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Final Supplemental Environmental Impact Statement for

Disposition of Depleted Uranium Oxide Conversion Product Generated from DOE’s Inventory of Depleted Uranium Hexafluoride

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COVER SHEET

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This document is available on the DOE NEPA website (http://energy.gov/nepa/nepa-documents), and the Portsmouth/Paducah Project Office website (https://www.energy.gov/em/disposition-uranium-oxide-conversion-depleted-uranium-hexafluoride) for viewing and downloading.

ABSTRACT:

On June 18, 2004, the U.S. Department of Energy (DOE) issued environmental impact statements for the construction and operation of facilities to convert depleted uranium hexafluoride (DUF_6) to depleted uranium (DU) oxide at DOE's Paducah Site (Paducah) in Kentucky and Portsmouth Site (Portsmouth) in Ohio (69 FR 34161). Both the *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Paducah, Kentucky Site* (DOE/EIS-0359) and the *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the*

Portsmouth, Ohio Site (DOE/EIS-0360) (collectively, the “2004 EISs”) were prepared to evaluate and implement DOE’s DUF_6 long-term management program.

Records of Decision (RODs) were published for the 2004 EISs on July 27, 2004 (69 FR 44654; 69 FR 44649). In the RODs, DOE decided that it would build facilities at both Paducah and Portsmouth and convert DOE’s inventory of DUF_6 to DU oxide. DOE decided the aqueous hydrogen fluoride produced during conversion would be sold for use pending approval of authorized release limits. The calcium fluoride (CaF_2) produced during conversion operations would be reused, pending approval of authorized release limits, or disposed of as appropriate. DOE also decided that the DU oxide conversion product would be reused to the extent possible or packaged in empty and heel cylinders for disposal at an appropriate disposal facility. Emptied cylinders would also be disposed of at an appropriate facility.

DOE had intended to identify disposal locations in the RODs for the 2004 EISs for any declared DU oxide waste. However, prior to issuing the RODs, DOE discovered it inadvertently had not formally provided copies of the Draft and Final EISs to the states of Nevada and Utah, and DOE concluded it was bound by the Council on Environmental Quality National Environmental Policy Act (NEPA) regulations described in 40 CFR 1502.19 to forego decisions on disposal location(s) until it had properly notified these states. Accordingly, in the RODs for the 2004 EISs, DOE did not include decisions with respect to specific disposal location(s) for DU oxide declared waste, but instead informed the public it would make the decisions later, and additional supplemental NEPA analysis would be provided for review and comment.

The purpose and need for this action is to identify and analyze alternatives for the disposition of DU oxide. If a beneficial use cannot be found for the DU oxide, all or a portion of the inventory may need to be disposed of. The proposed scope of this *DU Oxide SEIS* includes an analysis of the potential impacts from three Action Alternatives and a No Action Alternative (in accordance with 40 CFR 1502.14). Under the Action Alternatives, DU oxide would be disposed of at one or more of the three disposal facilities: (1) the Energy*Solutions* LLC site near Clive, Utah; (2) the Nevada National Security Site (NNSS) in Nye County, Nevada; and (3) the Waste Control Specialists LLC (WCS) site near Andrews, Texas. Under the No Action Alternative, transportation and disposal would not occur, and DU oxide containers would remain in storage at Paducah and Portsmouth. All other aspects of the DUF_6 conversion activities remain as described previously in the 2004 EISs and RODs and are not within the scope of this *DU Oxide SEIS*.

Under the Action Alternatives and the No Action Alternative, container storage, maintenance, and handling activities would occur within the industrialized areas of Paducah and Portsmouth; there would be no significant construction or ground disturbance, minor employment, minor utility use, and no routine releases of DU oxide or other hazardous materials. Therefore, potential impacts on site infrastructure; air quality and noise; geology and soils; water resources; biotic resources; public and occupational health and safety (during normal operations, accidents, and transportation); socioeconomics; waste management; land use and aesthetics; cultural resources; and environmental justice at Paducah and Portsmouth would be expected to be minor. A potential release of DU oxide from a container breach would be expected to result in uranium concentrations below benchmark levels, and therefore would have minimal impacts on soils, surface and groundwater quality, biotic resources, and human health.

Transport of the DU oxide by truck or train to a disposal site would be expected to result in no latent cancer fatalities to workers or the public, although there could be nonradiological fatalities from trauma during a truck or train accident. Greenhouse gas emissions from transportation vehicles would amount to a very small percentage of United States emissions and would be expected to have a small but indeterminate impact on global climate change. Waste disposal volumes would not be expected to exceed the capacities of the Energy*Solutions*, NNSS, or WCS disposal facilities.

On December 28, 2018, the U.S. Environmental Protection Agency (EPA) and DOE published notices in the *Federal Register* announcing the availability of the *Draft DU Oxide SEIS* (83 FR 67282 and 83 FR 67250). A 45-day comment period, ending February 11, 2019, was announced to provide time for interested parties to review and comment on the *Draft DU Oxide SEIS.* In response to public requests, DOE extended the public comment period by 21 days, through March 4, 2019 (84 FR 1716, February 5, 2019). During the public comment period, DOE held three web-based public hearings to provide interested members of the public with opportunities to hear DOE representatives present the results of the *Draft DU Oxide SEIS* analyses and to provide oral comments. DOE received 24 comment documents containing 115 comments during the public comment period. All comments received during the public comment period were considered in preparing this *Final DU Oxide SEIS*.

If a beneficial use cannot be found for the DU, all or a portion of the inventory may be characterized as waste and may need to be disposed of. DOE's Preferred Alternative would be to dispose of DU oxide at one or more of the disposal sites (Energy*Solutions*, NNSS, and/or WCS), understanding that any disposal location(s) must have a current license or authorization and capacity to dispose of DU oxide at the time shipping to a location is initiated. DOE does not have a preference among the Action Alternatives. Any decision related to the Proposed Action may also depend on competitive procurement practices necessary to contract for the transportation and disposal of the DU oxide. The decision regarding which alternative(s) DOE selects would be documented in a ROD, in accordance with 10 CFR 1021.315. The ROD would be published in the *Federal Register* no sooner than 30 days after publication of this *Final DU Oxide SEIS*.

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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 ABBREVIATIONS AND ACRONYMS

ABC	Articulated Bulk Container
AEA	Atomic Energy Act of 1954
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
AQCR	Air Quality Control Region
BLS	Bureau of Labor Statistics
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	*Code of Federal Regulations*
CRMP	cultural resource management plan
DD&D	decontamination, decommissioning, and demolition
DNL	day-night average sound level
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DSA	documented safety analysis
DU Oxide SEIS	*Supplemental Environmental Impact Statement for Disposition of Depleted Uranium Oxide Conversion Product Generated from DOE's Inventory of Depleted Uranium Hexafluoride*
DUF_6 PEIS	*Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*
DUF_4	depleted uranium tetrafluoride
EA	environmental assessment
EIS	environmental impact statement
EM	Office of Environmental Management (DOE)
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
ETTP	East Tennessee Technology Park (formerly K-25 site)
FONSI	Finding of No Significant Impact
FFS	Fluor Federal Services
FR	*Federal Register*
FTE	full-time equivalent
FWF	Federal Waste Facility

FY	fiscal year
GDP	gaseous diffusion plant
GHG	greenhouse gas
GIS	geographic information system
HMR	hazardous materials regulation
HMTA	Hazardous Materials Transportation Act
ICRP	International Commission on Radiological Protection
IHE	irreversible health effect
IPCC	Intergovernmental Panel on Climate Change
ISC	Industrial Source Complex
KAR	Kentucky Administrative Regulation
KDEP	Kentucky Department of Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
KRS	Kentucky Revised Statutes
LCF	latent cancer fatality
L_{eq}	equivalent steady sound level
LLW	low-level radioactive waste
MEI	maximally exposed individual
MLLW	mixed low-level radioactive waste
NAAQS	National Ambient Air Quality Standard(s)
NCRP	National Council on Radiation Protection and Measurements
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
non-DUF_6	non-depleted uranium hexafluoride
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NWS	new waste stream
OAC	Ohio Administrative Code
OAG	Ogallala-Antlers-Gatuna
OEPA	Ohio Environmental Protection Agency
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OSWDF	On-Site Waste Disposal Facility

PA	performance assessment
PAH	polycyclic aromatic hydrocarbons
PEIS	programmatic environmental impact statement
P.L.	Public Law
PM	particulate matter
PM_{10}	particulate matter with a mean aerodynamic diameter of 10 micrometer or less
$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 micrometers or less
PSD	prevention of significant deterioration
PGA	peak ground acceleration
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
ROD	Record of Decision
ROI	region of influence
RWMC	Radioactive Waste Management Complex
SAAQS	State Ambient Air Quality Standard(s)
SHPO	State Historic Preservation Officer
SODI	Southern Ohio Diversification Initiative
SWEI	sitewide environmental impact statement
SWMU	solid waste management unit
SWPPP	Stormwater Pollution Prevention Plan
TCEQ	Texas Commission on Environmental Quality
TRU	transuranic
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USEC	United States Enrichment Corporation
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WCS	Waste Control Specialists LLC
WIPP	Waste Isolation Pilot Plant
WKWMA	West Kentucky Wildlife Management Area
WM PEIS	*Waste Management Programmatic Environmental Impact Statement*

CHEMICALS

CaF_2	calcium fluoride
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
DU	depleted uranium
DUF_6	depleted uranium hexafluoride
HF	hydrogen fluoride
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
O_3	ozone
Pb	lead
PCB	polychlorinated biphenyl
SO_2	sulfur dioxide
Tc	technetium
TCE	trichloroethylene
U	uranium
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U_3O_8	triuranium octaoxide

UNITS OF MEASURE

°C	degree(s) Celsius
Ci	curie(s)
cm	centimeter(s)
d	day(s)
dB	decibel(s)
dB(A)	A-weighted decibel(s)
°F	degree(s) Fahrenheit
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
g	gram(s)
gal	gallon(s)
h	hour(s)
ha	hectare(s)
in	inch(es)
in^2	square inch(es)
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kPa	kilopascal(s)
L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MeV	million electron volts
mg	milligram(s)
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mL	milliliter(s)
mph	mile(s) per hour
mR	milliroentgen(s)
mrem	millirem(s)
mSv	millisievert(s)
MVA	megavolt-ampere(s)
MW	megawatt(s)
MWh	megawatt-hour(s)
nCi	nanocurie(s)
oz	ounce(s)
pCi	picocurie(s)
ppb	part(s) per billion
ppm	part(s) per million
psia	pound(s) per square inch absolute
psig	pound(s) per square inch gauge
rem	roentgen equivalent man
s	second(s)
Sv	sievert(s)
t	metric ton(s)
ton(s)	short ton(s)
wt%	percent by weight
yd^3	cubic yard(s)
yr	year(s)
µg	microgram(s)
µm	micrometer(s)

CONVERSIONS

METRIC TO ENGLISH			ENGLISH TO METRIC		
Multiply	**by**	**To get**	**Multiply**	**by**	**To get**
Area					
Square meters	10.764	Square feet	Square feet	0.092903	Square meters
Square kilometers	247.1	Acres	Acres	0.0040469	Square kilometers
Square kilometers	0.3861	Square miles	Square miles	2.59	Square kilometers
Hectares	2.471	Acres	Acres	0.40469	Hectares
Concentration					
Kilograms/square meter	0.16667	Tons/acre	Tons/acre	0.5999	Kilograms/square meter
Milligrams/liter	1 [a]	Parts/million	Parts/million	1 [a]	Milligrams/liter
Micrograms/liter	1 [a]	Parts/billion	Parts/billion	1 [a]	Micrograms/liter
Micrograms/cubic meter	1 [a]	Parts/trillion	Parts/trillion	1 [a]	Micrograms/cubic meter
Density					
Grams/cubic centimeter	62.428	Pounds/cubic feet	Pounds/cubic feet	0.016018	Grams/cubic centimeter
Grams/cubic meter	0.0000624	Pounds/cubic feet	Pounds/cubic feet	16,018.5	Grams/cubic meter
Length					
Centimeters	0.3937	Inches	Inches	2.54	Centimeters
Meters	3.2808	Feet	Feet	0.3048	Meters
Kilometers	0.62137	Miles	Miles	1.6093	Kilometers
Radiation					
Sieverts	100	Rem	Rem	0.01	Sieverts
Temperature					
Absolute					
Degrees C + 17.78	1.8	Degrees F	Degrees F - 32	0.55556	Degrees C
Relative					
Degrees C	1.8	Degrees F	Degrees F	0.55556	Degrees C
Velocity/Rate					
Cubic meters/second	2118.9	Cubic feet/minute	Cubic feet/minute	0.00047195	Cubic meters/second
Grams/second	7.9366	Pounds/hour	Pounds/hour	0.126	Grams/second
Meters/second	2.237	Miles/hour	Miles/hour	0.44704	Meters/second
Volume					
Liters	0.26418	Gallons	Gallons	3.7854	Liters
Liters	0.035316	Cubic feet	Cubic feet	28.316	Liters
Liters	0.001308	Cubic yards	Cubic yards	764.54	Liters
Cubic meters	264.17	Gallons	Gallons	0.0037854	Cubic meters
Cubic meters	35.314	Cubic feet	Cubic feet	0.028317	Cubic meters
Cubic meters	1.3079	Cubic yards	Cubic yards	0.76456	Cubic meters
Cubic meters	0.0008107	Acre-feet	Acre-feet	1233.49	Cubic meters
Weight/Mass					
Grams	0.035274	Ounces	Ounces	28.35	Grams
Kilograms	2.2046	Pounds	Pounds	0.45359	Kilograms
Kilograms	0.0011023	Tons (short)	Tons (short)	907.18	Kilograms
Metric tons	1.1023	Tons (short)	Tons (short)	0.90718	Metric tons

ENGLISH TO ENGLISH

Acre-feet	325,850.7	Gallons	Gallons	0.000003046	Acre-feet
Acres	43,560	Square feet	Square feet	0.000022957	Acres
Square miles	640	Acres	Acres	0.0015625	Square miles

a. This conversion is only valid for concentrations of contaminants (or other materials) in water.

METRIC PREFIXES

Prefix	Symbol	Multiplication factor
exa-	E	1,000,000,000,000,000,000 = 10^{18}
peta-	P	1,000,000,000,000,000 = 10^{15}
tera-	T	1,000,000,000,000 = 10^{12}
giga-	G	1,000,000,000 = 10^{9}
mega-	M	1,000,000 = 10^{6}
kilo-	k	1,000 = 10^{3}
deca-	D	10 = 10^{1}
deci-	d	0.1 = 10^{-1}
centi-	c	0.01 = 10^{-2}
milli-	m	0.001 = 10^{-3}
micro-	µ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}

1 INTRODUCTION AND PURPOSE AND NEED FOR AGENCY ACTION

1.1 BACKGROUND INFORMATION

The use of uranium as fuel for nuclear reactors or for military applications requires uranium enrichment; that is, increasing the proportion of the fissile uranium-235 isotope found in natural uranium. Industrial uranium enrichment in the United States began as part of atomic bomb development during World War II. Uranium enrichment for both civilian and military uses was continued by the U.S. Atomic Energy Commission and its successor agencies, including the U.S. Department of Energy (DOE). Uranium enrichment by gaseous diffusion was carried out at three locations now known as the Paducah Site (Paducah) in Kentucky, the Portsmouth Site (Portsmouth) in Ohio, and the East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee. The United States Enrichment Corporation (USEC) conducted enrichment operations at two of these sites: Paducah and Portsmouth. USEC began as a government agency, was later privatized, and is now Centrus Energy Corporation.

Depleted uranium hexafluoride (DUF_6)[1] results from the uranium enrichment process. The DUF_6 that remains after enrichment is stored in large steel cylinders that each contain approximately 9 to 12 metric tons (10 to 13 tons) of material. **Figure 1-1** shows a typical DUF_6 storage cylinder. The DUF_6 storage cylinders were initially stored at Paducah, Portsmouth, and ETTP where they were generated. However, all DUF_6 cylinders that were stored at ETTP were transported to Portsmouth. At its peak, Paducah stored approximately 46,000 DUF_6 cylinders (560,000 metric tons [617,000 tons]), and Portsmouth approximately 21,000 DUF_6 cylinders (250,000 metric tons [276,000 tons]), for a total of about 67,000 cylinders (810,000 metric tons [893,000 tons]) (PPPO 2018). The cylinders are stored two layers high on outdoor gravel or concrete storage areas known as "yards."

In addition to the DUF_6 cylinders, there are cylinders that contain enriched UF_6 or normal UF_6 or are empty or mostly empty (collectively called "non-DUF_6" cylinders). The *Final Environmental Impact Statement for Construction and Operation of Depleted Uranium Hexafluoride Conversion Facility at the Paducah, Kentucky, Site* (DOE/EIS-0359) (Paducah EIS), and *Final Environmental Impact Statement for Construction and Operation of Depleted Uranium Hexafluoride Conversion Facility at the Portsmouth, Ohio, Site* (DOE/EIS-0360) (Portsmouth EIS) (DOE 2004a, 2004b) (collectively, the "2004 EISs") assumed that the normal UF_6 and enriched UF_6 cylinders from both Paducah and Portsmouth would be put to beneficial uses; therefore, conversion of the contents of the non-DUF_6 cylinders was not considered at that time and are not considered in this *Final Supplemental Environmental Impact Statement for Disposition of Depleted Uranium Oxide Conversion Product Generated from DOE's Inventory of Depleted Uranium Hexafluoride* (*DU Oxide SEIS*). The empty and heel (mostly empty) cylinders[2] (8,483 at Paducah and 5,517 at

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[1] Depleted uranium is uranium that, through the enrichment process, has been stripped of a portion of the uranium-235 that it once contained so that its proportion is lower than the 0.707 weight-percent found in nature. The uranium in most of DOE's DUF_6 has between 0.2 and 0.4 weight-percent uranium-235. DUF_6 is considered a source material, not a waste.

[2] Empty cylinders have had the DUF_6 and heel material removed and contain limited residual material. Heel cylinders contain approximately 50 lb (23 kg) of residual nonvolatile material left after the DUF_6 has been removed.

Portsmouth) could be used as disposal containers for DU oxide. If not used as disposal containers, these cylinders would be disposed of as low-level radioactive waste (LLW)[3] (PPPO 2018). Disposal of empty and heel cylinders is evaluated in this *DU Oxide SEIS*.

Figure 1-1 Typical Depleted Uranium Hexafluoride Storage Cylinder (Source: ANL 2001)

Pursuant to Council on Environmental Quality (CEQ) and DOE National Environmental Policy Act (NEPA) implementing procedures described in Title 40 of the *Code of Federal Regulations* (40 CFR) Parts 1500–1508 and 10 CFR Part 1021, respectively, DOE evaluated potential broad management options for its DUF_6 inventory in the *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DUF_6 PEIS) (DOE 1999) issued in April 1999. In the DUF_6 PEIS ROD (Volume 64 of the *Federal Register*, page 43358 [64 FR 43358], August 10, 1999), DOE decided to promptly convert the DUF_6 inventory to a more stable uranium oxide form and stated it would put the DU oxide[4] to beneficial use as much as possible and store the remaining DU oxide for potential

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[3] Most of the heel material consists of DU oxide and uranium daughters (i.e., small quantities of radionuclides formed as a result of the natural radioactive decay of DU) as the radiological constituents and would be Class A LLW, as defined in 10 CFR Part 61, and LLW per DOE Order 435.1. The radiological characteristics of the majority of heel cylinders are bounded by the DU oxide characteristics. However, a small population of cylinders could contain transuranic (TRU) isotopes and/or technetium (Tc)-99 contaminants. TRU and Tc-99 suspect cylinders will be subjected to sampling and analysis to determine the levels of TRU isotopes and Tc-99. Cylinders deemed not acceptable for use as oxide containers (i.e., they exceed disposal facility waste acceptance criteria) will be shipped to a waste processor for further action to meet disposal facility waste acceptance criteria. DOE will only ship wastes that meet the disposal facility's waste acceptance criteria (PPPO 2019).

[4] When generated, DU oxide is considered a resource and may be sold or transferred for beneficial uses. DU oxide only becomes a waste when the sale or beneficial reuse options are exhausted and a decision is made to dispose of a quantity of the material. At the time of publication of this DU Oxide SEIS, if determined to be waste, DU oxide would be considered to be Class A LLW.

future uses or disposal, as necessary. DOE did not select specific sites for the conversion facilities or disposal at that time, but reserved that decision for subsequent NEPA review.

On June 18, 2004, DOE issued final EISs for construction and operation of DUF_6 conversion facilities and other actions at Paducah and Portsmouth (69 FR 34161, June 18, 2004). The 2004 EISs were prepared as a second level of the tiered[5] environmental review process being used to evaluate and implement DOE's DUF_6 long-term management program. The 2004 EISs include evaluations of the environmental impacts of transportation and disposal of DU oxide, empty and heel DUF_6 storage cylinders, calcium fluoride (CaF_2)—a conversion co-product—and ancillary LLW and mixed low-level radioactive waste (MLLW), at two potential off-site locations: the DOE LLW disposal facility at the Nevada National Security Site (NNSS) (formerly called the Nevada Test Site) and Energy*Solutions* LLC (formerly known as Envirocare of Utah, Inc.), a commercial LLW disposal facility near Clive, Utah.

RODs were published for the 2004 EISs on July 27, 2004 (69 FR 44654 and 69 FR 44649). In the RODs, DOE decided to build facilities at both Paducah and Portsmouth and convert DOE's inventory of DUF_6 to DU oxide. DOE decided the aqueous hydrogen fluoride (HF) produced during conversion would be sold for use pending approval of authorized release limits. The CaF_2 produced during conversion operations would be reused, pending approval of authorized release limits, or disposed of as appropriate. DOE also decided that the DU oxide conversion product would be reused to the extent possible or packaged in empty and heel cylinders for disposal at an appropriate disposal facility. Emptied cylinders would also be disposed of at an appropriate facility. In the ROD for the Portsmouth DUF_6 conversion facility (69 FR 44654), DOE also decided that all DUF_6 cylinders, once stored at DOE's ETTP, would be shipped to Portsmouth for conversion.

DOE had intended to identify disposal locations in the RODs for the 2004 EISs for any DU oxide declared waste. Prior to issuing the RODs, DOE discovered it had inadvertently not formally provided copies of the Draft and Final EISs to the states of Nevada and Utah, and concluded it was bound by the CEQ NEPA regulations described in 40 CFR 1502.19 to forego decisions on disposal location(s) until it had properly notified these states. Accordingly, in the RODs for the 2004 EISs, DOE did not include decisions with respect to specific disposal location(s) for DU oxide declared waste, but instead informed the public it would make the decisions later and additional supplemental NEPA analysis would be provided for review and comment.

