000; Hightower et al. 2000). In the unlikely event that a small fraction of transuranics and Tc-99 might be carried out of the cylinders with the gaseous UF$_6$ as particulates, it is expected that they would be captured in the filters that the UF$_6$ would pass through before entering the conversion equipment. However, because of the existence of some volatile technetium fluoride compounds, and for the purpose of analysis, all of the technetium was assumed to volatilize with UF$_6$ and be carried into the conversion process equipment. It was also assumed that technetium would be oxidized in the reaction chamber of the conversion plant along with uranium and would end up in the oxide product as technetium oxide.

Since the cylinders are expected to be reused as containers for the depleted uranium oxide product and the product will be disposed along with the cylinders, any remaining transuranics and technetium in the emptied cylinders will be incorporated into the disposal package for the depleted uranium oxide product. Under these conditions, the EISs concluded that the disposed material would be classified as LLW. Therefore, as long as such material meets the WAC, it would be acceptable for disposal at a LLW disposal facility. The site-specific EISs also considered the possibility that emptied cylinders at the conversion facilities may not be used as depleted uranium oxide containers, but instead would be disposed of separately after stabilization of the heel material remaining in them (DOE 2004a,b). The EIS assumed that these cylinders would be able to be disposed of as LLW. However, it was also stated in the EIS that the emptied cylinders would be surveyed at the conversion facilities to verify that assumption. UDS stated in its Waste Management Plan that it plans to characterize the cylinders for disposal using statistical sampling and analysis (UDS 2005). It is likely that some emptied cylinders being disposed by themselves would not meet the Envirocare WAC because of the presence of Tc-99. If this occurs, such cylinders could be disposed of at NTS, which has different WAC.

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[13] Questions were also raised about possible phosgene contamination in some smaller (Type 30A) cylinders in DOE's inventory that had prior use as phosgene containers by the military before they were filled with DUF$_6$ in the 1940s or 50s. DOE has completed an evaluation of the affected cylinders which concluded that no phosgene contamination is present.

Some cylinders in DOE's DUF_6 inventory are known to be coated with dry paint that contains PCBs. The existence of such cylinders in the DUF_6 inventory was acknowledged in the site-specific EISs, and issues associated with disposal were discussed in Appendix B of each site-specific EIS. The issue also is addressed in the UDS Waste Management Plan (UDS 2005). The UDS Waste Management Plan reports that transportation and disposal of such cylinders are not expected to present issues because the cylinders would be classified for the purpose of disposal as PCB/radioactive bulk product waste. This waste is allowed to be disposed of in accordance with requirements applicable to its radioactive component, without regard to its PCB component (40 CFR 761.50(b)(7)(ii)). Thus, PCB-contaminated cylinders could be disposed of at either Envirocare or NTS provided that all other non-PCB-related WAC at the destination facility are met. Both facilities have units into which LLW containing PCBs may be placed.

3.6 POTENTIAL IMPACTS ASSOCIATED WITH ADDING A FOURTH LINE TO THE CONVERSION PLANT AT PORTSMOUTH, OHIO

The potential for adding a fourth processing line to the conversion plant at Portsmouth, Ohio was considered in the Portsmouth EIS to provide for future planning flexibility. Section 5.2.8 of that EIS discusses the potential impacts associated with such an addition (DOE 2004b, page 5-113). The discussion addresses the impacts of transporting the depleted uranium oxide conversion product from the Portsmouth DUF_6 conversion facility to the Envirocare and NTS disposal facilities. It concludes that the overall transportation impacts would be the same regardless of whether there are three processing lines at Portsmouth or four. As Section 5.2.8.1.12 of the Portsmouth EIS states, the transportation impacts for the base case (three processing lines) presented in Section 5.2.5 of the EIS (DOE 2004b, page 5-93) (summarized in Section 2.2.1 of this Draft SA) are cumulative totals for the shipment of all materials resulting from the conversion of the Portsmouth and ETTP DUF_6 inventories. Therefore, since the DUF_6 inventories being converted at the Portsmouth facility would not change with the addition of a fourth processing line, the overall impacts of transporting the depleted uranium oxide conversion product from Portsmouth to either Envirocare or NTS would be the same regardless of whether there are three processing lines or four. However, the annual number of shipments from Portsmouth would increase by 33% if the fourth processing line is added, and the time period over which shipping occurs will decrease by 5 years.

The annual transportation impacts can be estimated by dividing the collective population impacts, as presented in Section 5.2.5 of the Portsmouth EIS and in Section 2.2.1 of this Draft SA, by the shipping campaign duration. This duration would be 18 years under the three-process-lines base case but 13 years under the four-process-lines case. Thus, annual transportation impacts would be greater if the Portsmouth plant throughput were increased by 33% because the DUF_6 inventories would be converted faster, and the depleted uranium oxide conversion product, emptied cylinders, and CaF_2 produced during normal conversion operations would be transported at higher rates. Specifically, the annual collective population risk and radiation exposure to a hypothetical individual living near Portsmouth from transportation would increase by approximately 33% for shipments from the Portsmouth plant under the four-process-lines case. Even so, as previously noted, the total transportation impacts over the life of the Portsmouth plant would be the same for both cases.

For the Paducah plant, both the number of shipments and the impacts from transporting all depleted uranium oxide conversion product to Envirocare or NTS would remain as reported in Section 2.2.2 of this Draft SA for both the three-process-lines base case and the four-process-lines case, because the Paducah EIS already assumed that the Paducah plant would have four processing lines. Accordingly, the combined total number of annual shipments from the Paducah and Portsmouth plants to the Envirocare or NTS disposal facility would increase under the four-process-lines case by approximately 15% over the three-process-lines base case. The combined annual collective population risk and exposure to radiation of a hypothetical person living near the disposal site would also increase by approximately 15% under the four-process-lines case.

Neither the increased annual collective population risk for shipments from the Portsmouth plant to either disposal facility nor the increased combined annual collective population risk for shipments from both DUF_6 conversion plants to either disposal facility would exceed regulatory limits or standards under the four-process-lines case.

The consequences of accidents during transportation would not change with the addition of a fourth processing line at Portsmouth because the amount of material involved in any accident is determined by the size of the shipping container and the vehicle capacity, neither of which would be changed. The annual probability of accident occurrences would increase, however, by the proportion of the increase in the number of annual shipments. Even so, this increase would not be large enough to change the frequency category designations of accidents given in the Portsmouth EIS (DOE 2004b, Section 5.2.8.1.2, page 5-116). Furthermore, the increase in annual accident frequency would be offset by the reduced operational period of the facility. Therefore, the probability of accident occurrences during the Portsmouth plant’s operating life would be about the same for the four-process-lines case as for the three-process-lines base case. As a result, the accident risk associated with the four-process-lines case would be the same as reported in the Portsmouth EIS and in Section 2.2.1.3 of this Draft SA.

Because there is no change in the combined amount of material being disposed from both DUF_6 conversion facilities, the discussions provided in Sections 3.1, 3.2, and 3.3 of this Draft SA regarding the disposal capacity at the candidate disposal sites would equally apply to the four-process-lines case. However, the annual throughput of depleted uranium oxide conversion product at a disposal facility could be approximately 15% higher during the operating period of the Portsmouth plant, which would be approximately 5 years shorter. It is anticipated that the potential annual increase in the volume of material requiring disposal would be manageable at either Envirocare or the NTS in a manner consistent with facility operating permits and in a manner protective of workers, the general population around the sites, and the environment.

As the Portsmouth ROD indicates (69 FR at 44653, July 27, 2004), DOE did not previously decide to add a fourth processing line at Portsmouth, and the Department still has not decided to do so. However, if the decision is made in the future to add a fourth processing line, the impacts associated with that addition are sufficiently covered in the site-specific EISs (DOE 2004a,b) and this Draft SA. None of the conclusions reached in this Draft SA would be changed by the addition of a fourth processing line at the Portsmouth plant.

4 DETERMINATION

The Draft SA identifies no significant new circumstances or information relevant to environmental concerns that bear on DOE's decisions on disposal locations or the impacts of those decisions. Since issuance of the two site-specific EISs, the following circumstances have changed. In May 2006, a sales contract was signed with Solvay Fluorides, a commercial vendor, for purchase of the HF co-product. On June 2, 2006, the NRC issued a Memorandum and Order determining that the Envirocare facility near Clive, Utah, appears to be suitable for near-surface disposal of depleted uranium. The transportation campaign has been slightly modified to include more cylinders per railcar with fewer shipments per year. Impacts from the modified campaign for both normal operations and accident scenarios are projected to be about the same or less than those presented in the site-specific EISs.

Based on the analysis presented in this Draft SA, DOE believes that existing NEPA documentation identifies reasonable disposal alternatives (i.e., NTS and Envirocare). In addition, DOE has determined that Envirocare's part of the impacts from construction and operation of the DUF_6 conversion facilities would be low. DOE believes that preparation of a supplemental EIS is not needed to support a decision for disposal at Envirocare. If DOE decides to dispose of the depleted uranium oxide conversion product, emptied cylinders, and CaF_2 produced during normal conversion operations at Envirocare, the Department would need to approve an exemption from its policy of using only DOE disposal facilities to manage DOE radioactive wastes. No depleted uranium oxide conversion product, emptied cylinders, or CaF_2 produced during normal conversion operations will be sent to Envirocare for disposal until the required exemption is granted.

The analysis presented in this Draft SA also indicates that adequate NEPA coverage exists for all actions leading up to delivery to the NTS of the depleted uranium oxide conversion product that would be generated from DOE's entire inventory of DUF_6, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations. Furthermore, site-specific NEPA coverage at the NTS is adequate for disposal of up to 60,000 m^3 (2.1 million ft^3) of unused depleted uranium oxide conversion product, and the NTS disposal capacity (i.e., 3.7 million m^3 [130 million ft^3]) is more than sufficient to accommodate the output from the conversion of DOE's entire existing DUF_6 inventory, emptied cylinders, and the small amount of CaF_2 produced during normal conversion operations. Therefore, DOE has determined that preparation of a supplemental EIS is not needed to support a decision for disposal at the NTS. However, additional site-specific NEPA analyses would be necessary to support any future DOE decision to dispose additional depleted uranium oxide conversion product volumes beyond 60,000 m^3 (2.1 million ft^3). Accordingly, disposal of the total volume of depleted uranium oxide conversion product to be generated by the DUF_6 conversion project will be addressed as part of the upcoming review and evaluation of the NTS site-wide EIS. Further analyses and documentation (i.e., SA, supplemental site-wide EIS or new site-wide EIS) will be prepared, as necessary, based on the results of that review. Depleted uranium oxide conversion product not acceptable for disposal at NTS, if any, would be disposed at Envirocare, or another disposal facility determined to be acceptable at that time, following appropriate NEPA review.

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