1.2 CHANGES SINCE THE PADUCAH AND PORTSMOUTH EIS'S WERE PREPARED IN 2004

In 2007, DOE prepared a *Draft Supplement Analysis for Location(s) to Dispose of Depleted Uranium Oxide Conversion Product Generated from DOE's Inventory of Depleted Uranium Hexafluoride* (Draft SA) (DOE 2007), in accordance with DOE NEPA implementing procedures procedures at 10 CFR 1021.314. This Draft SA was prepared in order to determine whether a Supplemental EIS was required prior to making a decision about DU oxide disposal locations as committed to in the 2004 RODs (DOE 2007). DOE prepared the Draft SA and made it publicly

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[5] According to 40 CFR Part 1500, tiering of EISs refers to a process of addressing a broad, general program, policy, or proposal in an initial EIS, and analyzing a narrower, site-specific proposal related to the initial program, plan, or policy in a subsequent EIS; in this case, an SEIS.

available on April 3, 2007 (72 FR 15869). Comments received on the Draft SA suggested that DOE should consider the Waste Control Specialists LLC (WCS) LLW disposal facility near Andrews, Texas, as a reasonable alternative for DU oxide disposal. DOE determined that more time was needed to allow for resolution of regulatory questions at the disposal sites and did not issue a Final SA. In May 2013, WCS was granted a license amendment that authorized disposal of bulk LLW, and in August 2014, WCS was granted a license amendment that authorized disposal of DU in its original metal container. As a result, DOE now assumes, for analysis purposes, that WCS may be a viable disposal site for DU oxide and other wastes.

Both of the Paducah and Portsmouth conversion facilities were operational in 2011. As of February 2018, 2,908 cylinders of DU oxide had been generated at Paducah, and 1,898 cylinders had been generated at Portsmouth (PPPO 2018). These cylinders are being stacked two layers high at the existing outdoor storage yards at Paducah and Portsmouth until a reuse or disposition disposition decision is made.

After considering the existing DOE NEPA analyses and changes in the disposition activities currently being considered, DOE determined in March 2016 that an SEIS is warranted due to potentially significant new circumstances or information relevant to environmental concerns (in this case, availability of a new alternative disposal site) since the 2004 Notice of Intent. Accordingly, on August 26, 2016, DOE announced its intent to prepare this *DU Oxide SEIS* (81 FR 58921). This *DU Oxide SEIS* represents the third phase of the environmental review process being used to evaluate and implement the DUF_6 long-term management program. This *DU Oxide SEIS* evaluates only the management of DU oxide, empty and heel cylinders, CaF_2, and ancillary LLW and MLLW. Decisions on the storage of DUF_6, conversion of DUF_6 to DU oxide, and management of HF were already made in the RODs for the 2004 EISs and are not reevaluated in this *DU Oxide SEIS*.

On November 19, 2019, DOE published the *Supplement Analysis (SA) for Bulk Hydrogen Storage Construction and Operation at the Paducah and Portsmouth DUF_6 Sites* (DOE/EIS-0359-SA-02 and EIS-0360-SA-02) (DOE 2019). The action analyzed in that SA, installation and operation of a bulk hydrogen storage backup supply to the plant hydrogen supply system at each conversion facility such that uninterrupted hydrogen supply is maintained for plant operations, would not affect the quantity of DU oxide conversion product or other materials that would be dispositioned in the action analyzed in this *DU Oxide SEIS* or any of the other impacts analyzed.

On January 23, 2020, DOE/National Nuclear Security Administration (NNSA) amended DOE's previous decision (69 FR 44649) and will install the fourth DUF_6 conversion line, analyzed in the 2004 Portsmouth EIS (DOE 2004b), and will slightly alter the process when reacting the DUF_6 to produce depleted uranium tetrafluoride (DUF_4) (85 FR 3903). Products of the conversion process and disposition of those products would remain substantially unchanged. The resulting DUF_4 will be provided to a commercial vendor for additional processing. This decision does not affect the quantity of DUF_6 to be converted, and a negligible amount, of approximately 2 percent, of the DU oxide product would be replaced with DUF_4. Because the amount of DUF_6 to be converted would remain the same and the amount converted to DUF_4 would be small, this action would have a negligible effect on the impacts of conversion as analyzed in the 2004 Portsmouth EIS, and would not represent a substantial change relevant to environmental concerns. Because less DU oxide would be produced and need to be transported and disposed, the impacts analyzed in this *DU Oxide SEIS* would remain bounding for DU oxide transportation and disposal.

1.3 PURPOSE AND NEED FOR AGENCY ACTION

If a beneficial use cannot be found for the DU, all or a portion of the inventory may be characterized as waste and may need to be disposed of. The purpose and need for this action to dispose of DU oxide resulting from converting DOE's DUF_6 inventory to a more stable chemical form and to dispose of other LLW and MLLW (i.e., empty and heel cylinders, CaF_2, and ancillary LLW and MLLW) generated during the conversion process. This need follows directly from the decisions presented in the RODs for the 2004 EISs that deferred DOE's decision related to the transportation and disposal of DU oxide at potential off-site disposal facilities.

1.4 PROPOSED ACTION

DOE's Proposed Action is to transport and dispose DU oxide and other LLW and MLLW generated during the conversion process at Paducah and Portsmouth, to a LLW disposal facility. To implement the Proposed Action, DOE identified three Action Alternatives. Under the Action Alternatives, DU oxide that cannot be reused would be transported to and disposed of at one or more of three disposal facilities: (1) the DOE LLW disposal facility at NNSS; (2) the Energy*Solutions* LLW disposal facility near Clive, Utah; and (3) the WCS LLW disposal facility near Andrews, Texas.

In addition, the scope of this *DU Oxide SEIS* includes a No Action Alternative in accordance with 40 CFR 1502.14. Under the No Action Alternative, the DU oxide cylinders would remain in storage at Paducah and Portsmouth and would not be transported to a disposal facility.

As decided in the RODs for the 2004 EISs (69 FR 44654; 69 FR at 44649), excess empty and heel cylinders, CaF_2, and ancillary LLW and MLLW would be transported off site and disposed of under all the evaluated alternatives. All other aspects of the DUF_6 conversion activities, except as discussed in the paragraph below, would remain as described previously in the 2004 EISs and RODs and are not within the scope of this *DU Oxide SEIS*. **Figure 1-2** shows the locations of facilities discussed in this *DU Oxide SEIS*.

Under the USEC Privatization Act (Title 42 of the *United States Code* Section [42 U.S.C. §] 2297h-11), DOE is required to accept LLW and mixed-LLW (MLLW) from a uranium enrichment facility licensed by the U.S. Nuclear Regulatory Commission (NRC). If requested by the generator, DOE must accept the DU once it is determined to be LLW. Under the USEC Privatization Act, the licensee must reimburse DOE for its costs to disposition the LLW and MLLW (including DU). At the present time, there are no plans or proposals for DOE to convert additional DUF_6 and dispose of additional DU oxide cylinders, beyond the current inventory for which it has responsibility. In anticipation of the potential future receipt of commercial DUF_6, DOE has estimated the impacts from management of 150,000 metric tons (165,000 tons; approximately 12,500 cylinders) of commercial DUF_6 as a reasonably foreseeable future event for cumulative impacts that would take place after the management of DOE DU oxide. The detailed

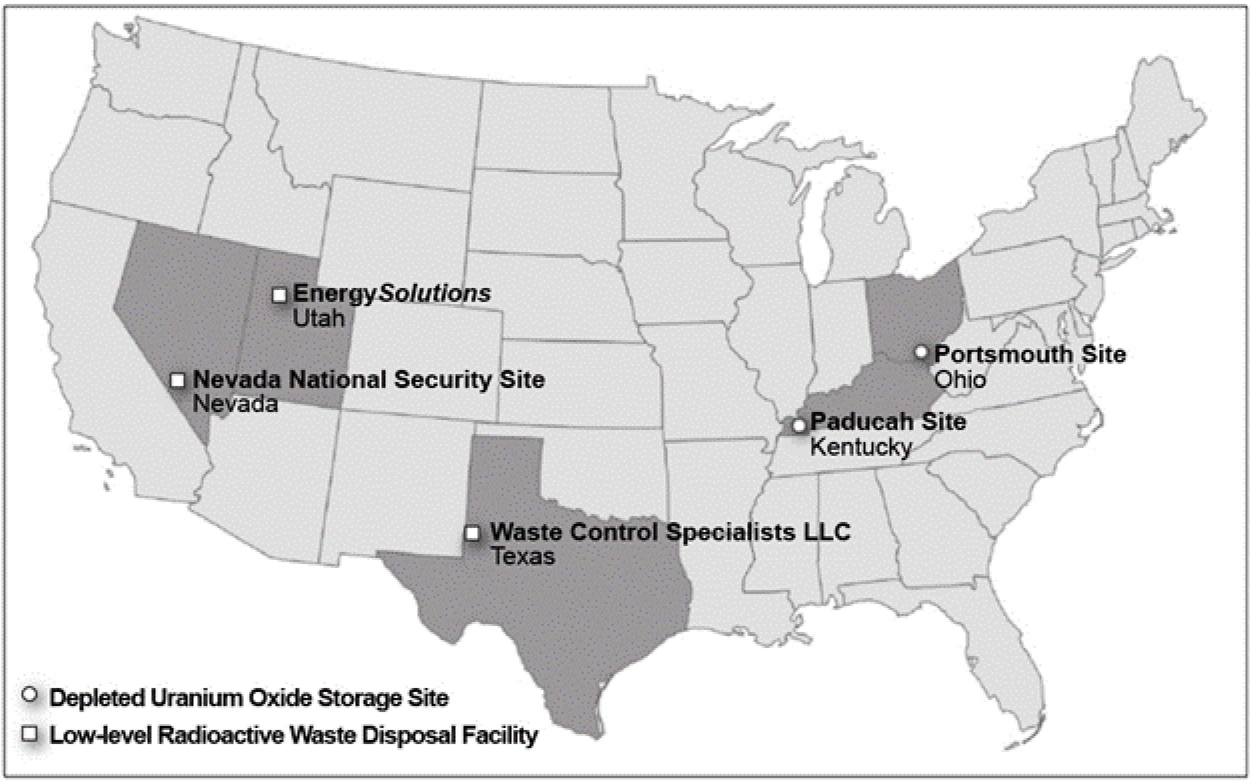

Figure 1-2 Locations of Facilities Discussed in this *DU Oxide SEIS*

analysis of the impacts of receipt, conversion, storage, handling, and disposal of commercial DUF_6 is presented in Appendix C of this *DU Oxide SEIS*. Where appropriate, the impacts of the management of commercial DUF_6 at Paducah or Portsmouth, and the transportation and disposal of the resulting DU oxide, are included in the cumulative impacts analysis of this SEIS (Chapter 4, Section 4.5).

1.5 PUBLIC INVOLVEMENT

In accordance with 10 CFR 1021.311(f), a public scoping process is not required for DOE SEISs. Public scoping was conducted on the 2004 EISs, and DOE determined that a separate public scoping period was not needed for this *DU Oxide SEIS*.

On December 28, 2018, the U.S. Environmental Protection Agency (EPA) and DOE published notices in the *Federal Register* announcing the availability of the *Draft DU Oxide SEIS* (83 FR 67282 and 83 FR 67250). A 45-day comment period, ending February 11, 2019, was announced to provide time for interested parties to review and comment on the *Draft DU Oxide SEIS.* In response to public requests, DOE extended the public comment period by 21 days, through March 4, 2019 (84 FR 1716, February 5, 2019). During the public comment period, DOE held three web-based public hearings to provide interested members of the public with opportunities to hear DOE representatives present the results of the *Draft DU Oxide SEIS* analyses and to provide oral comments. The public hearings were held on the following dates: January 22, 2019, from 2 to 4 pm, January 23, 2019, from 4 to 6 pm, and January 24, 2019, from 7 to 9 pm. All times are Eastern time.

In addition, Federal agencies, state and local governmental entities, American Indian tribal governments, and members of the public were encouraged to submit comments via email and the U.S. mail. All comments received by DOE were considered in preparing this *Final DU Oxide SEIS*. DOE did not receive any comments after the close of the comment period.

DOE received 24 comment documents containing 115 comments during the public comment period. Topics of interest from the comments received during the public comment period on the *Draft DU Oxide SEIS* are presented in Appendix E, of this *DU Oxide SEIS*. Scanned copies of the public comment documents and DOE's responses to individual comments are also provided in Appendix E.

1.6 SCOPE OF THIS SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

The scope of an SEIS refers to the range of actions, alternatives, and impacts it considers. In this *DU Oxide SEIS*, DOE examines potential public health and safety effects and environmental impacts from the Proposed Action within the following general topics: site infrastructure; climate change, air quality, and noise; geology and soils; water resources (surface water and groundwater); biotic resources; public and occupational health and safety (during normal operations, accidents, and transportation); socioeconomics; waste management; land use and aesthetics; cultural resources; environmental justice; and cumulative impacts. In accordance with 40 CFR 1502.2(b), this *DU Oxide SEIS* analyzes in more detail resource areas more likely to exhibit effects from storage, transportation, and disposal of DU oxide; namely, public and occupational health and safety, transportation, and disposal of DU oxide (waste management). The other topics are analyzed in less detail.

1.6.1 Human Health and Safety

This *DU Oxide SEIS* evaluates radiological and chemical impacts on workers and the public from normal operations and postulated DU oxide storage and handling accidents, as well as intentional destructive acts. The potential for industrial accidents that could impact worker safety are also evaluated.

1.6.2 Transportation

Because the Proposed Action involves the transport of DU oxide and other LLW to disposal facilities across the United States, transportation impacts are an important factor in evaluating impacts and comparing the potential disposal site alternatives. Transportation by truck and train are evaluated under incident-free and accident conditions. Accidents involving LLW have the potential for both radiological and nonradiological risks to transportation workers and the public. Radiation exposure impacts are evaluated for incident-free transportation and for transportation accidents where the release of radioactive materials is conservatively assumed to occur.

1.6.3 Disposal of Depleted Uranium Oxide and Other Wastes

This *DU Oxide SEIS* does not evaluate the impacts of handling and disposing of LLW at authorized DOE and commercial disposal facilities. The impacts of handling and disposal have already been evaluated in environmental and permitting documentation for the respective LLW disposal facilities. This *DU Oxide SEIS* compares the characteristics of the to-be-disposed of LLW to the waste acceptance criteria and capacity of each of the potential disposal facilities. If the LLW is within the waste acceptance criteria and capacity of the disposal facility, the impacts are assumed to be within the bounds of the existing documentation for the facility.

1.7 CHANGES FROM THE DRAFT *DU OXIDE SEIS*

In preparing this *Final DU Oxide SEIS*, DOE made revisions to the *Draft DU Oxide SEIS* in response to comments received from other Federal agencies, state and local government entities, American Indian tribes, and the public. This *Final DU Oxide SEIS* provides more environmental baseline information, updates impacts analyses, corrects inaccuracies, makes editorial corrections, and clarifies text. In addition, DOE updated information due to events or notifications made in other documents since the *Draft DU Oxide SEIS* was provided for public comment in December of 2018. The following summarizes the more important changes made to prepare this *Final DU Oxide SEIS*.

Public Comment Period and Comments Received on the *Draft DU Oxide SEIS*

DOE added new text to Section 1.5 to describe the public comment period on the *Draft DU Oxide SEIS*. A Comment-Response Document was added to this *Final DU Oxide SEIS* as Appendix E. The Comment-Response Document presents the comment documents (i.e., emails, letters, and public hearing transcripts) and DOE's responses to the individual comments.

Alternatives Considered but Dismissed from Detailed Study

DOE revised Chapter 2, Section 2.3, to discuss alternatives that were considered but eliminated from detailed study in previous NEPA documents, consistent with 40 CFR 1502.14(a).

Preferred Alternative

In the *Draft DU Oxide SEIS*, DOE had no Preferred Alternative for the disposition of the DU oxide that is the subject of this *DU Oxide SEIS*. Consistent with 40 CFR 1502.14(e), in this *Final DU Oxide SEIS*, DOE's Preferred Alternative is described in Section 2.5. Consistent with the requirements of NEPA, DOE would publish a ROD no sooner than 30 days after publication of this *Final DU Oxide SEIS*.

Transportation Analysis

Some modification to the transportation analyses were made. The *Final DU Oxide SEIS* was revised to include a refined analysis of shipment of DU oxide in bulk bags and resulting empty and heel cylinders to WCS. As described in more detail in Appendix B, Section B.8, the analysis is based on a combination of new information and analyses from this *DU Oxide SEIS* and previous analyses from the 2004 EISs.

The *Final DU Oxide SEIS* was also revised to include adjustments to the train transportation analyses for shipment of DU oxide in bulk bags, volume-reduced empty and heel cylinders, and CaF_2 in bulk bags, to assume 10 railcars in each train shipment rather than 1 railcar per train shipment as analyzed in the *Draft DU Oxide SEIS*. This approach is consistent with the assumptions used in the *Draft DU Oxide SEIS* for shipment of DU oxide in cylinders and for intact empty and heel cylinders.

In addition, the *Final DU Oxide SEIS* was revised to include an analysis of the option of shipping DU oxide cylinders in Articulated Bulk Container (ABC) railcars in addition to the gondola railcars analyzed in the *Draft DU Oxide SEIS*.

Environmental Documentation Review

Since the completion of the *Draft DU Oxide SEIS*, additional environmental documentation has become available. The new environmental documentation includes:

- *Paducah Site Annual Site Environmental Report for Calendar Year 2017* (FRNP 2018a)
- *U.S. Department of Energy, Portsmouth Gaseous Diffusion Plant Annual Site Environmental Report – 2016* (DOE 2018a).
- *DOE 2017 Occupational Radiation Exposure* (DOE 2018b).

As such, there was a possibility that some environmental data upon which the impact analyses in the *Draft DU Oxide SEIS* relied may have changed, potentially affecting the analyses and comparison of alternatives. DOE has reviewed the new data, compared the data with those presented in the *Draft DU Oxide SEIS*, and determined that the updated environmental information would result in minor changes to the discussion of the affected environment. The more recent information contained in the reports varies only slightly from the data used in the alternatives analyses and would not affect the relative impacts of the alternatives analyzed in the *Draft DU Oxide SEIS*. Therefore, updates for the affected environment and environmental impacts chapters in this *Final DU Oxide SEIS* using these new documents, were not required.

1.8 RELATIONSHIP TO OTHER NEPA REVIEWS

As described in Sections 1.1 and 1.2, this *DU Oxide SEIS* tiers from the 2004 EISs (DOE 2004a, 2004b), which tier from the DUF_6 PEIS (DOE 1999).

DOE published the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (WM PEIS) (DOE 1997) as a DOE complexwide study of the environmental impacts of managing five types of waste generated by past, present, and future nuclear defense and research activities. The WM PEIS considered alternatives for high-level, transuranic (TRU), LLW, and MLLW, as well as toxic and hazardous wastes. The WM PEIS provided information on the impacts of various siting configurations that DOE used to decide at which sites to locate additional treatment, storage, and disposal capacity for each waste type. DOE published RODs for all the waste types, but only the applicable waste type (LLW) is discussed here. In the ROD for LLW (65 FR 10061, February 25, 2000), DOE decided to perform minimal treatment of LLW at all sites and continue, to the extent practicable, on-site disposal of LLW at a number of sites, including NNSS. DOE's decision regarding LLW does not preclude the use of commercial disposal sites. The WM PEIS did not specifically evaluate management of DU oxide because the decision to produce and dispose of DU oxide had not been made when the WM PEIS was prepared in 1997. Disposal of DU oxide would need to be in accordance with decisions made in the WM PEIS.

Disposal of LLW at NNSS is analyzed in the *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada* (NNSS SWEIS) (DOE 2013a). The NNSS SWEIS analyzed the disposal of 19.1 million cubic feet (0.54 million cubic meters) of LLW from Paducah and Portsmouth, including waste related to DUF_6 conversion (DOE 2013a). If DOE determines that additional site-specific NEPA documentation is needed for the NNSS waste disposition option, DOE would prepare the documentation at that time.

1.9 ORGANIZATION OF THIS SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

This *DU Oxide SEIS* consists of Chapters 1 through 9 and Appendices A through D. Chapter 1 provides background information; describes the purpose and need; summarizes the Proposed Action; describes the scope of this *DU Oxide SEIS*; provides a description of related NEPA documents; and describes the organization of this SEIS. Chapter 2 describes the characteristics of DU oxide; describes alternatives for transportation and disposal of the DU oxide; and describes alternatives that were considered but not analyzed in detail. Chapter 2 also includes a comparison of potential impacts under each of the alternatives. Chapter 3 includes brief descriptions of the environments at Paducah, Portsmouth, and the three disposal sites in terms of resource areas or disciplines that establish the baselines for the impact analyses. Chapter 4 describes the potential impacts of the alternatives on the resource areas or disciplines discussed in Chapter 3. Chapter 4 also includes discussions of cumulative impacts; mitigation; unavoidable adverse impacts; irreversible and irretrievable commitments of resources; the relationship between short-term uses of the environment and long-term productivity; and pollution prevention and waste minimization. Chapter 5 describes the environmental, safety, and health permits and compliance requirements. Chapters 6, 7, 8, and 9 list the references cited, the SEIS preparers, a topical glossary, and index, respectively. Appendices A through D contain the list of related *Federal Register* notices; the transportation analysis; the commercial DUF_6 impacts analysis; and the contractor disclosure statements, respectively. Appendix E contains the comments received during the public comment period on the *Draft DU Oxide SEIS* and DOE’s responses.

2 DESCRIPTION AND COMPARISON OF ALTERNATIVES

DOE has prepared this *DU Oxide SEIS* to evaluate alternatives for transportation and disposal of DU oxide[6] from Paducah and Portsmouth in Paducah, Kentucky, and Piketon, Ohio, respectively. The locations of Paducah and Portsmouth are shown in **Figure 2-1** and **Figure 2-2**, respectively.

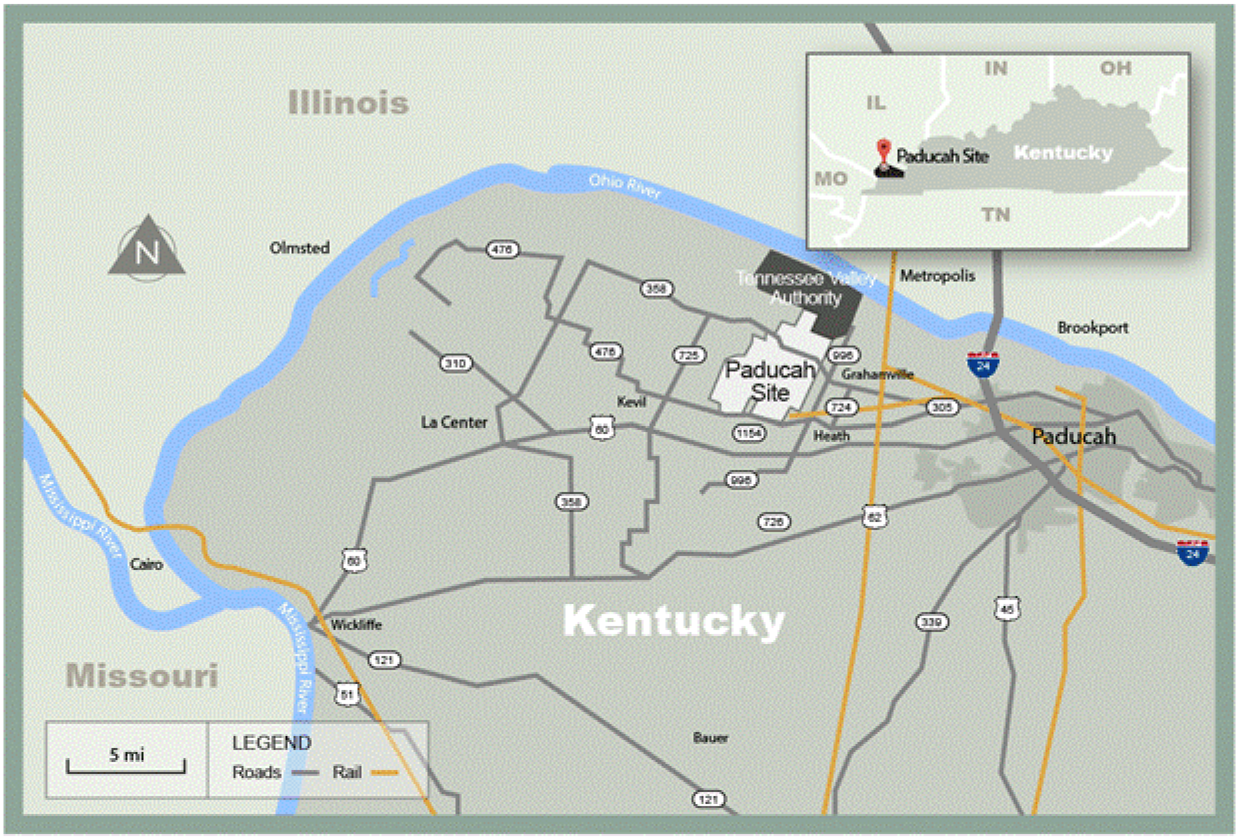

Figure 2-1 Location of the Paducah Site (Source: Modified from PPPO 2018)

2.1 DESCRIPTION OF RELATED ACTIVITIES AT PADUCAH AND PORTSMOUTH

Facilities for the conversion of depleted uranium hexafluoride (DUF_6) to DU oxide at Paducah and Portsmouth became fully operational in 2011. The DU oxide produced is a powder mixture of DU oxides, primarily triuranium octaoxide (U_3O_8). The U_3O_8 form is the most stable form, which is also the form most commonly found in nature. Uranium oxide has low solubility in water, has an average density of approximately 2.7 grams per cubic centimeter, and is relatively stable over a wide range of environmental conditions (PPPO 2018).

DU is defined as being less than 0.707 weight-percent uranium-235. Most of DOE's DU inventory contains from 0.2 to 0.4 weight-percent uranium-235 (ANL 2016a). The DU oxide at Paducah and Portsmouth is approximately 99.7 percent uranium-238, 0.25 percent uranium-235, and 0.001

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[6] This DU Oxide SEIS also evaluates the environmental impacts of transportation and disposal of related waste streams including empty and heel cylinders, CaF_2, and ancillary LLW and MLLW.

percent uranium-234. Appendix B, Table B-3, of this *DU Oxide SEIS* shows the assumed isotopic content of the DU oxide including minor impurities.

Figure 2-2 Location of the Portsmouth Site (Source: Modified from PPPO 2018)

2.1.1 DUF$_6$ Processing and Cylinder Movement

DUF$_6$ is stored in quarter-inch (approximately two-thirds-centimeter)-thick steel cylinders that are 19, 30, and 48 inches (48, 76, and 122 centimeters) in diameter with the majority being 48-inch-diameter cylinders. The 48-inch-diameter cylinders are either 116 inches (248 centimeters) or 147 inches (360 centimeters) long, depending on the cylinder model. The 48-inch-diameter cylinders hold from 9 to 12 metric tons (10 to 13 tons) of material.

During the DUF$_6$ conversion process described in detail in the 2004 EISs, DUF$_6$ is vaporized and converted to a mixture of uranium oxides (primarily U_3O_8) by reaction with steam and hydrogen. The DU oxide design output is approximately 14,300 metric tons (15,763 tons) per year from the Paducah conversion facility and 10,800 metric tons (11,905 tons) per year from the Portsmouth conversion facility (DOE 2004a, 2004b). The DU oxide is roll compacted to reduce the amount of fine powder and make the material easier to pour (PPPO 2018). The DU oxide conversion product is routinely sampled and analyzed to determine radiological, chemical, and physical characteristics. Analytical results provide feedback on conversion effectiveness and consistency and are the basis for determining if the DU oxide would meet the waste acceptance criteria of a disposal site (PPPO 2019). Currently, the DU oxide is collected and packaged for on-site storage in cylinders, emptied of their DUF$_6$, and processed for this purpose (PPPO 2018). In the future, DU oxide may be packaged in bulk bags and sent directly to a disposal facility. **Figure 2-3** shows a typical bulk bag.

Figure 2-3 Typical Bulk Bag

Approximately 11,000 metric tons (12,000 tons) and 8,300 metric tons (9,000 tons) per year of HF, a co-product of the conversion reaction, are captured and recycled for commercial use at Paducah and Portsmouth, respectively (PPPO 2018). Approximately 24 metric tons (26.4 tons) and 18 metric tons (19.8 tons) per year of CaF_2 are estimated to be generated at Paducah and Portsmouth, respectively, during the conversion process. Per the 2004 EISs, the CaF_2 may contain very low levels of radionuclide contamination; therefore, this *DU Oxide SEIS* conservatively assumes that the CaF_2 would be disposed of as LLW. Additional CaF_2 (11,800 metric tons [13,000 tons] per year at Paducah and 8,800 metric tons [9,700 tons] per year at Portsmouth) would be generated if HF is not sold and instead converted to CaF_2 for disposal as waste (DOE 2004a, 2004b).

Emptied DUF_6 cylinders are processed to be used for DU oxide packaging for storage, and potentially transportation and disposal. Typically, cylinders emptied of DUF_6 by heating and vaporization at the conversion facility are placed into temporary storage while residual, short-lived radioactivity is allowed to decay. Stabilizing agents are then introduced into the cylinders to neutralize any residual fluoride in the remaining material. After neutralization is complete, a hole is cut on each cylinder head and a flange is welded to the cylinder to facilitate loading with DU oxide. Once filled with DU oxide, a gasket and a cover plate are affixed to the flange (DOE 2004a; PPPO 2018). Filled DU oxide cylinders are moved to the cylinder storage yards for storage pending reuse or disposition.[7]

As described in Chapter 1, Section 1.2, this *DU Oxide SEIS* evaluates only the management of DU oxide, empty and heel cylinders, CaF_2, and ancillary LLW and MLLW. Decisions on the storage of DUF_6, conversion of DUF_6 to DU oxide, and management of HF were already made in the RODs for the 2004 EISs (69 FR 44654; 69 FR at 44649) and are not reevaluated in this *DU Oxide SEIS*. **Figure 2-4** shows the activities analyzed in this SEIS.

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[7] As discussed in Chapter 1, DOE considers DU oxide a resource that may be sold or transferred for beneficial uses. It would only become a waste when a decision is made to dispose of a quantity of the material.

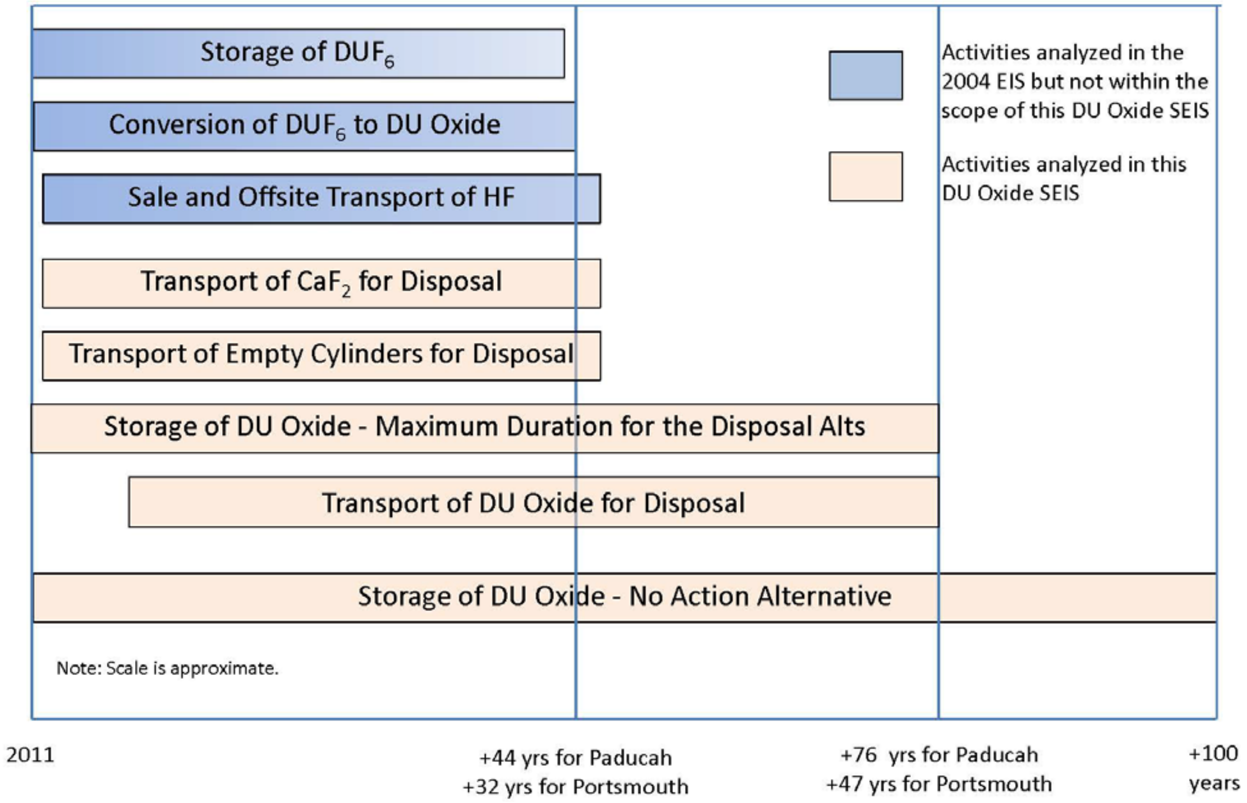

Figure 2-4 Anticipated Activities at the Paducah and Portsmouth Sites Analyzed in this *DU Oxide SEIS*[8]

2.1.2 Quantities of Depleted Uranium Oxide to be Managed

Prior to the start of conversion operations, there were approximately 560,000 metric tons (617,288 tons) of DUF_6 stored in 46,000 cylinders at Paducah and approximately 250,000 metric tons (275,575 tons) of DUF_6 stored in 21,000 cylinders at Portsmouth (approximately 4,800 of these cylinders were transferred from ETTP). By February 2018, the inventory had been reduced to approximately 523,524 metric tons (577,086 tons) of DUF_6 in 42,961 cylinders at Paducah and approximately 227,439 metric tons (250,709 tons) of DUF_6 in 19,009 cylinders at Portsmouth as the DUF_6 was converted to DU oxide. As the DUF_6 inventory is reduced, the DU oxide inventory at each site will increase. As of February 2018, there were approximately 30,145 metric tons (33,229 tons) of DU oxide stored in 2,908 cylinders at Paducah and approximately 18,570 metric tons (20,469 tons) of DU oxide stored in 1,898 cylinders at Portsmouth (PPPO 2018). By the end of the project, conversion of the entire DUF_6 inventory could result in the generation of a total of approximately 46,150 cylinders (446,515 metric tons [492,193 tons]) of DU oxide at Paducah and approximately 22,850 cylinders (199,337 metric tons [219,729 tons]) of DU oxide at Portsmouth (PPPO 2018).

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[8] The 2004 EISs analyzed disposal of DU oxide, empty and heel cylinders, CaF_2, and ancillary LLW and MLLW at NNSS and Energy*Solutions*. This *DU Oxide SEIS* analyzes revised quantities of these materials for disposal and includes disposal at an additional facility (i.e., WCS).

There are also 205, 55-gallon (208-liter) steel drums of DU oxide stored at Portsmouth (PPPO 2018). These drums were generated during the first five years of conversion facility start-up operations and outages. As many as five drums could be generated at each conversion facility annually during recovery from future off-normal events (PPPO 2018). Therefore, a total of 220 and 365 drums of DU oxide could be generated at Paducah and Portsmouth, respectively.[9]

2.1.3 Container Storage

Cylinders are typically stacked two high in cylinder storage yards such as the one shown in **Figure 2-5**. The storage yards are large outdoor areas that typically have a gravel or concrete base. DU oxide cylinders are stored on concrete pads; only empty and heel cylinders are stored on gravel storage areas. The bottom cylinders are placed on concrete saddles to keep them off the ground (ANL 2016b).

Figure 2-5 DUF_6 Cylinder Storage Yard (Source: BWXT 2016b)

DU oxide stored in 55-gallon (208-liter) drums is protected from the elements by storing the drums in intermodal containers (BWXT 2016b). Typical intermodal containers would be 20, 30, and 40 feet (6, 9, and 12 meters) long. Portsmouth is currently using 20-foot containers, storing up to 32 drums per container. This configuration allows access for routine inspections and retrieval as needed. Therefore, approximately 7, 20-foot storage containers would be needed at Paducah and 12 at Portsmouth for the estimated drum inventory to be generated at each site. The drum storage containers are located in the cylinder storage yards (PPPO 2019).

Figure 2-6 shows the location of the storage yards at Paducah. There are multiple storage yards at Paducah, for a total of approximately 3.6 million square feet (334,451 square meters), or 83 acres (34 hectares), of storage space. This is enough space to store nearly 77,000 cylinders. These yards vary in size from 17,000 to 470,400 square feet (1,579 to 43,702 square meters). Seven of the yards are composed of compacted dense-grade aggregate, two are partially dense-grade aggregate and partially concrete, and ten are concrete. All the cylinder storage yards are located inside security fences. As shown in Figure 2-5, two of the cylinder storage yards are located in

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[9] In order to be conservative, the total DU oxide quantity analyzed in this DU Oxide SEIS for disposal in cylinders or bulk bags includes the quantities that may be generated and disposed of in the 55-gallon steel drums.

the northwest portion of Paducah, two are located in the northeast portion of the site, and the remaining 15-cylinder storage yards are clustered in the southern portion of the site (PPPO 2018).

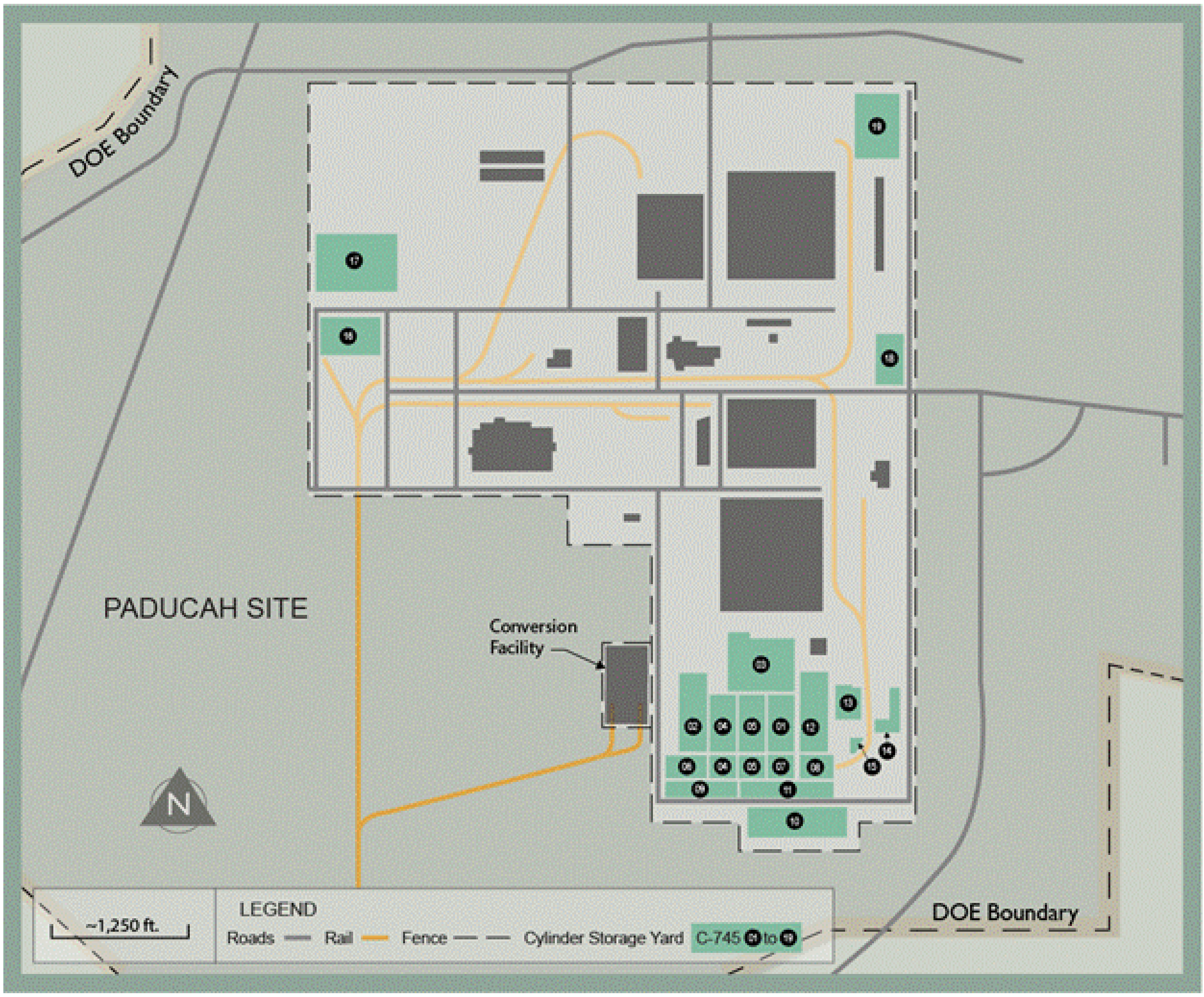

Figure 2-6 Location of Storage Yards at Paducah
(Sources: modified from DOE 2004a; PPPO 2018)

Figure 2-7 shows the location of the cylinder storage yards at Portsmouth. The storage yards at Portsmouth provide a total of approximately 1 million square feet (92,903 square meters) or 23 acres (9.3 hectares) of storage space (PPPO 2018). The storage yards have a concrete base and all are located inside security fences. As shown in Figure 2-6, seven of the cylinder storage yards are located inside Perimeter Road in the northern portion of the site and one of the cylinder storage yards is located north of the Perimeter Road (PPPO 2018).

The Paducah and Portsmouth storage yards are monitored, and the DU oxide cylinders are inspected and maintained in accordance with the Cylinder Surveillance and Maintenance Plan (MCS 2017). This plan describes the methods, organizational structure, and documents involved in cylinder surveillance and maintenance, including the basis for corrosion control and maintenance decisionmaking. In addition, the plan describes the methods associated with the inspection and storage of DU oxide containers. Inspectors performing routine inspections access information in the Cylinder Inventory Database about each cylinder and can enter surveillance data for review and uploading to the database as a permanent record (MCS 2017).

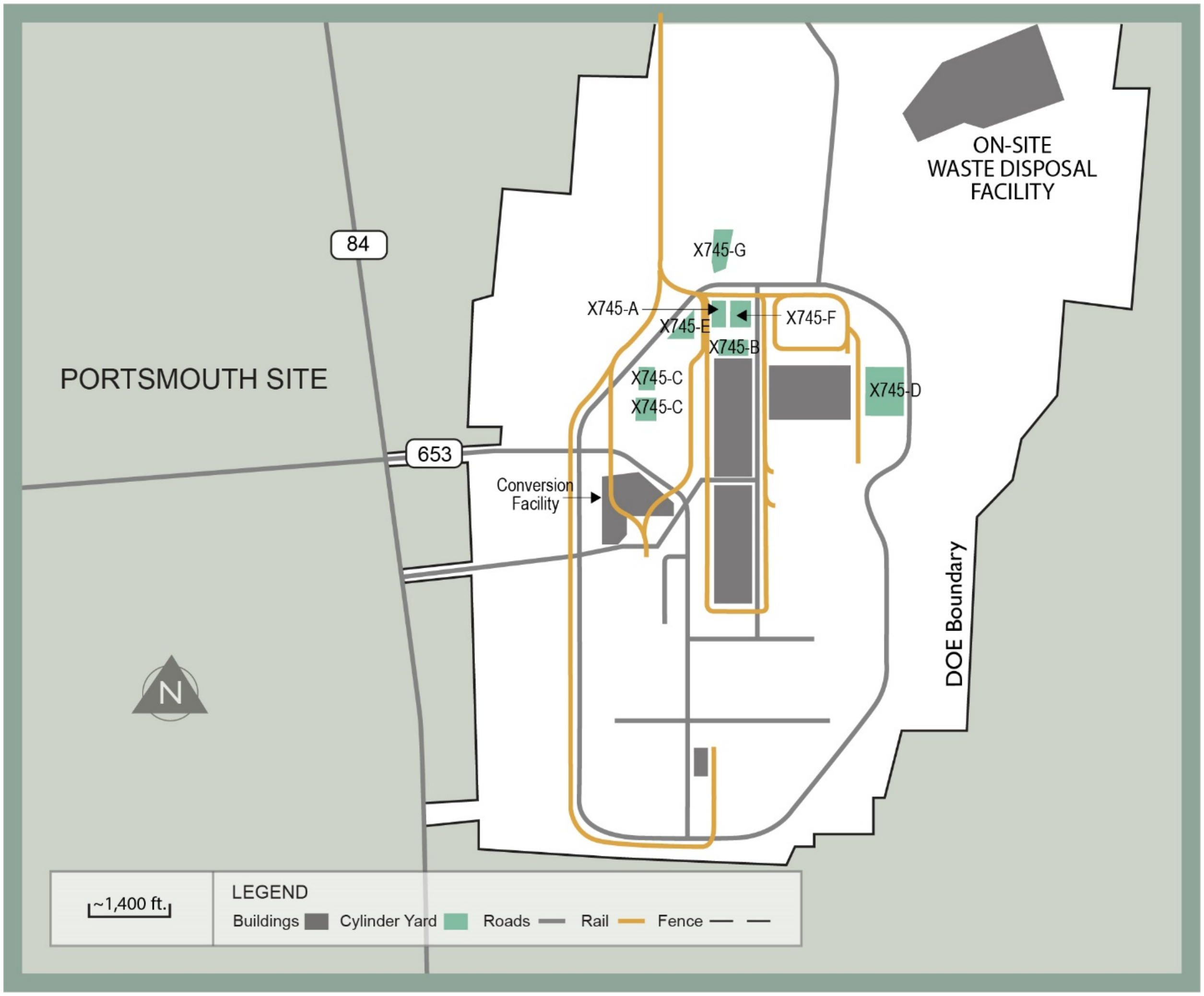

Figure 2-7 Location of Storage Yards at Portsmouth
(Sources: modified from DOE 2004b; PPPO 2018)

2.2 ALTERNATIVES

This section describes the three Action Alternatives being evaluated for disposal of the DU oxide produced by the conversion process described in Section 2.1.1 and the No Action Alternative, which is required under NEPA. The No Action Alternative is described in Section 2.2.1. The on-site activities common to the three Action Alternatives are described in Section 2.2.2. Sections 2.2.2.1, 2.2.2.2, and 2.2.2.3 provide brief descriptions of the proposed disposal sites and identify the modes of transport for shipments to those sites.

2.2.1 No Action Alternative

Under the No Action Alternative, DU oxide containers would not be transported for disposal. Instead, DU oxide containers would be stored indefinitely at the sites (i.e., Paducah and Portsmouth) where they would be produced. Therefore, the No Action Alternative does not meet the purpose and need for agency action as described in Chapter 1, Section 1.3, of this *DU Oxide SEIS*, and would only defer a final decision on the ultimate disposition of the DU oxide. In accordance with the RODs for the 2004 EISs (69 FR 44654; 69 FR 44649), the empty and heel cylinders, CaF_2, and ancillary LLW and MLLW would be shipped to off-site disposal facilities.

Although under the No Action Alternative, the DU oxide containers would remain in storage at Paducah and Portsmouth indefinitely; for analysis purposes in this *DU Oxide SEIS* and for comparison to the Action Alternatives, the potential impacts of storage are evaluated for 100 years beginning with storage of the first DU oxide cylinders in 2011 and ending in 2110.[10] During the conversion periods, the numbers of DUF_6 cylinders would decrease, while the numbers of DU oxide cylinders would increase until all DUF_6 is converted to DU oxide. Based on the rate of conversion of DUF_6 to DU oxide, DOE estimates that conversion activities will be completed and the last DU oxide cylinders produced between 2044 and 2054 at Paducah and between 2032 and 2042 at Portsmouth (PPPO 2018). Therefore, storage of DU oxide cylinders after the completion of conversion activities would be for 56 to 66 years at Paducah and for 68 to 78 years at Portsmouth. Consistent with the completion dates for conversion activities, disposal of empty and heel cylinders is conservatively analyzed to occur over 34 years at Paducah and over 22 years at Portsmouth.

There are also the 220 and 365, 55-gallon (208-liter) drums of DU oxide that could be generated at Paducah and Portsmouth, respectively (PPPO 2018). The drums of DU oxide would be stored on site in intermodal shipping containers in the cylinder storage yards.

Under the No Action Alternative, DOE would ensure the continued safe storage of the DU oxide containers for as long as they remain in storage by providing site security, and by monitoring and inspecting the storage yards and containers in accordance with the Cylinder Surveillance and Maintenance Plan (MCS 2017) described in Section 2.1.3. The surveillance and maintenance activities include routine surveillance and maintenance of the cylinder yards, container inspections, and repair or replacement of corroded or damaged storage cylinders.

For assessment purposes, the 2004 EISs (DOE 2004a, 2004b) evaluated two cylinder breach cases. In the first case, “controlled corrosion,” it was assumed that the planned cylinder maintenance program and improved storage conditions would maintain the cylinders in a protected condition and control further corrosion. In that case, it was assumed that some cylinder breaches would occur from handling damage; a total of 36 future breaches were estimated to occur through 2039

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[10] Storage under the No Action Alternative could extend beyond the 100 years analyzed in this DU Oxide SEIS. Storage for longer than 100 years would not change the maximum reasonably foreseeable annual impacts of operations, but would extend the impacts described in this DU Oxide SEIS further out in time. The contributions attributable to those facilities to total lifecycle impacts, such as those for total worker and population dose and latent cancer fatalities (LCFs), and total waste generation, would increase in proportion to the extended period. These impacts can be estimated from the analyses provided in this DU Oxide SEIS under the No Action Alternative by multiplying the additional years of operation by the annual impacts.

at Paducah and 23 at Portsmouth (16 breaches in the Portsmouth cylinders and 7 in the ETTP cylinders). In the second case, "uncontrolled corrosion," it was assumed that external corrosion would not be halted by the improved cylinder maintenance program. In that case, the number of future breaches estimated through 2039 was 444 for cylinders stored at Paducah and 287 for cylinders stored at Portsmouth (74 breaches in the Portsmouth cylinders and 213 in the ETTP cylinders). These breach estimates were determined based on historical corrosion rates when cylinders were stored under poor conditions (i.e., cylinders were stacked too close together, were stacked on wooden chocks, or came into contact with the ground). Because storage conditions have improved dramatically as a result of cylinder yard upgrades and the improved cylinder maintenance program, it is expected that the breach estimates based on historical corrosion rates provide a worst case for estimating the potential impacts from continued cylinder storage (DOE 2004a, 2004b). No new cylinder breaches have occurred at Paducah and Portsmouth since improved storage conditions have been implemented (PPPO 2018).

Table 2-1 summarizes information on cylinder breach scenarios from the 2004 EISs (DOE 2004a, 2004b) and provides the estimated breach rates derived from this data for cylinders from Paducah, Portsmouth, and ETTP.

Table 2-1 Estimate of Potential Cylinder Breach Rates

Site	Number of Cylinders	Storage Period (Years)	Number of Breaches		Breach Rate (per cylinder per year)	
			Controlled Corrosion	Uncontrolled Corrosion	Controlled Corrosion	Uncontrolled Corrosion
Paducah	36,191	40	36	444	2.49×10^{-5}	3.07×10^{-4}
Portsmouth	16,109	40	16	74	2.48×10^{-5}	1.15×10^{-4}
ETTP	4,822	40	7	213	3.63×10^{-5}	1.10×10^{-3}
Portsmouth and ETTP	20,931	NA-	23	287	NA	NA

ETTP = East Tennessee Technology Park; NA = not applicable.
Sources: DOE 2004a, 2004b

Impacts on human health and safety, surface water, groundwater, soil, air quality, and ecology from uranium releases from breached cylinders were assessed in the 2004 EISs (DOE 2004a, 2004b). For all hypothetical cylinder breaches, it was assumed that the breach would be undetected for four years, which is the period between planned inspections for most of the cylinders. In practice, cylinders that show evidence of damage or heavy external corrosion are inspected annually, so it is very unlikely that a breach would be undetected for a 4-year period (DOE 2004a, 2004b).

The estimated cylinder breach rates shown in Table 2-1 were used to calculate the number of cylinders that could be breached under the various corrosion scenarios and storage periods for the alternatives analyzed in this *DU Oxide SEIS*. The results of these estimates are presented in **Table 2-2** and are used in the impact analyses presented in Chapter 4 of this *DU Oxide SEIS*.

As decided in the RODs for the 2004 EISs (69 FR 44649, 69 FR 44654), under the No Action Alternative, DOE would ship the 14,000 intact empty and heel cylinders (8,843 from Paducah and 5,517 from Portsmouth) for off-site disposal as LLW. In addition, if DOE is unable to sell the HF, the HF could be converted to CaF_2 for disposal as LLW. Approximately 25,262 bulk bags of CaF_2 at Paducah and 13,559 bulk bags at Portsmouth were analyzed in the 2004 EISs (DOE 2004a, 2004b), while 32,417 bulk bags of CaF_2 at Paducah and 13,554 bulk bags of CaF_2 at Portsmouth would be expected under the quantities analyzed in this *DU Oxide SEIS*. In addition, ancillary LLW and MLLW would be shipped to the LLW disposal sites. Appendix B of this SEIS includes additional information on how wastes would be shipped for off-site disposal.

Table 2-2 Estimate of Potential Cylinder Breaches for this *DU Oxide SEIS* Alternatives

Site	Number of Cylinders[a]	Alternative	Storage Period (years)[b]	Number of Breaches[c]	
				Controlled Corrosion	Uncontrolled Corrosion
Paducah	46,150	No Action	100	115	1,415
		Disposal	76	87	1,076
Portsmouth	17,586	No Action	100	44	202
		Disposal	47	21	95
ETTP	5,264	No Action	100	19	581
		Disposal	47	9	273
Portsmouth and ETTP	22,850	No Action	100	63	783
		Disposal	47	30	368

Key: DU = depleted uranium; ETTP = East Tennessee Technology Park; SEIS = supplemental environmental impact statement.

[a] Source: PPPO 2018

[b] In order to produce a conservative estimate of the number of cylinder breaches, the maximum storage period was analyzed for the disposal alternatives (i.e., 76 years at Paducah and 47 years at Portsmouth). The maximum storage period for Paducah includes the storage of DU oxide containers for the 44 years of conversion facility operation plus 32 years to ship all the containers to the disposal facility. The maximum storage period for Portsmouth includes the storage of DU oxide containers for the 32 years of conversion facility operation plus 15 years to ship all the containers to the disposal facility.

[c] Annual rates can be estimated by dividing the total number of cylinder breaches by the duration of the storage period in years.

DU oxide cylinders are moved around the sites using a straddle buggy or NCH-35, depicted in **Figure 2-8** and **Figure 2-9**, respectively (ORNL 1997). The NCH-35 is used at Paducah; both straddle buggy and NCH-35 are used at Portsmouth. Cylinders would be lifted and positioned on the railcars or truck beds using overhead cranes (PPPO 2018). Cylinder movement is performed in accordance with technical procedures. USEC-651, *The UF_6 Manual: Good Handling Practices for Uranium Hexafluoride*, contains specific guidance for processing, handling, and transporting DUF_6 and DU oxide cylinders (USEC 2017). The requirements in this procedure are intended to ensure both safety of personnel and protection of the cylinders from damage during handling and movement.

Figure 2-8 Straddle Buggy

Figure 2-9 NCH-35

Rail access is available at both Paducah and Portsmouth and at two of the potential disposal sites: Energy*Solutions* in Utah and WCS in Texas. For these sites, train transport would be directly from Paducah or Portsmouth to either of these disposal sites. NNSS does not have rail access. Therefore, train transport to NNSS would not be direct: DU oxide containers would be transferred from railcars to trucks at an intermodal facility for the final leg of the trip to NNSS. For analysis purposes, this *DU Oxide SEIS* assumes the intermodal facility located in Barstow, California, would be used. **Figure 2-10** and **Figure 2-11** show the analyzed routes from Paducah and Portsmouth, respectively, to the potential disposal sites.

The 2004 EISs (DOE 2004a, 2004b) analyzed the transport of empty and heel cylinders, CaF_2, and ancillary LLW and MLLW from Paducah and Portsmouth for disposal at Energy*Solutions* and NNSS. Because the quantities of these wastes have changed and DOE is now considering disposal at WCS, this *DU Oxide SEIS* is reevaluating the transport and disposal of these wastes for all three sites.

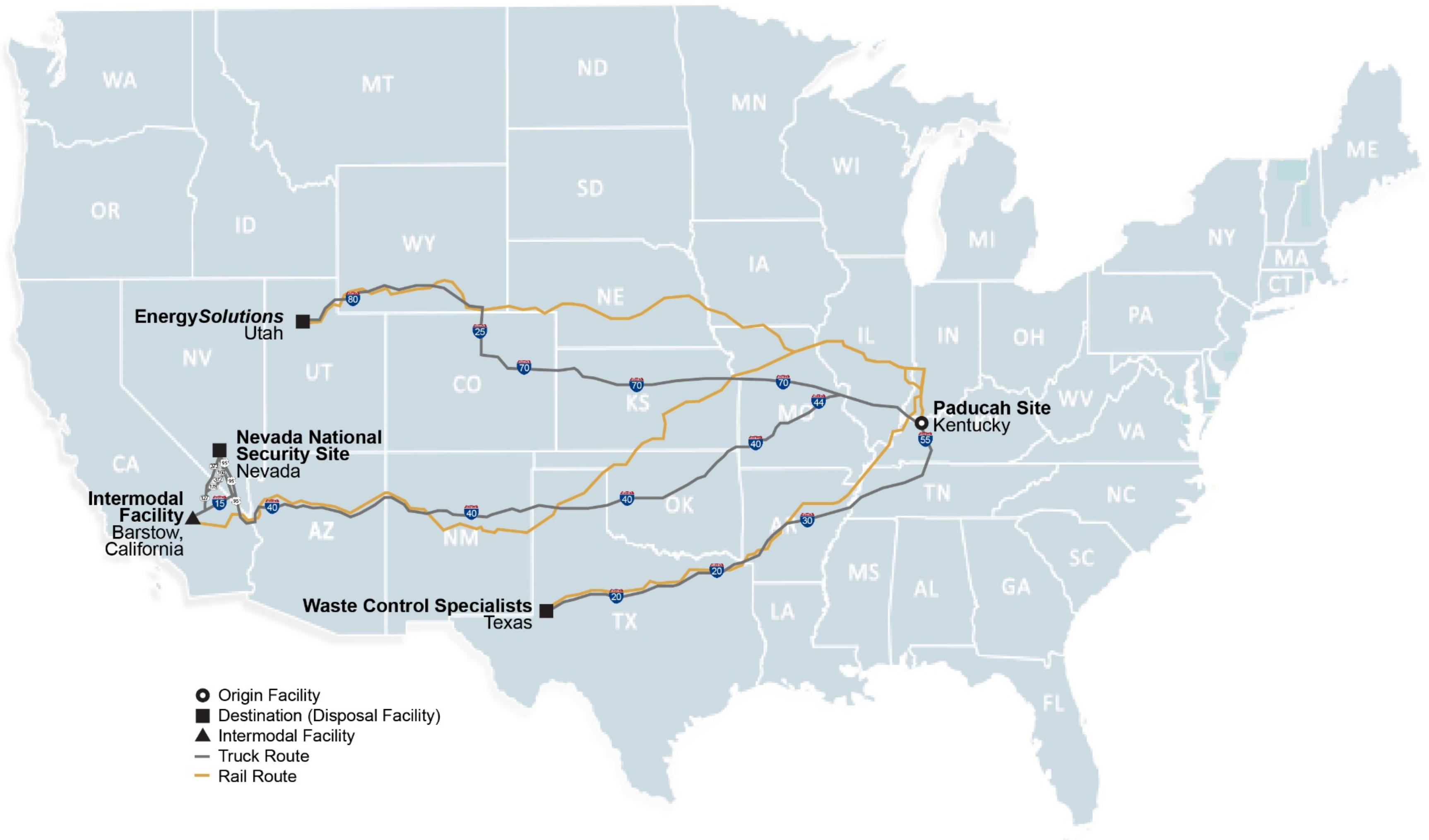

Figure 2-10 Analyzed Train and Truck Routes from Paducah to Potential Disposal Sites

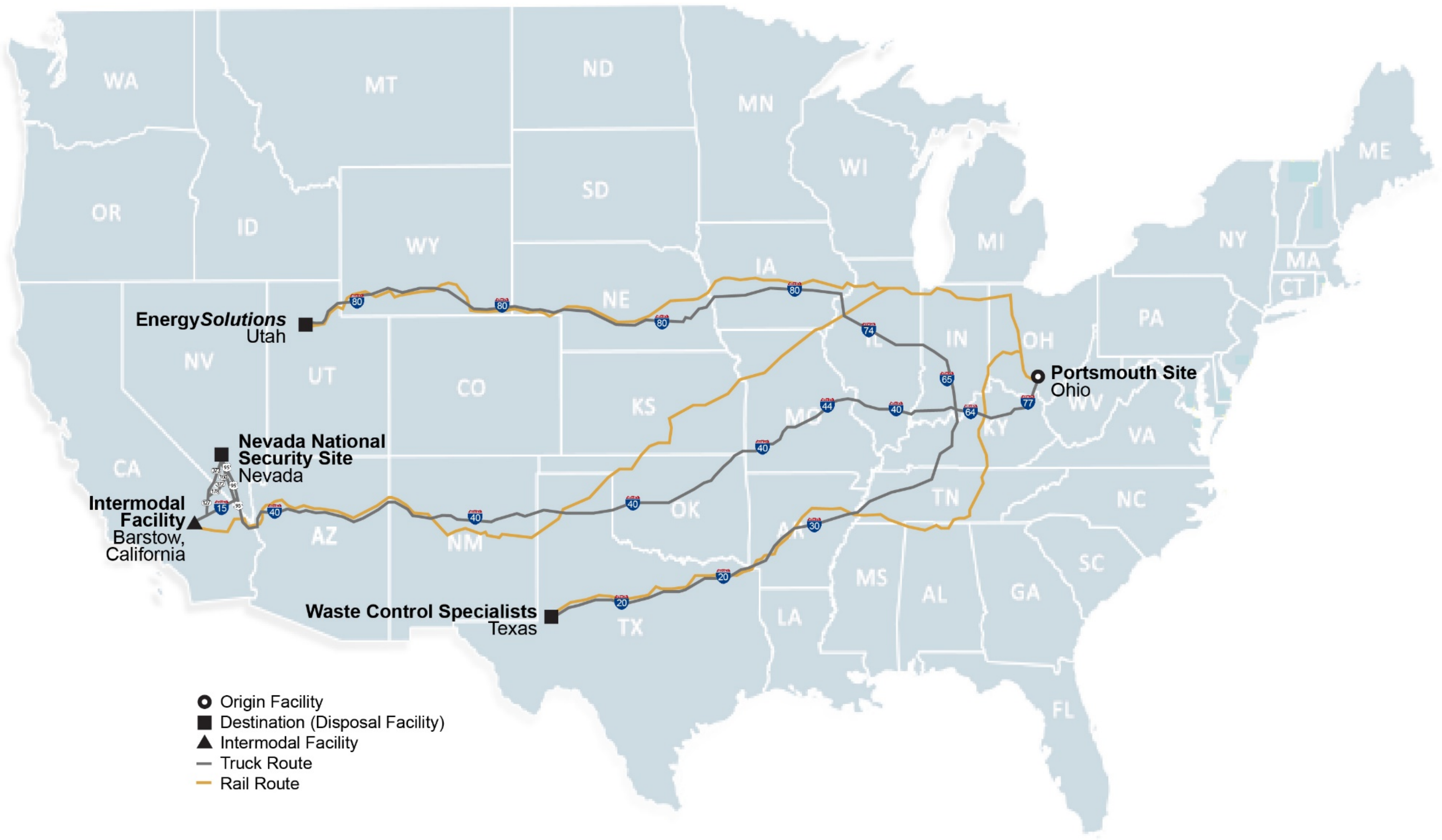

Figure 2-11 Analyzed Train and Truck Routes from Portsmouth to Potential Disposal Sites

2.2.1.1 Train Transport

Under the No Action Alternative, 141 train shipments would be needed from Paducah and another 92 train shipments from Portsmouth to transport the 14,000 intact empty and heel cylinders (8,483 from Paducah and 5,517 from Portsmouth) to the disposal site. If empty and heel cylinders are volume-reduced, 42 railcar shipments would be needed from Paducah and another 28 railcar shipments from Portsmouth to transport the empty and heel cylinders to the disposal site. As analyzed in the 2004 EISs, 6,316 railcar shipments would be needed from Paducah and 3,390 railcar shipments from Portsmouth to transport the 189,910 cubic yards of CaF_2 (122,500 from Paducah and 67,410 from Portsmouth) to the disposal site. For the quantities analyzed in this *DU Oxide SEIS*, and assuming 10 railcars per shipment, 811 train shipments would be needed from Paducah and 339 train shipments from Portsmouth to transport the 224,578 cubic yards of CaF_2 (157,195 from Paducah and 67,383 from Portsmouth) to the disposal site. The small quantities of ancillary LLW and MLLW would be shipped by truck only.

2.2.1.2 Truck Transport

If shipped by truck, 4,242 shipments would be needed from Paducah and another 2,759 truck shipments from Portsmouth to transport the 14,000 intact empty and heel cylinders (8,483 from Paducah and 5,517 from Portsmouth to the disposal site). Approximately 848 truck shipments would be needed from Paducah and another 552 truck shipments from Portsmouth to transport volume-reduced empty and heel cylinders to the disposal site. As analyzed in the 2004 EISs, if shipped by truck, 25,262 truck shipments would be needed from Paducah and 13,559 truck shipments from Portsmouth to transport the CaF_2 to a disposal site. For the quantities analyzed in this *DU Oxide SEIS*, 32,400 truck shipments would be needed from Paducah and 13,600 truck shipments from Portsmouth to transport the CaF_2 to a disposal site. The small quantities of ancillary LLW and MLLW would require about one truck shipment per year from each site; although because of logistics and regulations on the length of time waste can be stored, this waste might be shipped in two to three smaller shipments.

2.2.2 Action Alternatives

Under the Action Alternatives, DU oxide would be transported and disposed of at one or more of three disposal sites (i.e., Energy*Solutions*, NNSS, or WCS). The activities at Paducah and Portsmouth would be the same for the three Action Alternatives. Only the destination of the DU oxide cylinder shipments would be different. Under each of the three Action Alternatives, DU oxide containers would be loaded onto either railcars or trucks for transport from Paducah and Portsmouth to the proposed disposal sites. The containers in which the DU oxide is stored would be used as the transportation package and disposal container, and as such would need to meet U.S. Department of Transportation (DOT) requirements and disposal facility waste acceptance criteria. DU oxide containers not meeting transportation requirements would be repaired, replaced, or overpacked[11] before shipment. Approximately 46,150 cylinders of DU oxide would be shipped

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[11] As defined in the DOT Hazardous Materials Regulations (49 CFR 171.8), an overpack is an enclosure that is used to provide protection or convenience in handling a transportation package or to consolidate two or more packages. An example of an overpack is one or more packages placed in a protective outer packaging such as a crate or drum. The overpack does not include the transport vehicle or freight container.

from Paducah and 22,850 cylinders of DU oxide would be shipped from Portsmouth over the life of the project.

As mentioned in Section 2.2.1, there would be 220 and 365, 55-gallon (208-liter) drums of DU oxide that would be generated at Paducah and Portsmouth, respectively (PPPO 2018). The drums of DU oxide would be shipped to the disposal facilities via truck or train along with the cylinders of DU oxide under the Action Alternatives.

As an option, this *DU Oxide SEIS* also evaluates the transport and disposal of DU oxide in bulk bags. The 2004 EISs evaluated shipping approximately 32,840 bulk bags of DU oxide from Paducah and 17,692 bulk bags of DU oxide from Portsmouth over the life of the project (DOE 2004a, 2004b).[12] Because of the larger volume of DU oxide analyzed in this *DU Oxide SEIS*, it is estimated that approximately 41,016 bulk bags of DU oxide would be generated at Paducah and 18,142 bulk bags of DU oxide would be generated at Portsmouth over the life of the project. Under the bulk bag disposal option, 69,000 volume-reduced empty and heel cylinders (46,150 from Paducah and 22,850 from Portsmouth) would also require disposal.

As described in Section 2.2.1, 14,000 empty and heel cylinders, CaF_2, and ancillary LLW and MLLW would be shipped to the LLW disposal sites. The information from Section 2.2.1 is not repeated here. Additional information on how wastes would be shipped to the disposal sites is included in Appendix B of this *DU Oxide SEIS*.

The 2004 EISs (DOE 2004a, 2004b) analyzed the transport of DU oxide in cylinders (or bulk bags) from Paducah and Portsmouth for disposal at Energy*Solutions* and NNSS. Because the quantities of these wastes have changed and DOE is now considering disposal at WCS, this *DU Oxide SEIS* is reevaluating transport and disposal of these wastes for all three sites.

2.2.2.1 Train Transport

Paducah and Portsmouth each have 40 gondola railcars available for transporting the DU oxide cylinders. Trains consisting of 10 gondola railcars, carrying 6 cylinders in each railcar, would transport the DU oxide from Paducah and Portsmouth to the disposal sites. It would take approximately two months for each train to make one complete cycle, which would allow time for the railcars to be loaded, travel to the disposal site, be emptied, and return to the site. This would mean a total of 1,440 cylinders would be transported in 24 train shipments annually from each site. At this rate, it would take approximately 32 years to transport all the DU oxide cylinders from Paducah and 15 years to transport all the DU oxide cylinders from Portsmouth (PPPO 2018).

As analyzed in the 2004 EISs, 7,240 railcar shipments would be needed from Paducah and 4,200 railcar shipments from Portsmouth to transport the DU oxide in cylinders to the disposal site (DOE 2004a, 2004b). For the quantities analyzed in this *DU Oxide SEIS*, DOE assumes that 769 train shipments would come from Paducah and 381 train shipments from Portsmouth, assuming 10 gondola railcars per shipment.

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[12] The 2004 EISs analyzed disposal of DU oxide in bulk bags at NNSS and Energy*Solutions*. This DU Oxide SEIS incorporates those analyses for NNSS and Energy*Solutions* and uses those analyses to estimate impacts for disposal at WCS.

As another shipping option, DOE could ship 12 cylinders per railcar using an ABC railcar. Trains consisting of 10 ABC railcars, carrying 12 cylinders in each railcar, could be used to transport the DU oxide to the disposal site. One hundred twenty cylinders could be shipped in a 10-ABC railcar train versus 60 cylinders in a 10-gondola railcar train. The same number of cylinders would be shipped each year in half the number of train shipments. Similarly, half the number of shipments (385 train shipments from Paducah and 191 train shipments from Portsmouth) would be needed to transport the entire inventory of DU oxide cylinders to a disposal site.

As analyzed in the 2004 EISs, if bulk bags were used for disposal of DU oxide, a total of 4,105 railcar shipments would be needed from Paducah and 2,212 railcar shipments would be needed from Portsmouth (DOE 2004a, 2004b). For the quantities analyzed in this *DU Oxide SEIS*, and assuming 10 railcars per train shipment, if bulk bags were used for disposal of DU oxide, a total of 513 train shipments would be needed from Paducah and 227 train shipments would be needed from Portsmouth. In addition, if bulk bags were used, another 769 train shipments would be needed from Paducah and another 381 train shipments from Portsmouth to transport the 69,000 intact empty and heel cylinders (46,150 from Paducah and 22,850 from Portsmouth) to the disposal site. If empty and heel cylinders are volume-reduced, 231 train shipments would be needed from Paducah and 114 train shipments from Portsmouth to transport the empty and heel cylinders to the disposal site.

2.2.2.2 Truck Transport

Because truck shipments would be made by legal-weight semitrailer trucks, only one full DU oxide cylinder would be loaded on each truck. Assuming 1,440 truck shipments were made each year from each site, approximately six trucks would be loaded and leave each site each work day. At this rate, it would take approximately 32 years to transport all of the DU oxide cylinders from Paducah and 15 years to transport all of the DU oxide cylinders from Portsmouth.

As analyzed in the 2004 EISs, if bulk bags were used, two bulk bags would be loaded on each truck. If bulk bags were used, a total of 16,420 truck shipments would be needed at Paducah and 8,846 truck shipments would be needed at Portsmouth (DOE 2004a, 2004b). For the quantities analyzed in this *DU Oxide SEIS*, a total of 20,500 truck shipments would be needed at Paducah and 9,070 truck shipments would be needed at Portsmouth. In addition, if bulk bags were used, another 23,100 truck shipments would be needed from Paducah and another 11,400 truck shipments from Portsmouth to transport the 69,000 intact empty and heel cylinders (46,150 from Paducah and 22,850 from Portsmouth) to the disposal site. If empty and heel cylinders are volume-reduced, 4,620 truck shipments would be needed from Paducah and another 2,290 truck shipments from Portsmouth to transport the empty and heel cylinders to the disposal site.

Transportation, both by train and truck, would be in accordance with DOT requirements at 49 CFR Part 173, Subpart I, and DOE Orders and guidance, including Chapter 5, “Protection During Transportation,” of DOE Order 473.3A, *Protection Program Operations.*

Table 2-3 shows the key attributes of the activities analyzed under this *DU Oxide SEIS* alternatives.

Table 2-3 Attributes of the Activities Analyzed under this *DU Oxide SEIS* Alternatives

	Paducah		**Portsmouth**	
Activity	**No Action Alternative**	**Disposal Alternatives**	**No Action Alternative**	**Disposal Alternatives**
Evaluated in the 2004 EISs (DOE 2004a, 2004b) but not in this *DU Oxide SEIS*[a]				
Conversion of DUF_6 to DU Oxide				
Start of Conversion Operations	2011		2011	
Duration of Conversion Operations	34 to 44 years[b]		22 to 32 years[b]	
Evaluated in this *DU Oxide SEIS*				
Amount of DU Oxide	446,515 MT		199,337 MT	
DU Oxide in Cylinders[c]	46,150 cylinders		22,850 cylinders	
DU Oxide in Drums	220 drums		365 drums	
Disposal of CaF_2[d]	379,000 MT		159,000 MT	
Disposal of Empty and Heel Cylinders	8,483 cylinders		5,517 cylinders	
Start of DU Oxide Storage	2011		2011	
Storage of DU Oxide Containers	100 years[e]	76 years[f]	100 years[e]	47 years[f]
Employment Associated with DU Oxide Container Storage	16 FTEs		12 FTEs	
Transport of DU Oxide Containers to Off-site Disposal Facilities	NA	32 years[g]	NA	15 years[g]
Disposal of DU Oxide at ES, NNSS, or WCS[h]	NA	258,000 cubic yards	NA	128,000 cubic yards

Key: DU = depleted uranium; ES = Energy*Solutions*; FTE = full-time equivalent; HF = hydrogen fluoride; LLW = low-level radioactive waste; MT = metric tons; NA = not applicable; NE = not evaluated in this *DU Oxide SEIS*; NNSS = Nevada National Security Site; SEIS = supplemental environmental impact statement; WCS = Waste Control Specialists LLC.

[a] Storage of DUF_6 cylinders, conversion of DUF_6 to DU oxide, management of hydrogen fluoride, and size reduction of empty and heel cylinders were analyzed in the 2004 EISs (DOE 2004a, 2004b) and are not part of the Proposed Action evaluated in this *DU Oxide SEIS*, but were considered as part of cumulative impacts.

[b] As described in Section 2.2.1, based on the rate of conversion of DUF_6 to DU oxide, DOE now believes conversion activities would occur over a 34- to 44-year period at Paducah and a 22- to 32-year period at Portsmouth.

[c] As an option, DU oxide could be disposed of in bulk bags. At Paducah 41,016 bulk bags would be needed, while at Portsmouth 18,142 bulk bags would be needed. Under the disposal in bulk bags option, an additional 69,000 empty and heel cylinders would be volume-reduced and disposed of as LLW.

[d] Under the scenario where HF cannot be sold and is instead converted to CaF_2 and disposed of as LLW. Information is derived from the 2004 EISs (DOE 2004a, 2004b).

[e] For purposes of analysis in this *DU Oxide SEIS*, under the No Action Alternative, storage of DU Oxide containers was evaluated for 100 years. The impacts of storage beyond 100 years are also discussed.

[f] Based on the DUF_6 to DU oxide conversion rates, DU oxide containers would be stored at Paducah for at least 34 to 44 years, and at Portsmouth for at least 22 to 32 years. Based on the schedule for shipping DU oxide to the disposal sites, DU oxide containers could be shipped from Paducah over a period of 32 years and from Portsmouth over a period of 15 years. Therefore, this *DU Oxide SEIS* analyzes storage of DU oxide containers for 76 (44 + 32) years at Paducah and 47 (32 + 15) years at Portsmouth. The impact analysis uses the maximum duration and assumes that all DU oxide containers would be stored for this entire period in order to maximize the potential impacts (i.e., be the most conservative).

[g] As described in Section 2.2.2.1, based on the schedule for shipping DU oxide to the disposal sites, DU oxide containers could be shipped from Paducah over a period of 32 years and from Portsmouth over a period of 15 years. This is unlikely because the DU oxide would be generated at Paducah over a period of 34 to 44 years, and at Portsmouth over a period of 22 to 32 years, and much of the DU oxide would likely be shipped as it is generated. Nonetheless, the transportation impacts analysis uses the shipping durations (32 years at Paducah and 15 years at Portsmouth) in order to maximize annual transportation impacts (i.e., be the most conservative).

[h] Information is from Chapter 4, Section 4.2.3.

Source: Information is based on PPPO 2018 except where noted.

Disposal of Waste at Energy*Solutions*

Disposal at Energy*Solutions* near Clive, Utah, was evaluated in the 2004 EISs. At that time, the name of the site was Envirocare of Utah, Inc. This site is 5 miles (8 kilometers) south of the Clive exit on Interstate 80 in Tooele County, approximately 80 miles (130 kilometers) west of Salt Lake City, Utah. This site can accept waste by train or truck transport. The site is approximately 1 square mile (2.6 square kilometers) in size and is licensed to handle and dispose of Class A LLW, naturally occurring and accelerator-produced material, MLLW, and uranium and thorium byproduct material under Utah Radioactive Material License UT2300249. There are more than 8 million cubic yards (6.1 million cubic meters) of licensed/permitted capacity at the Clive site (ES 2016a). As discussed in Chapter 3, Section 3.3 of this *DU Oxide SEIS*, Energy*Solutions* has applied for a license amendment to construct and operate a dedicated unit for disposal of DU. This disposal unit is currently designed to accept approximately 378,000 cubic yards (289,000 cubic meters) of DU oxide but could be sized to accommodate the actual disposal volume (Shrum 2016a).

Disposal of Waste at the Nevada National Security Site

Disposal at NNSS in Nye County, Nevada, was evaluated in the 2004 EISs. Continued disposal of LLW from DOE and certain U.S. Department of Defense (DoD) facilities at NNSS was also evaluated in the NNSS SWEIS (DOE 2013a). LLW management and disposal occurs within the NNSS Area 5 Radioactive Waste Management Complex (RWMC). Area 5 is an active LLW and MLLW disposal facility, managing and disposing of LLW (and MLLW) generated on site at NNSS. NNSS also accepts wastes for disposal from other approved generators at DOE and National Nuclear Security Administration sites and certain DoD sites throughout the United States. This is consistent with the February 25, 2000, ROD (65 FR 10061) for the WM PEIS (DOE 1997), in which DOE announced that NNSS (called the Nevada Test Site at that time) would be one of two regional sites to be used for DOE-generated LLW and MLLW disposal. NNSS currently has the capacity to dispose of up to 1,778,000 cubic yards (1,359,000 cubic meters) of LLW, and 148,000 cubic yards (113,000 cubic meters) of MLLW.

NNSS does not have rail access. Therefore, DU oxide containers would need to arrive by truck. The containers could be transported either entirely by truck from Paducah or Portsmouth or could travel by train to an intermodal facility, assumed, for analysis purposes, to be in Barstow, California, where the containers would be transferred from railcars to trucks for the remainder of the trip.

Disposal of Waste at Waste Control Specialists LLC

Disposal at WCS was not evaluated in the 2004 EISs because it was not licensed for disposal of radioactive waste at the time the 2004 EISs were prepared. The WCS site is located near Andrews, Texas, in the western part of the state that borders New Mexico. This facility can accept waste by train or truck and accepts waste from both commercial and government generators, with separate facilities for each. The Federal Waste Disposal Facility at WCS opened in June 2013 and has a licensed capacity of up to 963,000 cubic yards (736,000 cubic meters) of LLW and MLLW. The facility was constructed solely for the disposal of waste for which the Federal Government is responsible, as defined by the Low-Level Radioactive Waste Policy Act, as amended (WCS 2016c). The Federal Waste Disposal Facility is licensed through September 2024, with provision for 10-year renewals thereafter under Texas Commission on Environmental Quality (TCEQ) Radioactive Material License R04100. DOE has signed an agreement to take ownership of the Federal Waste Disposal Facility after decommissioning.

2.3 ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

As described in Chapter 1, Section 1.1, this *DU Oxide SEIS* tiers from, and relies on, the analyses in the DUF_6 PEIS (DOE 1999) and the 2004 EISs (DOE 2004a, 2004b). These documents considered, but eliminated from detailed study, a number of other alternatives and options including DU reuse, storage, and disposal options. This *DU Oxide SEIS* incorporates the description of those alternatives and options by reference.

As described in Section 2.2, this *DU Oxide SEIS* analyzes the potential impacts from on-site storage of DU oxide at Paducah and Portsmouth, and transport and disposal of DU oxide at the Energy*Solutions* site near Clive, Utah; NNSS in Nye County, Nevada; and the WCS site near Andrews, Texas. DOE identified the following additional Action Alternatives that it considered for evaluation but ultimately dismissed from detailed study, as discussed in Sections 2.3.1 through 2.3.4: (1) transportation alternatives, (2) on-site disposal of DU oxide, (3) disposal of DU oxide at other LLW disposal facilities, and (4) disposal of DU oxide at WIPP.

2.3.1 Transportation Alternatives

Alternatives considered but not analyzed in detail in the 2004 EISs (DOE 2004a, 2004b) include those for alternative modes of transportation. The 2004 EISs included a discussion of why transportation of DUF_6 cylinders between the Paducah and Portsmouth conversion facilities by either air or barge was not reasonable and therefore not carried forward for detailed analysis. Although this *DU Oxide SEIS* is analyzing DU oxide transport to disposal sites, rather than DUF_6 transport between the conversion facilities, similar conditions apply.

Air transportation was eliminated from detailed analysis in the 2004 EISs because of the types and quantities of materials that would be shipped. Those reasons are also valid for the proposed shipments of DU oxide for disposal. The physical nature of the DU oxide (e.g., uranium powder), the packaging in large containers (i.e., steel cylinders or bulk bags), the large number of cylinders (69,000) or bulk bags (59,158), and both the weight of the individual containers and the total weight of DU oxide to be transported (approximately 645,852 metric tons [711,923 tons]), makes air transport impractical.

In addition, Paducah and Portsmouth and the Energy*Solutions* and WCS sites are not directly adjacent to an airport capable of handling large aircraft. Therefore, the DU oxide could not be transported directly by air between Paducah or Portsmouth and the disposal sites; intermodal transport would be required. In order to fly the DU oxide containers, they would first need to be loaded onto trucks or railcars at Paducah or Portsmouth for transport to an airport where the containers would be loaded onto the airplanes, transported by air, and then offloaded onto trucks or railcars for the final leg to the Energy*Solutions* and WCS disposal facilities. DOE maintains an airstrip at NNSS. Even air transport to NNSS would involve transporting the DU oxide containers from Paducah and Portsmouth by truck or train to an airport capable of handling large aircraft. Therefore, because of the large mass of DU oxide to be shipped, the size and weight of the individual containers, and the unduly complex and time-consuming effort involved with air transport relative to transport by truck or train, transport by air is eliminated from detailed analysis in this *DU Oxide SEIS*.

Barge transportation was eliminated from detailed analysis in the 2004 EISs because of the lack of barge facilities at the conversion facilities and in proximity to the proposed disposal sites. None of the proposed disposal sites is situated directly on a river or other waterway navigable by barges. Even if there were waterways and barge terminals in reasonably close proximity to the selected disposal location, containers of DU oxide would need to be transported by truck from Paducah and Portsmouth to the barge terminals where the containers would be loaded onto the barges, transported by barge, and then offloaded onto trucks for the final leg to the disposal site. Depending on the disposal site, the barge routes could involve long distances on intracoastal and coastal waterways, the open ocean, and major rivers. Intermodal barge transportation would be unduly complex and time-consuming relative to shipment by truck or train. Therefore, transport by barge is eliminated from detailed analysis in this *DU Oxide SEIS*.

2.3.2 On-Site Disposal of DU Oxide

The DUF_6 PEIS (DOE 1999) analyzed disposal of DU oxide in shallow earthen structures, vaults and mines, and in dry and wet settings. Disposal was analyzed as an untreated DU oxide and in grouted form. Energy*Solutions*, NNSS, and WCS are considered to be "dry" settings, while Paducah and Portsmouth are considered to be "wet" settings. In dry settings, no radiation or chemical exposure to the public would be expected within 1,000 years of disposal. In wet settings, radiation and chemical exposure to contaminated groundwater could exceed regulatory standards for a member of the public within 1,000 years of disposal. Therefore, the DUF_6 PEIS and subsequent tiered NEPA documents, including this *DU Oxide SEIS*, did not analyze disposal of DU oxide at Paducah and Portsmouth.

2.3.3 Disposal of Wastes at Other LLW Disposal Facilities (e.g., Barnwell, Hanford)

Commercial LLW disposal facilities not evaluated as alternatives in this *DU Oxide SEIS* are those in operation in Barnwell County, South Carolina, and at the Hanford Site in the state of Washington. Disposal of LLW at these facilities is limited to LLW generated by members of state compacts established pursuant to the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240). Disposal of LLW at the Barnwell facility is limited to non-DOE generators in states comprising the Atlantic Compact (Connecticut, New Jersey, and South Carolina), while disposal of LLW at the commercial facility at the Hanford Site is limited to non-DOE generators in states comprising the Northwest and Rocky Mountain Compacts (Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Washington, Wyoming, Colorado, Nevada, and New Mexico). DOE would not be able to dispose of DU oxide at either facility without approval by these compacts to accept DOE LLW, which would not be a certainty and would likely involve a long, time-consuming process.[13] Therefore, disposal of DU oxide at the Barnwell and Hanford commercial facilities is eliminated from detailed analysis in this *DU Oxide SEIS*.

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[13] It is expected that any future LLW compact facilities, even those that would include waste generated in Ohio or Kentucky, would have similar restrictions, requirements, and uncertainty for approval for disposal of DOE waste. According to DOE Manual 435.1-1, DOE has a longstanding practice of avoiding actions with the potential to affect State Compact disposal facilities. DOE would only consider the use of State Compact disposal facilities if petitioned by a State Compact for reasons such as economic feasibility.

In its February 25, 2000, ROD for the WM PEIS (65 FR 10061), DOE established the Hanford Site and NNSS as regional LLW and MLLW disposal sites for the DOE complex. However, with certain limitations and exceptions, the DOE facility at the Hanford Site does not accept LLW or MLLW generated from off-site sources, but may do so in the future after the on-site Waste Treatment Plant is in operation.[14] DOE does not expect full operation of the Waste Treatment Plant until 2039, although operation of the plant for treatment of some waste is expected sooner (TCH 2015). Because of uncertainty about the timing for availability of the Hanford Site for disposal of DU oxide, disposal at the Hanford Site is eliminated from detailed analysis in this *DU Oxide SEIS*.

2.3.4 Disposal of Wastes at the Waste Isolation Pilot Plant

The Waste Isolation Pilot Plant Land Withdrawal Act (Public Law 102-579) restricts materials to be disposed of at WIPP, a deep geologic repository in New Mexico, to transuranic waste[15] generated from the Nation's atomic energy defense activities. The DU oxide destined for disposal is classified as Class A LLW rather than transuranic waste. Therefore, disposal of the DU oxide (and other LLW that would be generated under the Proposed Action) is not authorized under the Act, and could not be disposed of at WIPP without a statutory amendment to the Act. Furthermore, disposal of DU oxide at WIPP would unnecessarily use limited disposal space in a geologic repository intended for waste requiring a higher degree of isolation from the environment. For these reasons, disposal of DU oxide at WIPP is eliminated from detailed analysis in this *DU Oxide SEIS*.

2.4 COMPARISON OF ALTERNATIVES

2.4.1 General Information

This section summarizes estimated potential impacts on the environment, including impacts on workers and members of the general public, under the No Action Alternative and the Action Alternatives for disposal of DU oxide[16] at Energy*Solutions* near Clive, Utah; NNSS in Nye County, Nevada; and WCS near Andrews, Texas. This section also describes the potential for cumulative impacts (Section 2.4.3).

This *DU Oxide SEIS* does not address the impacts of the storage of DUF_6 cylinders, conversion of DUF_6 to DU oxide, and the management and disposition of HF. These activities were evaluated in the 2004 EISs (DOE 2004a, 2004b) and decisions announced in RODs for these EISs (69 FR

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[14] In DOE's December 13, 2013, ROD (78 FR 75913) for the *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (DOE/EIS-0391) (DOE 2012), DOE deferred a decision on importing wastes from other sites (with limited exceptions) for disposal at the Hanford Site at least until the Waste Treatment Plant at Hanford becomes operational.

[15] Transuranic waste is radioactive waste that is not classified as high-level radioactive waste and that contains more than 100 nanocuries (3,700 becquerels) per gram of alpha-emitting transuranic isotopes with half-lives greater than 20 years, except for waste that DOE has determined, with EPA concurrence, does not need the degree of isolation called for by 40 CFR Part 191, or waste that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61 (DOE Order 435.1).

[16] This DU Oxide SEIS also evaluates the environmental impacts of transportation and disposal of related waste streams including empty and heel cylinders and CaF_2.

44654; 69 FR 44649). The impacts of these activities are considered as part of potential cumulative impacts.

No Action Alternative: As described in Section 2.2.1, under the No Action Alternative, DU oxide would continue to be stored at Paducah and Portsmouth. DU oxide would not be disposed of as LLW. For purposes of analysis, the duration of the No Action Alternative at Paducah and Portsmouth is 100 years beginning with storage of the first DU oxide cylinders in 2011, and ending in 2110.[17] Based on the rate of conversion of DUF_6 to DU oxide, DOE believes conversion activities will occur over a 34-year period at Paducah and over a 22-year period at Portsmouth (PPPO 2018). The time period considered for conversion of DUF_6 to DU oxide at Paducah and Portsmouth under this alternative is 44 and 32 years, respectively (PPPO 2018).[18] This corresponds with the duration of conversion activities plus a 10-year cushion to account for unanticipated outages. Therefore, for purposes of this analysis, under the No Action Alternative, storage of DU oxide cylinders after the completion of conversion activities would be for at least 56 to 66 years at Paducah and for at least 68 to 78 years at Portsmouth.

This *DU Oxide SEIS* considers impacts associated with the following activities under the No Action Alternative: (1) long-term storage of DU oxide containers, (2) surveillance and maintenance of the containers including routine inspections, (3) release of DU oxide from damaged or breached containers, and (4) repair of any containers that might be damaged or breached. These activities are described in Chapter 2, Section 2.2.1. Because no DU oxide would be shipped from Paducah or Portsmouth to the disposal sites under the No Action Alternative, there would be only incremental impacts at the Energy*Solutions*, NNSS, or WCS sites from the disposal of approximately 46,000 bulk bags of CaF_2 (if HF could not be sold), 14,000 empty and heel cylinders, and ancillary LLW and MLLW from container surveillance and maintenance activities.

Action Alternatives: As described in Section 2.2.2, under the Action Alternatives, DU oxide would be disposed of at one or more of three disposal facilities (i.e., Energy*Solutions*, NNSS, and WCS). This section presents the following estimated potential environmental impacts for these alternatives: (1) impacts from storage of DU oxide at Paducah and Portsmouth until shipment to the disposal site, (2) impacts from transportation of the DU oxide and other wastes to the disposal site, and (3) impacts on the capacity of the disposal facility. For purposes of analysis and to bound the impacts under each Action Alternative, it was assumed that all 69,000 DU oxide cylinders (or 59,000 bulk bags and 69,000 empty and heel cylinders), all remaining 14,000 empty and heel cylinders, all 46,000 bulk bags of CaF_2, and all ancillary LLW and MLLW would be disposed of

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[17] Storage under the No Action Alternative could extend beyond the 100 years analyzed in this DU Oxide SEIS. Storage for longer than 100 years would not change the maximum annual impacts of operations, but would extend the impacts described in this DU Oxide SEIS further out in time. The contributions attributable to those facilities to total life-cycle impacts, such as those for total worker and population dose and LCFs, and total waste generation, would increase in proportion to the extended period. These impacts can be estimated from the analyses provided in this DU Oxide SEIS under the No Action Alternative by multiplying the additional years of operation by the annual impacts.

[18] The storage periods for DU oxide were assumed based on current plans and schedules and could vary somewhat upon implementation. Any dates cited in this DU Oxide SEIS are for purposes of analyses only.

at each disposal site (i.e., Energy*Solutions*, NNSS, or WCS). In practice, waste could be disposed of at more than one disposal site.

DU oxide would be stored at Paducah and Portsmouth until it is shipped to the disposal site. As described in Section 2.2.1, based on the rate of conversion of DUF_6 to DU oxide, DOE now believes conversion activities will occur over a 34- to 44-year period at Paducah, and a 22- to 32-year period at Portsmouth (PPPO 2018).[19] Because the shipment schedule is uncertain, it was assumed that the entire inventory of DU oxide would be stored for the entire conversion period.

DOE has conservatively assumed (likely overestimating potential annual impacts) that shipping DU oxide cylinders to a disposal facility would not occur until after conversion is complete and all DU oxide has been generated. It is assumed that DOE would then begin shipping DU oxide cylinders to a disposal facility and would continue shipping until all DU oxide was disposed. It is estimated that transport of DU oxide from Paducah via truck or train would require about 32 years, based on transport of up to 1,440 cylinders per year. About 46,150 cylinders, containing 447,000 metric tons (492,000 tons) of DU oxide, would be transported from Paducah. The transport of DU oxide from Portsmouth via truck or train requires about 15 years, also based on the transport of up to 1,440 cylinders per year. About 22,850 cylinders, containing 199,000 metric tons (220,000 tons) of DU oxide, would be transported from Portsmouth (PPPO 2018).

This is a conservative assumption that likely over-estimates the impacts of storage at Paducah and Portsmouth because: (1) DU oxide would be generated over the duration of the conversion period by conversion from DUF_6 and (2) DU oxide would likely be shipped off site for disposal soon after it is generated and not stored for the entire storage and shipping periods.

Because bulk bags would only be used if they could be sent directly to a disposal facility, DOE assumes that shipping DU oxide in bulk bags to a disposal facility would occur as soon as the bags are filled. Therefore, bulk bags would be shipped during the 34-to-44-year conversion period at Paducah and the 22-to-32-year conversion period at Portsmouth. DOE assumes transport would occur over the shorter periods to provide a conservative estimate of annual impacts.

This *DU Oxide SEIS* describes the impacts on disposal facility capacity. Other potential environmental impacts of disposal are not analyzed in this *DU Oxide SEIS*. Consistent with common practice, as long as the waste to be disposed of is within the authorized capacity and waste acceptance criteria of the disposal facility, the impacts of disposal have already been considered and found to be acceptable as part of the licensing and permitting process. Chapter 5, Section 5.4, of this *DU Oxide SEIS* briefly describes the licenses and permits held by the disposal sites.

2.4.2 Summary and Comparison of Potential Environmental Impacts of the Alternatives

Potential environmental impacts associated with the Action Alternatives and the No Action Alternative could include impacts on the following resource areas: site infrastructure; climate, air quality, and noise; geology and soils; water resources; biotic resources; public and occupational

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[19] The storage periods for DU oxide were assumed based on current plans and schedules and could vary somewhat upon implementation. Any dates cited in this DU Oxide SEIS are for purposes of analyses only.

health and safety (during normal operations, accidents, and transportation); socioeconomics; waste management; land use and aesthetics; cultural resources; and environmental justice. The potential environmental impacts at Paducah and Portsmouth under the No Action and Action Alternatives are summarized in **Table 2-4**.

The potential environmental impacts of transportation and the impacts on the capacity of the three disposal sites (i.e., Energy*Solutions*, NNSS, and WCS) under the No Action and Action Alternatives are presented in **Table 2-5**. The tables are intended to facilitate comparison of the alternatives. Additional details and discussion are provided in Chapter 4 for each alternative and resource area.

The No Action Alternative would not meet the purpose and need for agency action as described in Chapter 1, Section 1.3, and would only defer a final decision on the ultimate disposition of the DU oxide. Because the No Action Alternative defers a disposition decision, it is possible that at some future time the cylinders of DU oxide would be transported off site for disposal or some undetermined future use. Transportation and disposal of the DU oxide would likely be similar to the activities described under the Action Alternatives.

Table 2-4 Summary Comparison of Potential Environmental Impacts of the Alternatives at the Paducah and Portsmouth Sites

Resource Area / Parameter		Paducah		Portsmouth	
		Action Alternatives	**No Action**	**Action Alternatives**	**No Action**
Site Infrastructure	Electricity (MWh/yr) (percent of current use)	0.167 (2)	0.167 (2)	0.167 (0.8)	0.167 (0.8)
	Water (gal/day) (percent of current use)	230,000 (7)	230,000 (7)	73,000 (4)	73,000 (4)
	Diesel Fuel (gal/yr) (percent of current use)	15,600 (NA)	Minimal (NA)	15,600 (NA)	Minimal (NA)
	Gasoline (gal/yr) (percent of current use)	2,080 (NA)	Minimal (NA)	2,080 (NA)	Minimal (NA)
	Discussion: There would be no new significant construction and no substantial change in DU container storage, maintenance, and handling activities at Paducah and Portsmouth. Annual utility use including DU container storage, maintenance, and handling activities would be little changed from existing utility use. Infrastructure needs would be small when compared to site capacity and current use. Long term storage of cylinders may require maintenance, repair, or replacement of select infrastructure if the storage duration exceeds designed life. Therefore, impacts on infrastructure at Paducah and Portsmouth would be expected to be minor.				
Climate, Air Quality, and Noise	**Climate and Air Quality**	There would be no significant construction, and little painting or other industrial processes requiring fossil fuel combustion or other release of hazardous air pollutants, criteria air pollutants, or GHG to the environment.			
		Emissions from diesel and gasoline fuel combustion associated with container handling, loading, and shipment of DU oxide, ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 would be minimal whether DU oxide was disposed of in cylinders or bulk bags, and would not contribute to any exceedances of ambient air quality standards.	Minimal	Emissions from diesel and gasoline fuel combustion associated with container handling, loading, and shipment of DU oxide, ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 would be minimal whether DU oxide was disposed of in cylinders or bulk bags, and would not contribute to any exceedances of ambient air quality standards.	Minimal
	Noise	Container storage, maintenance, and handling activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be no significant construction, and no increase in activities above current operations that would contribute to the noise environment. Any increase in noise due to shipment of DU oxide, ancillary LLW and MLLW, empty and heel cylinders, and/or CaF_2 would be minimal and likely imperceptible in the context of the existing traffic in the region around the sites and the millions of trucks, trains, and general transportation vehicles traveling public roadways and rails that could be used to transport materials associated with the project.			
	Discussion: Potential impacts on air quality, climate, and noise would be expected to be minor.				

Resource Area / Parameter		**Paducah**			**Portsmouth**		
		Action Alternatives		**No Action**	**Action Alternatives**		**No Action**
Geology and Soils	**Discussion:** Container storage, maintenance, and handling activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be no significant construction, no use of geologic and soils materials, and no routine releases of DU oxide or hazardous materials. The release of uranium as a result of a potential cylinder breach would result in soil concentrations considerably below the EPA health-based value for residential exposure. Therefore, potential impacts on geology and soils would be expected to be minor.						
Water Resources	**Discussion:** Container storage, maintenance, and handling activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be no significant construction, no increases in water use and wastewater discharge, no change to groundwater recharge, and no routine releases of DU oxide or hazardous materials. As described in Site Infrastructure, water usage would be a very small percentage of current use. Therefore, potential impacts on water resources would be minor. Potential impacts on surface and groundwater quality as a result of a release associated with a potential container breach would result in uranium concentrations below radiological benchmark levels (i.e., 30 micrograms per liter Safe Drinking Water Act maximum contaminant levels).						
Biotic Resources	**Discussion:** Container storage, maintenance, and handling activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be no significant construction and no routine releases of DU oxide or hazardous materials. Therefore, potential impacts on biotic resources would be expected to be minor. Potential impacts on biotic resources as a result of a release associated with a potential container breach indicate that groundwater uranium concentrations could exceed the ecological screening value for surface water (2.6 microgram per liter). However, contaminants in groundwater discharging to a surface water body, such as a local stream, would be quickly diluted to negligible concentrations.						
Human Health and Safety – Normal Operations	**Radiological Exposure**						
	Involved Workers	***DU Cylinder Storage and Shipment***	***DU Bulk Bag Option***		***DU Cylinder Storage and Shipment***	***DU Bulk Bag Option***	
	Average dose (millirem/yr)	550	430	74	570	240	63
	Annual LCF risk	3×10^{-4}	3×10^{-4}	4×10^{-5}	3×10^{-4}	2×10^{-4}	4×10^{-5}
	Total dose (person-rem)	170	68	120	74	30	76
	Total health effects (LCF)	0 (0.1)	0 (0.04)	0 (0.07)	0 (0.04)	0 (0.02)	0 (0.05)
	Discussion: Doses would be below regulatory limits and no LCFs would be expected. 10 CFR Part 835 imposes an individual worker dose limit of 5,000 millirem in a year. In addition, worker doses must be monitored and controlled below the regulatory limit to ensure that individual doses are less than an administrative limit of 2,000 millirem per year (DOE 2017f). The average dose for the Action Alternatives is associated with loading DU oxide containers for shipment to the disposal facility and assumes the same team performs all loading operations.						
	Noninvolved workers						
	Maximum dose to MEI (millirem/yr)	0.15		0.15	0.15		0.15
	Total dose (person-rem)	0.2		0.3	0.05		0.1
	Total LCF risk	0 (1×10^{-4})		0 (2×10^{-4})	0 (3×10^{-5})		0 (6×10^{-5})
	Discussion: Doses would be below regulatory limits and no LCFs would be expected. 10 CFR Part 835 imposes an individual dose limit of 5,000 millirem in a year. In addition, worker doses must be monitored and controlled below the regulatory limit to ensure that individual doses are less than an administrative limit of 2,000 millirem per year (DOE 2017f). Values presented are for DU cylinder storage and shipment. Implementation of the bulk bag option would not result in any incremental noninvolved worker impacts above the impacts associated with the DU cylinder storage and shipment option.						

Resource Area / Parameter		**Paducah**		**Portsmouth**	
		Action Alternatives	**No Action**	**Action Alternatives**	**No Action**
	General public				
	MEI dose (millirem/yr)	5.0	5.0	1.3	1.3
	Annual LCF risk	3×10^{-6}	3×10^{-6}	8×10^{-7}	8×10^{-7}
	Total dose (millirem)	220	500	42	130
	Total LCF risk	0 (1×10^{-4})	0 (3×10^{-4})	0 (3×10^{-5})	0 (8×10^{-5})
	Discussion: MEI doses would be well below regulatory limits for radiation exposure to a member of the public established by EPA and DOE and no LCFs would be expected. The EPA has set a radiation dose limit to a member of the general public of 10 millirem per year from airborne sources (40 CFR Part 61). DOE Order 458.1 imposes an annual individual dose limit of 10 millirem from airborne pathways, 100 millirem from all pathways, and 4 millirem from the drinking-water pathway.				
	Population dose (person-rem/yr)[a]	0.01	0.01	0.002	0.002
	Total dose (person-rem)	0.76	1.0	0.094	0.2
	Total health effects (LCF)	0 (5×10^{-4})	0 (6×10^{-4})	0 (6×10^{-5})	0 (1×10^{-4})
	Discussion: Because of the distance from the DU oxide storage containers, members of the general public would receive no direct radiation dose. DU oxide released in potential cylinder breaches due to corrosion would result in no additional cancer fatalities (6×10^{-4} at Paducah and 1×10^{-4} at Portsmouth) in the general population during the full duration (up to 100 years) of cylinder storage. Values presented are for cylinder storage and shipment. Implementation of the bulk bag option would not result in any incremental general public impacts above the impacts associated with the DU cylinder storage and shipment option.				
	Chemical exposure (HI)[b]				
	Worker MEI	<1	<1	<1	<1
	General public MEI	<0.1 air <0.05 water	<0.1 air <0.05 water	<0.1 air <0.05 water	<0.1 air <0.05 water
	Discussion: The Hazard index (HI) associated with airborne releases of uranium would be less than 0.1 and the HI for releases into the waters around Paducah and Portsmouth would be less than 0.05. Therefore, no adverse impacts would be expected from chemical exposure.				
Human Health and Safety – Accidents	***Bounding Accident***	***Hopper - Broken Discharge Chute***	***Hopper - Broken Discharge Chute***	***Hopper - Broken Discharge Chute***	***Hopper - Broken Discharge Chute***
	Release amount (kilograms)	6	6	6	6
	Radiological exposure				
	Noninvolved workers				
	Dose to MEI (rem)	1.3	1.3	1.3	1.3
	Risk of LCF	8×10^{-4}	8×10^{-4}	8×10^{-4}	8×10^{-4}
	General public				
	Dose to MEI (rem)	0.0065	0.0065	0.0065	0.0065
	Risk of LCF	4×10^{-6}	4×10^{-6}	4×10^{-6}	4×10^{-6}
	Chemical Exposure (HI)				
	Chemical Exposure (HI)	<1	<1	<1	<1

<table>
<tr><th colspan="2" rowspan="2">Resource Area / Parameter</th><th colspan="2">Paducah</th><th colspan="2">Portsmouth</th></tr>
<tr><th>Action Alternatives</th><th>No Action</th><th>Action Alternatives</th><th>No Action</th></tr>
<tr><td></td><td colspan="5">Discussion: All accidents that involved DU oxide storage were found to have low unmitigated (without preventive or mitigative features) radiological and chemical consequences to facility or collocated workers and negligible radiological and chemical consequences to the public. As a result, no DU oxide storage accidents were evaluated in detail. The DU oxide powder hopper accident bounds the potential consequences of events for DU oxide container storage. Note: The accident analyses are conservative. Preventative and mitigative measures may reduce consequences, as discussed in Chapter 4, Section 4.1.1.6.</td></tr>
<tr><td rowspan="2">Socioeconomics</td><td>Employment (FTEs)</td><td>16</td><td>16</td><td>12</td><td>12</td></tr>
<tr><td colspan="5">Discussion: There would be no significant construction activities. The employment associated with DU oxide container storage, maintenance, and handling (i.e., 16 FTEs for Paducah and 12 FTEs for Portsmouth) would be approximately 1 percent of total site employment and approximately 5 to 6 percent of conversion facility employment. Disposal of DU oxide in bulk bags would likely be similar to disposal of DU oxide in cylinders since bulk bags would require fewer bags than DU oxide in cylinders (less labor) but would generate a greater number of volume-reduced empty and heel cylinders (more labor). In addition, management of large quantities of CaF_2 would only be required if the DOE was unable to sell HF; in which case, staff assigned to manage HF could manage CaF_2. Therefore, because of the small numbers of employees involved, no appreciable in-migration or out-migration is expected, and there would be no impacts on population and regional growth, housing, or community services in the Paducah and Portsmouth ROIs.</td></tr>
<tr><td rowspan="5">Waste Management</td><td>Ancillary LLW (yd^3/yr) (percent of current generation)</td><td>2.1 (1.0)</td><td>2.1 (1.0)</td><td>1.6 (1.0)</td><td>1.6 (1.0)</td></tr>
<tr><td>Ancillary MLLW (yd^3/yr) (percent of current generation)</td><td>0.014 (1.0)</td><td>0.014 (1.0)</td><td>0.010 (1.0)</td><td>0.010 (1.0)</td></tr>
<tr><td>LLW – empty and heel cylinders (yd^3/yr) (percent of current generation)</td><td>1,400 (NWS)</td><td>1,400 (NWS)</td><td>1,400 (NWS)</td><td>1,400 (NWS)</td></tr>
<tr><td>LLW – CaF_2 (yd^3/yr) (percent of current generation)</td><td>4,600 (NWS)</td><td>4,600 (NWS)</td><td>3,100 (NWS)</td><td>3,100 (NWS)</td></tr>
<tr><td colspan="5">Discussion: Container storage, maintenance, and handling are projected to generate small amounts of LLW and MLLW. In addition, empty and heel cylinders (also LLW) and CaF_2 (assumed to be LLW) could be generated. All LLW and MLLW generated during storage and maintenance of DU oxide containers at Paducah and Portsmouth would be transported to off-site facilities for treatment and/or disposal. Although these empty and heel cylinders and CaF_2 would be very large percentages of current LLW generation, the site waste management infrastructure was modified during construction of the conversion facilities to handle these volumes of wastes. Therefore, managing these waste would not adversely affect the waste management infrastructure. Any trash or sanitary wastewater generated would represent small fractions of the same types of waste generated by all site personnel and would be managed with no impacts on site infrastructure.</td></tr>
<tr><td>Land Use and Aesthetics</td><td colspan="5">Discussion: Container storage, maintenance, and handling activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be no new significant construction and no change in land use. Therefore, potential impacts of the No Action and Action Alternatives on land use and aesthetics would be minor.</td></tr>
<tr><td>Cultural Resources</td><td colspan="5">Discussion: Container storage, maintenance, handling activities, and routine shipping of wastes off-site would occur within the industrialized areas of Paducah and Portsmouth and there would be no new significant construction. The existing storage yards at Paducah and Portsmouth are located in previously disturbed areas that were graded during original storage yard construction, and are unlikely to contain cultural properties or resources listed on or eligible for listing on the NRHP. There would be no impacts and no effects on historic properties at either location. In addition, there would be no impacts on religious or sacred sites, burial sites, or resources significant to Native Americans because none have been identified at these locations.</td></tr>
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Resource Area / Parameter	Paducah		Portsmouth	
	Action Alternatives	No Action	Action Alternatives	No Action
Environmental Justice	**Discussion:** Minimal impacts on the general public related to air quality, climate, noise, and water resources have been identified, including at the population and individual level. In addition, accidents were found to have negligible radiological and chemical consequences to the public. There would be no disproportionately high and adverse impacts on minority or low-income populations.			

Key: CEQ = Council on Environmental Quality; DOE = U.S. Department of Energy; DU = depleted uranium; DUF_6 = depleted uranium hexafluoride; EPA = U.S. Environmental Protection Agency; FTE = full time equivalent; GHG = greenhouse gas; HAP = hazardous air pollutant; HF = hydrogen fluoride; LCF = latent cancer fatality; LLW = low-level radioactive waste; MEI = maximally exposed (off-site) individual; MLLW = mixed low-level radioactive waste; NA = not applicable; NWS = new waste stream; NRHP = National Register of Historic Places; TSCA = Toxic Substances Control Act.

[a] Based on a population within 50 miles of the site of 534,000 people for Paducah and 677,000 people for Portsmouth.

[b] The hazard index (HI) is the sum of the hazard quotients for all chemicals to which an individual is exposed. A value less than 1 indicates that the exposed person is unlikely to develop adverse human health effects.

Notes: To convert cubic yards (solid) to cubic meters, multiply by 0.76456; gallons to liters, multiply by 3.78533; kilograms to pounds, multiply by 2.2046.

Table 2-5 Summary Comparison of Potential Environmental Impacts of Transportation and Disposal at Energy*Solutions*, Nevada National Security Site, or Waste Control Specialists LLC

Resource Area / Parameter		Action Alternatives			No Action
		Energy*Solutions*	NNSS	WCS	
Transportation DU oxide in cylinders option	***Train – Incident-free***				
	Crew dose (person-rem)	100	145[a]	84	0.2[c]
	Crew LCF	0 (0.06)	0 (0.09)[a]	0 (0.05)	0 (0.0002)
	Population dose (person-rem)	135	217[a]	136	0.4[c]
	Population LCF	0 (0.08)	0 (0.1)[a]	0 (0.08)	0 (0.0002)
	Train – Accidents				
	Population LCF risk	3×10^{-3}	3×10^{-3}(a)	5×10^{-3}	2×10^{-6}
	Traffic fatalities	1.0	2.0[a]	1.0	0.2[c]
	Truck – Incident-free				
	Crew dose (person-rem)	224	276	155	0.3[c]
	Crew LCF	0 (0.1)	0 (0.2)	0 (0.09)	0 (2×10^{-4})
	Population Dose (person-rem)	591	723	403	0.7[c]
	Population LCF	0 (0.4)	0 (0.4)	0 (0.2)	0 (4×10^{-4})
	Truck – Accidents				
	Population LCF risk	4×10^{-4}	5×10^{-4}	3×10^{-4}	1×10^{-7}
	Traffic fatalities	11	11	10	1[c]
Transportation DU oxide in bulk bags and 69,000 empty and heel cylinders[c]	***Train – Incident-free***				
	Crew dose (person-rem)	84	115[a]	71	0.2[c]
	Crew LCF	0 (0.05)	0 (0.07) [a]	0 (0.04)	0 (0.0002)
	Population dose (person-rem)	104	155[a]	104	0.4[c]
	Population LCF	0 (0.06)	0 (0.09)[a]	0 (0.06)	0 (0.0002)
	Train – Accidents				
	Population LCF risk	4×10^{-3}	3×10^{-3}(a)	$6x10^{-3}$	2×10^{-6}
	Traffic fatalities	1	1[a]	1	0.2[c]
	Truck – Incident-free				
	Crew Dose (person-rem)	120	148	83	0.3[c]
	Crew LCF	0 (0.07)	0 (0.09)	0 (0.05)	0 (2×10^{-4})
	Population dose (person-rem)	358	438	244	0.7 [c]
	Population LCF	0 (0.2)	0 (0.3)	0 (0.1)	0 (4×10^{-4})
	Truck – Accidents				
	Population LCF risk	3×10^{-4}	2×10^{-4}	3×10^{-4}	1×10^{-7}
	Traffic fatalities	5	5	5	1 [c]
	Discussion: Transport of radioactive wastes from Paducah and Portsmouth to the disposal sites would likely result in no LCFs, but there could be nonradiological fatalities from trauma during the accident.				

Resource Area / Parameter		Action Alternatives			No Action
		Energy*Solutions*	NNSS	WCS	
Transport of CaF_2[d]	**Truck:** Traffic Fatalities	6.4	7.0	5.8	7.0 [c]
	Train: Traffic Fatalities	1.0	2.5[a]	1.2	2.5 [c]
	Discussion: Transport of CaF_2 from Paducah and Portsmouth to the disposal sites could result in nonradiological fatalities from trauma during an accident.				
Waste Management (cubic yards) Percent of disposal facility capacity in parenthesis	LLW – DU oxide	386,000 (100)[b]	386,000 (22)	386,000 (40)	NA
	LLW – ancillary waste	230 (0.0056)	230 (0.013)	230 (0.024)	370 (0.0088 to 0.038)
	MLLW – ancillary waste	1.5 (0.00066)	1.5 (0.00010)	1.5 (0.00016)	2.4 (0.00025 to 0.0016)
	LLW – intact empty and heel cylinders	78,300 (1.9)	78,300 (4.4)	78,300 (8.2)	78,300 (1.9 to 8.2)
	LLW – volume-reduced empty and heel cylinders (if bulk bags were used)	38,600 (0.9)	38,600 (2.2)	38,600 (4.0)	NA
	LLW – CaF_2	225,000 (5.4)	225,000 (13)	225,000 (24)	225,000 (5.4 to 24)
	Discussion: Wastes would be within the capacities of the three disposal facilities.				
Greenhouse Gas Emissions (CO_2e tons/yr)	***Train Transport***	344	2.039[a]	232	1,890 [a]
	Truck Transport	13,977	17,564	9,528	6,738
	Discussion: Total annual GHG emissions from transportation of waste to the disposal sites would be minimal in comparison to national GHG emissions from train and truck transportation of 52,500,000 and 449,100,000 tons per year, respectively.				

Key: CO_2e = carbon dioxide equivalents; DOE = U.S. Department of Energy; DU = depleted uranium; GHG = greenhouse gas; LCF = latent cancer fatality; LLW = low-level radioactive waste; MEI = maximally exposed individual; MLLW = mixed low-level radioactive waste; NA = not applicable; NNSS = Nevada National Security Site; WCS = Waste Control Specialists LLC.

[a] Because NNSS lacks a direct rail connection for waste delivery, truck transports were evaluated for shipments from an intermodal facility to NNSS. For purposes of analysis and consistent with the NNSS SWEIS (DOE 2013a); the intermodal facility was assumed to be the rail yard in Barstow, California. The impacts for the entire transportation route are reported in this table.

[b] DU oxide would be disposed of in a separate disposal unit sized to receive all DU oxide waste. Therefore, the percent capacity will always be 100 percent.

[c] Transportation impacts for the No Action Alternative reflect the risk from transporting 14,000 intact empty and heel cylinders and CaF_2 to NNSS, which reflect the maximum risks because of the larger distance.

[d] Although conservatively considered LLW for purposes of disposal, the CaF_2 has such low levels of radiation it would provide a negligible dose to the crew and the public during transport. The impacts of the transport of CaF_2, if it were to occur, could lead to additional traffic fatalities.

[e] Bulk bags are not appropriate for long-term storage and, therefore, would not be used for long-term storage of DU oxide under the No Action Alternative.

Note: To convert cubic yards to cubic meters, multiply by 0.76456.

2.4.3 Cumulative Impacts

CEQ regulations define cumulative impacts as the effects on the environment that result from implementing the Proposed Action or any of its alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the other actions (40 CFR 1508.7). Thus, the cumulative impacts of an action can be viewed as the total impact on a resource, ecosystem, or human community of that action and all other activities affecting that resource irrespective of the source. Noteworthy cumulative impacts can result from individually small, but collectively significant, effects of all actions.

Cumulative impacts were assessed by combining the effects of alternative activities evaluated in this *DU Oxide SEIS* with the effects of other past, present, and reasonably foreseeable actions in the regions of influence (ROIs). These actions may occur at different times and locations and may not be truly additive. The effects were combined irrespective of the time and location of the impact to envelop any uncertainties in the projected activities and their effects. This approach produces a conservative estimation of cumulative impacts for the activities considered.

This section summarizes the cumulative impacts of activities at Paducah and Portsmouth, disposal of DU oxide and other wastes at the Energy*Solutions*, NNSS, and WCS disposal sites, and nationwide impacts from transportation and on climate change.

Paducah and Portsmouth: DOE's missions involve ongoing activities at Paducah and Portsmouth including continued management of DUF_6 cylinders; operation of the facilities for DUF_6-to-DU oxide conversion; waste management; decontamination, decommissioning, and demolition (DD&D) of surplus facilities; and environmental remediation (contributing to "Existing Conditions" in Tables 2-6 and 2-7). The affected environment information presented in Chapter 3 of this *DU Oxide SEIS* reflects the impacts of ongoing activities at Paducah and Portsmouth. Future activities that are being considered for Paducah include additional DD&D of surplus facilities, disposal of LLW from remediation (i.e., Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]) activities in an on-site disposal facility, land and facilities transfers, conversion of additional commercially generated DUF_6,[20] and construction of a laser enrichment facility. Future activities at Portsmouth include additional DD&D of surplus facilities, disposal of LLW from remediation (CERCLA) activities in an on-site disposal facility, land and facilities transfers, and conversion of additional commercially generated DUF_6. Other actions occurring in the ROIs near Paducah and Portsmouth that could contribute to current and future cumulative impacts include electrical power generation, conversion of uranium ore to UF_6, and industrial and commercial development. For more information, see Chapter 4, Section 4.5, of this *DU Oxide SEIS*.

As summarized in Section 2.4.2, the alternatives evaluated in this *DU Oxide SEIS* would be expected to cause little to no impacts on the following resource areas: site infrastructure, air quality

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[20] In anticipation of the potential future receipt of commercial DUF_6, DOE has estimated the impacts from management of 150,000 metric tons (approximately 12,500 cylinders) of commercial DUF_6. The detailed analysis of the impacts of the receipt, conversion, storage, handling and disposal of commercial DUF_6 is presented in Appendix C of this DU Oxide SEIS. For purposes of the cumulative impacts analysis in this SEIS and as a conservative measure of impacts, DOE assumes that the entire mass of commercial DUF_6 (150,000 metric tons) could be managed at either Paducah or Portsmouth.

and noise, geology and soils, water resources, biotic resources, socioeconomics, land use, cultural resources, and environmental justice in the Paducah and Portsmouth ROIs. Because the alternatives would be expected to produce little or no impacts on these resource areas, they would not substantially contribute to cumulative impacts. Thus, this section analyzes cumulative impacts on the remaining resource areas: public and occupational health and safety and waste management for the Paducah and Portsmouth ROIs. The results of the cumulative impacts analyses for Paducah and Portsmouth are summarized in **Tables 2-6** and **2-7**, respectively.

Also note that under the Action Alternatives, the impacts of management of the DU oxide at Paducah and Portsmouth would cease after the material is shipped off site for reuse or disposal. This is in contrast to the No Action Alternative, where storage of the DU oxide at Paducah and Portsmouth was assumed to occur for 100 years and could continue indefinitely.

On November 19, 2019, DOE published the *Supplement Analysis (SA) for Bulk Hydrogen Storage Construction and Operation at the Paducah and Portsmouth* DUF_6 *Sites* (DOE/EIS-0359-SA-02 and EIS-0360-SA-02) (DOE 2019). The action analyzed in that SA, installation and operation of a bulk hydrogen storage backup supply to the plant hydrogen supply system at each conversion facility such that uninterrupted hydrogen supply is maintained for plant operations, would not affect the quantity of DU oxide conversion product or other materials that would be dispositioned in the action analyzed in this *DU Oxide SEIS*, would not substantially change the impacts of conversion facilities operation, and therefore would not substantially contribute to cumulative impacts.

As shown in Tables 2-6 and 2-7, the cumulative collective radiological exposure to the off-site population would be well below the maximum DOE dose limit of 100 millirem per year to the off-site maximally exposed individual (MEI) for the No Action and Action Alternatives and below the limit of 25 millirem per year specified in 40 CFR Part 190 for uranium fuel cycle facilities. Doses to individual involved workers would be below the regulatory limit of 5,000 millirem per year (10 CFR Part 835) and less than an administrative limit of 2,000 millirem per year (DOE 2017f).

As described in Chapter 4, Sections 4.1.1 and 4.2.1 of this *DU Oxide SEIS*, impacts associated with chemical exposure are expected to be very small under the No Action and Action Alternatives, respectively. Impacts from the cumulative exposure to chemicals are unlikely due to regulations that limit the release of hazardous chemicals, and the distances to other potential sources of these chemicals.

As shown in Tables 2-6 and 2-7, the alternatives evaluated in this *DU Oxide SEIS* would generate LLW in the form of empty and heel cylinders, CaF_2, and small quantities of ancillary LLW and MLLW. The quantities of waste generated under the alternatives evaluated in this SEIS could be a large percentage of cumulative waste generation. The cumulative quantities of all wastes generated from activities at Paducah and Portsmouth would be managed using existing and planned on-site[21] and off-site capabilities (see Chapter 3, Sections 3.1.8 and 3.2.8) and would not be expected to result in substantial cumulative impacts on the waste management infrastructure represented by those facilities.

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[21] No LLW generated under the alternatives evaluated in this DU Oxide SEIS are planned for on-site disposal.

Table 2-6 Annual Cumulative Impacts at the Paducah Site

Impact Category	Existing Conditions[a]	*DU Oxide SEIS* Alternatives[b]		Commercial Conversion Scenarios[i]		Other Actions[d]	Cumulative Impacts[e]	
		Action Alternatives	No Action Alternative	Conversion and Disposal	Conversion and Storage		Action Alternatives	No Action Alternative
Public and Occupational Safety and Health								
Worker dose[f] (person-rem/yr)	6.2	3.6	1.2	16[j]	17[j]	14.7[g]	49.5	39.1
Worker LCF	0 (0.004)	0 (2×10^{-3})	0 (7×10^{-4})	0 (0.01)[j]	0 (0.01)[j]	0 (0.01)[g]	0 (0.01)	0 (0.01)
Public dose (person-rem/yr)	0.89	0.01	0.01	0.003	0.003	3.81[g]	4.7	4.7
Public LCF	0 (0.0005)	0 (5×10^{-6})	0 (5×10^{-6})	0 (2×10^{-6})	0 (2×10^{-6})	0 (0.002)[g]	0 (0.003)	0 (0.003)
Off-site MEI dose (millirem/yr)	4.5[j]	5.0[j]	5.0[j]	0.2	0.2	0.57[g7]	6.1[h,i]	6.1[h,i]
Waste Management								
LLW (including empty and heel cylinders and CaF_2) (yd^3/yr)	210	6,030[i]	6,030[j]	5,180	5,180	92[hk]	6.030[l]	6,030[l]
MLLW (yd^3/yr)	1.4	0.014	0.014	0.014	0.014	52[k]	52[l]	52[l]

Key: DD&D = decontamination, decommissioning, and demolition; DU = depleted uranium; LCF = latent cancer fatality; LLW = low-level radioactive waste; MEI = maximally exposed individual; MLLW = mixed low-level radioactive waste; OSWDF = On-Site Waste Disposal Facility; SEIS = supplemental environmental impact statement; yd^3 = cubic yard; yr = year.

[a] Based on information presented in Chapter 3, Section 3.1, of this *DU Oxide SEIS*.

[b] Based on results presented in Chapter 4, Sections 4.1.1 and 4.2.1 of this *DU Oxide SEIS*.

[c] Impacts from the conversion of 150,000 metric tons (165,000 tons) of commercial DUF_6 and storage or disposal of the converted commercial DU oxide (see Appendix C of this *DU Oxide SEIS*).

[d] Includes impacts of other actions as described in Section 4.5.2 of this *DU Oxide SEIS*.

[e] Cumulative impacts equal the sum of the impacts of the management alternative and other past, present, and reasonably foreseeable future actions. The cumulative impacts of the Action Alternatives include the sum of existing conditions; *DU Oxide SEIS* alternatives – Action Alternatives; commercial conversion scenarios – Conversion and Disposal; and other actions. The cumulative impacts of the No Action Alternative include the sum of existing conditions; *DU Oxide SEIS* alternatives – No Action Alternative; commercial conversion scenarios – Conversion and Storage; and other actions. This is a conservative assumption because some site activities are counted twice and some will not occur concurrently. For example: (1) LLW and MLLW from existing conditions include wastes generated from conversion of DOE DUF_6 to DU oxide and (2) conversion of DOE DUF_6 to DU oxide may not occur in the same years that conversion of commercial DUF_6 to DU oxide would occur.

[f] Includes involved and noninvolved worker doses.

[g] Impacts from operation of the Honeywell Metropolis Works, a uranium conversion facility in Metropolis, Illinois (Enercon 2017; NRC 2006).

[h] The MEI doses occur at different locations for different facilities. Therefore, adding the MEI doses is a very conservative estimate of potential cumulative doses to an MEI.

[i] The off-site MEI dose reported in Section 3.1.6 of this SEIS for existing conditions and in Sections 4.1.1.6 and 4.2.1.6 for each of the alternatives includes the same direct radiation dose from cylinders stored in the cylinder yard (4.2 millirem per year). When calculating the cumulative MEI dose, this direct exposure was only counted once.

[j] The increased generation of LLW during the alternatives primarily reflects the assumed increased generation of LLW in the form of empty and heel cylinders and CaF_2 (PPPO 2018). DU oxide is not considered in this estimate because it is a resource until shipped off site for disposal.

[k] Reflects generation of LLW and MLLW from DD&D of the oxide conversion capability (DOE 2004a). Approximately 3.2 million cubic yards (2.5 million cubic meters) of lightly contaminated LLW, 70,708 cubic yards (54,060 cubic meters) of MLLW, and 356 cubic yards (272 cubic meters) of TSCA waste could be generated from future environmental restoration and DD&D activities over the period from 2018 through 2065 (see Table 3-10). DOE is currently evaluating the potential to dispose of 3.2 million cubic yards of lightly contaminated LLW in the OSWDF.

[l] The scenarios for conversion of commercial DUF_6 were not added to the cumulative annual impacts because the majority of these activities would not take place at the same time as the management of DOE DU oxide. Therefore, only the maximum values among the *DU Oxide SEIS* alternatives, other actions, and the commercial conversion scenarios were used in the totals.

Sources: DOE 2004a; PPPO 2018

Table 2-7 Annual Cumulative Impacts at the Portsmouth Site

Impact Category	Existing Conditions[a]	Impacts of *DU Oxide SEIS* Alternatives[b]		Commercial Conversion Scenarios[c]		Impacts of Other Actions[d]	Cumulative Impacts[e]	
		Action Alternatives	No Action Alternative	Conversion and Disposal	Conversion and Storage		Action Alternatives	No Action Alternative
Public and Occupational Safety and Health								
Worker dose[f] (person-rem/yr)	2.5	3.8	0.76	13	13	No Data	19.3	16.3
Worker LCF	0 (3×10-4)	0 (2.3×10^{-3})	0 (4.6×10^{-4})	0 (0.008)	0 (0.008)	No Data	0 (0.01)	0 (0.01)
Public dose (person-rem/yr)	0.22	0.002	0.002	2×10^{-3}	2×10^{-3}	No Data	0.22	0.22
Public LCF	0 (1×10^{-4})	0 (1.2×10^{-6})	0 (1.2×10^{-6})	0 (9×10^{-7})	0 (9×10^{-7})	No Data	0 (1×10^{-4})	0 (1×10^{-4})
Off-site MEI dose (millirem/yr)	1.1	1.3	1.3	0.4	0.4	No Data	2.8[g]	2.8[g]
Waste Management								
LLW (including empty and heel cylinders and CaF_2) (yd^3/yr)	160	4,470[h]	4,470[h]	4,020	4,020	92[i]	4,470[j]	4,470[j]
MLLW (yd^3/yr)	1.0	0.010	0.010	0.010	0.010	52[i]	52[j]	52[j]

Key: DD&D = decontamination, decommissioning, and demolition; DU = depleted uranium; LCF = latent cancer fatality; LLW = low-level radioactive waste; MEI = maximally exposed individual; MLLW = mixed low-level radioactive waste; OSWDF = On-Site Waste Disposal Facility; SEIS = supplemental environmental impact statement; yd^3 = cubic yard; yr = year.

[a] Based on information presented in Chapter 3, Section 3.2 of this *DU Oxide SEIS*.

[b] Based on results presented in Chapter 4, Sections 4.1.1 and 4.2.1 of this *DU Oxide SEIS*. No action impacts were considered over 100 years. Action Alternative impacts were considered for 22 or 32 years, whichever had the greatest impacts.

[c] Impacts from the conversion of 150,000 metric tons (165,000 tons) of commercial DUF_6 and storage or disposal of the converted commercial DU oxide (see Appendix C of this SEIS).

[d] Includes impacts of other actions as described in Section 4.5.3. The impacts of other future actions on public and occupational safety and health is unknown, but would be limited by compliance with applicable regulations.

[e] Cumulative impacts equal the sum of the impacts of the management alternative and other past, present, and reasonably foreseeable future actions. The cumulative impacts of the Action Alternatives include the sum of existing conditions; *DU Oxide SEIS* alternatives – Action Alternatives; commercial conversion scenarios – Conversion and Disposal; and other actions. The cumulative impacts of the No Action Alternative include the sum of existing conditions; *DU Oxide SEIS* alternatives – No Action Alternative; commercial conversion scenarios – Conversion and Storage; and other actions. This is a conservative assumption because some site activities are counted twice and some will not occur concurrently. For example: (1) LLW and MLLW from existing conditions include wastes generated from conversion of DOE DUF_6 to DU oxide and (2) conversion of DOE DUF_6 to DU oxide may not occur in the same years that conversion of commercial DUF_6 to DU oxide would occur.

[f] Includes involved worker and noninvolved worker doses.

[g] The MEI doses occur at different locations for different facilities operations. Therefore, adding the MEI doses is a very conservative estimate of potential cumulative doses to an MEI.

[h] The increased generation of LLW during the alternatives primarily reflects the assumed increased generation of LLW in the form of empty and heel cylinders and CaF_2 (PPPO 2018). DU oxide is not considered in this estimate because it is a resource until shipped off site for disposal.

[i] Reflects generation of LLW and MLLW from DD&D of the oxide conversion capability (DOE 2004b). Approximately 1.26 million cubic yards (0.96 million cubic meters) of lightly contaminated LLW, and 100 cubic yards (76 cubic meters) of MLLW are estimated to be generated from future environmental restoration and DD&D activities (see Table 3-23). Approximately 1.14 million cubic yards (0.87 million cubic meters) of LLW are estimated to be disposed of in the OSWDF.

[j] The scenarios for conversion of commercial DUF_6 were not added to the cumulative annual impacts because the majority of these activities would not take place at the same time as the management of DOE DU oxide. Therefore, only the maximum values among the *DU Oxide SEIS* alternatives, other actions, and the commercial conversion scenarios were used in the totals.

Sources: DOE 2004b; PPPO 2018

Waste Disposal Facilities: As shown in **Table 2-8**, the cumulative impacts of the disposal of DU oxide and other wastes would not exceed the planned capacities of any evaluated disposal facility, even if each facility received all DU oxide and other waste from both Paducah and Portsmouth. However, as discussed in Sections 4.5.2.1 and 4.5.3.1, about 3.6 million cubic yards (2.75 million cubic meters) of waste from environmental restoration and DD&D activities may be generated at Paducah as well as about 1.36 million cubic yards (1.04 million cubic meters) at Portsmouth. At this time, the total quantities of LLW and MLLW that would be generated from DD&D activities that could require off-site disposition is uncertain, but initial estimates indicate 9,559 cubic yards (7,308 cubic meters) of LLW and 70,708 cubic yards (54,061 cubic meters) of MLLW from Paducah, and approximately 53,600 cubic yards (40,980 cubic meters) of LLW and MLLW from Portsmouth would be disposed of at off-site facilities, such as Energy*Solutions*, NNSS, and WCS. In the event that most of this waste would require off-site disposition, then the total quantity of waste that could be disposed of at any single facility could challenge that facility's disposal capacity. Impacts on any facility's capacity could be reduced by distributing waste shipments to multiple disposal facilities, or by developing additional capacity at one or more disposal sites.

Transportation: Shipments associated with the alternatives evaluated in this *DU Oxide SEIS* could result in maximum doses (and latent cancer fatalities [LCFs]) of 145 person-rem (0 [0.09] LCF) to workers and 217 person-rem (0 [0.1] LCF) to the public for train transportation. Maximum doses (and LCFs) for truck transportation would be 276 person-rem (0 [0.2] LCF) to workers and 723 person-rem (0 [0.4] LCF) to the public.

Shipments associated with DOE management of commercial DUF_6 could result in additional maximum doses (and LCFs) of 30 person-rem (0 [0.02] LCF) to workers and 43 person-rem (0 [0.03] LCF) to the public for train transportation. Maximum doses (and LCFs) for truck transportation would be an additional 55 person-rem (0 [0.03] LCF) to workers and 144 person-rem (0 [0.09] LCF) to the public.

Based on the cumulative impacts analysis presented in Table 4-48 of the *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement* (DOE 2015), other past, present, and reasonably foreseeable radioactive material transport activities could result in population doses (and LCFs) for workers and the public of 421,300 person-rem (253 LCFs) and 436,800 person-rem (262 LCFs), respectively. Therefore, the impacts of transportation activities related to the actions evaluated in this *DU Oxide SEIS*, including DOE management of commercial DUF_6, would be very small in comparison and would not be expected to appreciably add to cumulative impacts.

Climate Change: The "natural greenhouse effect" is the process by which part of terrestrial radiation is absorbed by gases in the atmosphere, warming the Earth's surface and atmosphere. This greenhouse effect and the Earth's radiation balance are affected largely by water vapor, carbon dioxide (CO_2), and trace gases, which absorb infrared radiation and are referred to as "greenhouse gases" (GHGs) (DOE 2015a)

Table 2-8 Cumulative Impacts on Radioactive Waste Disposal Capacity(cubic yards)

		Wastes Generated at Paducah and Portsmouth						Cumulative Total (Percent of Capacity in Parenthesis)[e]	
			DU Oxide SEIS Alternatives[c]		Commercial Conversion Scenarios				
Waste	**Facility Capacity[a]**	**Existing Operations[b]**	**Action Alternatives**	**No Action Alternative**	**Conversion and Disposal**	**Conversion and Storage**	**Other Actions[d]**	**Action Alternatives**	**No Action Alternative**
Energy*Solutions*									
LLW – DU oxide	Dedicated cell	NA	386,000	0	69,900	0	NA	456,000 (100)[f]	0 (NA)
LLW – empty and heel cylinders	4,200,000	14,300	78,500	78,300	4,200	4,200	520	97,500 (2.3)	97,600 (2.3)
LLW – CaF$_2$	4,200,000	NA	225,000	225,000	40,600	40.600	NA	266,000 (6.4)	266,000 (6.4)
MLLW	358,000	92	1.5	2.4	1.1	1.4	290	380 (0.10)	380 (0.10)
Nevada National Security Site									
LLW – DU oxide	1,800,000	NA	386,000	0	69,900	0	NA	456,000 (26)	0 (NA)
LLW – empty and heel cylinders	1,800,000	14,300	78,500	78,300	4,200	4,200	520	97,500 (5.5)	97,600 (5.5)
LLW – CaF$_2$	1,800,000	NA	225,000	225,000	40,600	40,600	NA	266,000 (15)	266,000 (15)
MLLW	148,000	92	1.5	2.4	1.1	1.4	290	380 (0.26)	380 (0.26)
Waste Control Specialists									
LLW – DU oxide	955,000	NA	386,000	0	69,900	0	NA	456,000 (48)	0 (NA)
LLW – empty and heel cylinders	955,000	14,300	78,500	78,300	4,200	4,200	520	97,500 (10)	97,600 (11)
LLW – CaF$_2$	955,000	NA	225,000	225,000	40,600	40,600	NA	266,000 (28)	266,000 (28)
MLLW	955,000	92	1.5	2.4	1.1	1.4	290	380 (0.04)	380 (0.04)

Key: DOE = U.S. Department of Energy; DU = depleted uranium; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NA = not applicable; SEIS = supplemental environmental impact statement.

[a] Based on information presented in Chapter 3, Sections 3.3, 3.4, and 3.5, of this *DU Oxide SEIS*.

[b] Based on current generation rates for LLW and MLLW as described in Chapter 3, Sections 3.1.8 and 3.2.8, of this *DU Oxide SEIS*, except for empty and heel cylinders, for 44 and 32 years, respectively, for Paducah and Portsmouth. Current waste generation is due to on-site activities including DU oxide conversion and ongoing remediation and decontamination and decommissioning activities.

[c] Based on results presented in Chapter 4, Sections 4.1, 4.2, 4.3, and 4.4, of this *DU Oxide SEIS*. No Action Alternative impacts were considered over 100 years. Action Alternative impacts were considered for operations over 44 or 32 years, respectively, for Paducah and Portsmouth. Wastes include those from DU oxide, ancillary LLW and MLLW, empty and heel cylinders, and CaF$_2$.

[d] Reflects waste from decontamination and decommissioning of the oxide conversion capabilities at Paducah and Portsmouth (DOE 2004a, 2004b). Additional waste will be generated from future environmental restoration and DD&D activities at Paducah and Portsmouth. Initial estimates indicate 9,559 cubic yards (7,308 cubic meters) of additional LLW and 70,708 cubic yards (54,061 cubic meters) of MLLW from Paducah and approximately 53,600 cubic yards (40,980 cubic meters) of additional LLW and MLLW from Portsmouth would be disposed of at off-site facilities, such as Energy*Solutions*, NNSS, and WCS (see Section 4.5.4).

[e] Cumulative impacts equal the sum of the impacts of the alternative and other past, present, and reasonably foreseeable future actions. Volumes and projected impacts on waste disposal facility capacities reflect the assumption that each facility receives all LLW and MLLW from both Paducah and Portsmouth. The Action Alternatives include waste from the Conversion and Disposal Scenario; the No Action Alternative includes waste from the Conversion and Storage Scenario.

[f] There would be no impacts on disposal capacity at Energy*Solutions* from disposal of DU oxide because, as described in Chapter 3, Section 3.3, of this *DU Oxide SEIS*, the disposal unit that would receive the DU oxide would be separate from the other disposal units at the site and, would be designed to receive all DU oxide that may be sent from both Paducah and Portsmouth.

Notes: To convert cubic yards to cubic meters, multiply by 0.76456.

The GHGs emitted by the activities analyzed in this *DU Oxide SEIS* would add a small increment to emissions of these gases in the United States and the world. Overall GHG emissions in the United States during 2014 totaled about 7.57 billion tons (6.87 billion metric tons) of carbon dioxide equivalent (CO_2e) (EPA 2016a). By way of comparison, the maximum annual CO_2e emissions under the *DU Oxide SEIS* alternatives would be approximately 17,564 tons (15,934 metric tons), an exceedingly small percentage of the United States' total emissions. Emissions from the Proposed Action could contribute in a small way to the climate change impacts described above.

2.5 PREFERRED ALTERNATIVE

In accordance with CEQ regulations at 40 CFR 1502.14(e), this section identifies DOE's Preferred Alternative, or alternatives. As described in Section 2.2.2, this *DU Oxide SEIS* evaluated three Action Alternatives for the Proposed Action and the No Action Alternative. If a beneficial use cannot be found for the DU oxide, all or a portion of the inventory may be characterized as waste and may need to be disposed of. The Action Alternatives include transporting and disposing of the DU oxide at one or more of three LLW disposal sites (i.e., Energy*Solutions*, NNSS, or WCS). DOE's Preferred Alternative would be to dispose of DU oxide at one or more of the disposal sites (NNSS, Energy*Solutions*, and/or WCS), understanding that any disposal location(s) must have a current license or authorization and capacity to dispose of DU oxide at the time shipping to that location is initiated. While DOE's Preferred Alternative is one or a combination of the Action Alternatives over the No Action Alternative, DOE does not have a preference among the Action Alternatives. Any decision related to the Proposed Action may also depend on competitive procurement practices necessary to contract for the transportation and disposal of the DU oxide. The decision regarding which alternative(s) DOE selects would be documented in a ROD, in accordance with 10 CFR 1021.315. The ROD would be published in the *Federal Register* no sooner than 30 days after publication of this *Final DU Oxide SEIS*. DOE will consider cost, schedule, worker and public safety, environmental impacts, public comments, and strategic and policy considerations in making the decision.

3 AFFECTED ENVIRONMENT

In accordance with the CEQ's NEPA regulations (40 CFR Parts 1500–1508) and DOE's NEPA implementing procedures (10 CFR Part 1021), this chapter succinctly describes those areas that could be affected by the Proposed Action. This chapter includes descriptions of the physical and natural environment and the ROI at Paducah and Portsmouth, the two sites where DUF_6 is currently stored. This chapter also includes descriptions of three potential sites for the disposal of DU oxide: the Energy*Solutions* site near Clive, Utah; the NNSS in Nye County, Nevada; and the WCS site near Andrews, Texas.

The affected environment descriptions in this chapter provide the context for understanding the potential direct, indirect, and cumulative environmental effects of each of the alternatives described in Chapter 4 of this *DU Oxide SEIS*, and serve as baselines from which any potential environmental impacts can be evaluated.

The discussion is categorized by resource area to ensure that all relevant issues are included. This chapter discusses the following resource areas, and includes other topic areas that support the impact assessment in Chapter 4.

- Site Infrastructure
- Climate, Air Quality, and Noise
- Geology and Soils
- Water Resources
- Biotic Resources
- Public and Occupational Safety and Health
- Socioeconomics
- Waste Management
- Land Use and Aesthetics
- Cultural Resources
- Environmental Justice

3.1 PADUCAH SITE

This section presents a brief description of the affected environment at the Paducah Site commensurate with the level of analysis required in this *DU Oxide SEIS*. Additional information on the affected environment for Paducah is presented in the *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Paducah, Kentucky, Site* (DOE 2004a) and the *Paducah Site Annual Site Environmental Report for Calendar Year 2015* (DOE 2017a).

The Paducah Site is located in western Kentucky, in the northwestern portion of rural McCracken County, about 10 miles (16 kilometers) west of the City of Paducah and 3.5 miles (5.6 kilometers) south of the Ohio River (see Chapter 2, Figure 2-1). The Paducah Site encompasses 3,556 acres (1,439 hectares) (DOE 2017a). Approximately 837 acres (339 hectares) of the site are within a fenced security area, approximately 600 acres (243 hectares) are located outside the security fence, 133 acres (54 hectares) are in acquired easements, and the remaining 1,986 acres (803 hectares) are licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife

Management Area (WKWMA) for use in wildlife conservation and for recreational purposes (DOE 2004a, 2017d). The former Paducah Gaseous Diffusion Plant (Paducah GDP) occupies a 750-acre (303-hectare) area within the Paducah Site fenced security area (see Chapter 2, Figure 2-6). The fenced area also contains the Conversion Facility. The Paducah GDP included about 115 buildings with a combined floor space of approximately 8.2 million square feet (0.76 million square meters) (DOE 2004a). The Paducah GDP ceased operations in 2012 and is now undergoing DD&D activities (DOE 2015b). The Paducah Conversion Facility includes four major buildings with a combined floor space of about 87,693 square feet (8,147 square meters) (PPPO 2018).

3.1.1 Site Infrastructure

3.1.1.1 Transportation

The Paducah Site is within a well-established transportation network. This includes Interstate Highway 24; several U.S., Kentucky, and local highways; the Paducah and Louisville Railway; and the Barkley and Metropolis Municipal airports. Because McCracken County is predominantly a residential, commercial, industrial, and medical services area, its traffic is heavily influenced by peak travel patterns of commuting workers (DOE 2015b).

Traffic on Interstate Highway 24 ranges from 26,400 to 35,500 cars per day (DOE 2015b). In addition to Interstate Highway 24, U.S. Highways 60 and 45 presently carry more than 25,000 vehicles per day. Paducah Site-associated traffic is about 1,200 vehicle trips a day, which is less than 5 percent of daily traffic volume on U.S. Highway 60 and Interstate Highway 24 (DOE 2015b).

The Paducah Site is served by several rail lines, and there are nine miles of rail spurs providing access throughout the site; rail spurs lie in close proximity to the cylinder storage yards (DOE 2012a).

The Paducah Site can be served indirectly by barge transportation on the Ohio River (PPPO 2018). The nearest existing barge terminal is approximately 20 to 30 miles (32 to 48 kilometers) from the Paducah Site, requiring on-land transport by truck or train (DOE 2004a). Loading and unloading of cargo is done by a flat top tower crane at the Paducah-McCracken County Riverport Authority open-air terminal. The Ohio River provides barge access to the Gulf of Mexico via the Mississippi River (PPPO 2018).

Commercial air service to the Paducah Site is limited. Barkley Regional Airport, the nearest commercial airport, is located approximately 10 miles (16 kilometers) east of the plant (PPPO 2018). This airport provides jet service to Chicago O’Hare Airport. Barkley Regional Airport also serves private aircraft owners and business travelers. Two international airports are located within a 3-hour drive of the Paducah Site: the St. Louis Lambert International Airport and the Nashville International Airport (PPPO 2018).

3.1.1.2 Water

At present, Paducah gets all of its water from the Ohio River through an intake near the Shawnee Fossil Plant (DOE 2015b). The amount of water withdrawn from the Ohio River varies, but it averaged about 15 to 26 million gallons (57 to 98 million liters) per day with peaks of up to 30 to

32 million gallons (114 to 121 million liters) per day during the 8-year period through 2012 when the Paducah GDP was still operating (DOE 2012a, 2015b). Groundwater directly beneath Paducah is not used as a domestic, municipal, or industrial water supply.

With the USEC shutdown of the Paducah GDP and transition of the Paducah Site back to DOE, the total amount of water withdrawn from the Ohio River has decreased significantly and usage varies from 3 to 4 million gallons (11 to 15 million liters) per day (PPPO 2018). DOE treats the water on the site before using it, and about 15 percent of the flow receives additional treatment and goes to the potable water system (DOE 2015b). The design capacity for the potable water system is 8.6 million gallons per day (PPPO 2018).

3.1.1.3 Electricity

The Tennessee Valley Authority (TVA), Kentucky Utilities Company, Jackson Purchase Energy Corporation, and Electric Energy Corporation provide electricity to the Paducah Site (DOE 2015b). The TVA power grid is a generating system with more than 34,000 megawatts of generating capacity, which is about 5,000 megawatts above recent summer peak demand needs (DOE 2015b).

The Paducah Site historically operated four electrical switchyards to handle electrical requirements (DOE 2015c). These switchyards were found to be inefficient to operate and expensive to maintain. The Paducah GDP design enrichment capacity was 3,040 megawatts and operated approximately at a maximum of slightly above 2,000 megawatts. The future site projected peak demand is between 25 and 35 megawatts. In May 2015 a project was completed to supply the Paducah Site’s electrical requirements from a single switchyard. Projects are underway to separate the remaining three switchyards from the external area electrical grid (PPPO 2018). With the termination of production activities, the average electrical power demand for 2017 was approximately 12 megawatts (PPPO 2018).

3.1.1.4 Natural Gas

Atmos Energy Corporation provides natural gas to the Paducah Site, local residences, and other buildings (DOE 2015b). Natural gas lines at the site are plentiful in the industrial area where most activities have taken place (DOE 2015b). The design capacity for the natural gas line supplying the Paducah site is 100 million cubic feet per hour (2.8 million cubic meters per hour). Natural gas usage at the site in 2017 was approximately 154,000 million cubic feet (4,360 million cubic meters) (PPPO 2018).

3.1.1.5 Steam

For more than 62 years, the Paducah Site operated three coal-fired boilers, each capable of supplying 100,000 pounds (45,000 kilograms) of steam per hour (DOE 2015d). The steam was used for site projects as well as building heat. The Paducah Site decommissioned these coal-fired boilers. The Paducah Site has installed five gas-fired package boiler units (22,500 pounds per hour each) to meet reduced site demands resulting from termination of gaseous diffusion plant operations. Two of the five units are capable of running on either gas or fuel oil. The new site demand of up to 100,000 pounds per hour can be provided by the installed package systems. A connection for a sixth package boiler is available should it be determined that additional steam capacity is required.

3.1.2 Climate, Air Quality, and Noise

3.1.2.1 Climate

The location of the Paducah Site is classified as the humid continental zone, characterized by warm summers and moderately cold winters (DOE 2017a). The annual average temperature for the period from 1981 through 2010 is 57.8 degrees Fahrenheit (°F) (14.9 degrees Celsius [°C]) (NWS 2016), with July the hottest month (average temperature of 79.0°F [26.1°C]) and January the coldest month (average temperature of 35°F [1.67°C]). Annual precipitation averages about 49.0 inches (124.5 centimeters), primarily as rain (DOE 2017a). Precipitation is relatively evenly distributed throughout the year but is somewhat higher in spring and summer than in winter and fall. Snowfall in Paducah averages 9.0 inches (22.86 centimeters) per year, typically occurring from December to March (NWS 2016). The comfort index,[22] which is based on humidity during the hot months, is a 28 out of 100, where higher is more comfortable. The U.S. average on the comfort index is 44 (Sperling 2016).

Wind data collected at Barkley Regional Airport about 5 miles (8 kilometers) to the southeast of the Paducah Site were evaluated. For the period from 1981 through 2010, the average wind speed was about 6.4 miles per hour (10 kilometers per hour) (NWS 2016). The dominant wind direction was from the south-southwest (DOE 2017a). The highest wind speed was approximately 37 miles per hour (60 kilometers per hour) from the west-southwest (NWS 2016).

Tornadoes are rare in the area surrounding the Paducah Site, and those that do occur are less frequent and destructive than those occurring in other parts of the Midwest. For the period from 2011 through 2015, only five tornadoes were reported in McCracken County, Kentucky (NCDC 2016). All of those tornadoes were relatively weak; at most, F2 on the Fujita tornado scale (average winds from 113 to 157 miles per hour).[23]

3.1.2.2 Air Quality

The Paducah Site is located near the center of the Paducah (Kentucky)-Cairo (Illinois) Interstate Air Quality Control Region (AQCR) (40 CFR 81.69), which includes 17 counties in Kentucky and 6 in Illinois. **Table 3-1** provides baseline annual emissions data obtained from the EPA's 2014 National Emissions Inventory (NEI) for McCracken County and the Paducah-Cairo AQCR (EPA 2018a). The data include emissions from point sources, area sources, and mobile sources. Point sources are stationary sources that can be identified by name and location. Area sources are stationary sources from which emissions are too low to track individually, such as a home or small office building, or a diffuse stationary source, such as wildfires or agricultural tilling. Mobile sources are any kind of vehicle or equipment with gasoline or diesel engine, an airplane, or a ship.

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[22] The comfort index gives a numerical value reflecting outdoor atmospheric conditions of temperature and humidity as a measure of comfort (or discomfort) during the warm season of the year.

[23] The Fujita Scale, developed by Tetsuya Fujita in 1971 at the University of Chicago, is a scale for rating tornado intensity, based primarily on the damage tornadoes inflict on human-built structures and vegetation. The scale ranges from F0 (less than 73 miles per hour average winds) to F5 (261 to 318 miles per hour average winds).

Currently, areas within the Paducah Site and its surrounding counties are in attainment for all National Ambient Air Quality Standards (NAAQS) for criteria air pollutants (EPA 2016b). The Kentucky State Ambient Air Quality Standards (SAAQS) for six criteria pollutants: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), particulate matter with a diameter less than or equal to 10 microns and 2.5 microns (PM_{10} and $PM_{2.5}$, respectively), and lead (Pb) are the same as the NAAQS (KAR 2016). Ozone is not emitted directly into the air but is created by chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) (EPA 2018b). Therefore, ozone is analyzed and reported as NO_x and VOCs throughout this document.

Table 3-1 Baseline Criteria Pollutant Emissions Inventory for McCracken County and the Paducah-Cairo AQCR

Region	Criteria Pollutant Emissions (tons per year)					
	CO	NO_2	PM_{10}	$PM_{2.5}$	SO_2	VOC
McCracken County	13,217	15,200	2,464	826	30,162	6,378
Paducah-Cairo Interstate AQCR	156,682	73,542	81,595	19,676	107,285	151,620

Key: AQCR = air quality control region; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Source: EPA 2018a

Major air pollution sources around the Paducah Site in Kentucky include the TVA’s coal-fired Shawnee Fossil Plant, about 3 miles (5 kilometers) northeast of the Paducah Site (Source Watch 2016). In Illinois, the Joppa Power Plant and Lafarge Corporation are major sources, located 7 miles (11 kilometers) north-northwest of the Paducah Site. The Paducah Site operates under Kentucky Department of Environmental Protection (KDEP) Title V Conditional Major, Construction/Operating Permit V-14-012 R1, issued on August 14, 2015. The Paducah Site has two emission points. Emission point EP 01 is the stack for the Conversion Building. Emission point EP 02 is the HF storage and load-out area. Air that is displaced during filling and emptying of HF storage tanks is vented through a dedicated scrubber system. On February 4, 2014, USEC applied for a renewal of its Title V permit. This permit application added 21 emergency motor emission units under 40 CFR Part 63, Subpart ZZZZ, “National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines.” On October 21, 2014, at the termination of USEC’s lease and prior to issuance of a renewed permit, USEC transferred its Title V Air Permit to Fluor Federal Services (FFS) (DOE 2016a).

KDEP issued a Title V Permit V-14-012 to FFS. On February 10, 2015, FFS applied to KDEP for a significant revision to the Title V permit that proposed adding five new low and ultra-low emission package boilers to replace three coal-fired boilers. KDEP issued the Title V permit revision, V-14-012 R1, on August 14, 2015 (DOE 2017a). The coal-fired boilers are no longer in use and have been replace by the efficient, low-emission boilers currently in operation.

Prevention of significant deterioration (PSD) regulations (40 CFR 52.21) limit the maximum allowable incremental increases in ambient concentrations SO_2, NO_2, and PM_{10} above established baseline levels. The PSD regulations, which are designed to protect ambient air quality in Class I and Class II attainment areas, apply to major new sources and major modifications to existing sources. Class I areas are areas of special national or regional natural, scenic, recreational, or historic value for which the PSD regulations provide special protection. Class I and Class II areas are subject to maximum limits on air quality degradation called air quality increments (often referred to as PSD increments). Class II area air quality increments are more stringent than the NAAQS, though less stringent than in Class I areas. The nearest Class I PSD areas are Mingo National Wildlife Refuge in Missouri, about 70 miles (113 kilometers) west of the Paducah Site, and Mammoth Cave National Park, about 140 miles (225 kilometers) east of the Paducah Site. These Class I areas are not located downwind of prevailing winds at the Paducah Site.

The "natural greenhouse effect" is the process by which part of the terrestrial infrared radiation is absorbed by gases in the atmosphere, thereby warming the Earth's surface and atmosphere. This greenhouse effect and the Earth's radiative balance are affected largely by water vapor, CO_2, and trace gases, all of which are absorbers of infrared radiation and commonly referred to as "greenhouse gases" (GHGs). Other trace gases include nitrous oxide, chlorofluorocarbons, methane, and sulfur hexafluoride. Current EPA reporting for the NEI does not include GHGs. CO_2, methane, and nitrous oxide annual GHG emissions data for both McCracken County and the Paducah-Cairo AQCR from the EPA's 2011 NEI are provided in **Table 3-2**.

Table 3-2 Baseline Greenhouse Gas Emissions Inventory for McCracken County and the Paducah-Cairo Interstate AQCR

Region of Interest	Greenhouse Gas (tons per year)			
	CO_2	CH_4	N_2O	Total CO_2e[a]
McCracken County	490,751	67	17	497,850
Paducah-Cairo AQCR	4,725,572	1,294	125	4,795,202

Key: AQCR = air quality control region; CH_4 = methane; CO_2 = carbon dioxide; CO_2e = carbon dioxide equivalent; N_2O = nitrous oxide.

[a] CO_2e is the internationally recognized measure of GHGs, which weights GHGs based on their Global Warming Potential (GWP) and the chemical's ability to impact global warming.

Source: EPA 2016c

3.1.2.3 Noise

The Noise Control Act of 1972, along with its subsequent amendments (Quiet Communities Act of 1978; 42 U.S.C. §§ 4901–4918), delegates authority to the states to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. The Commonwealth of Kentucky and McCracken County, where the Paducah Site is located, have no quantitative noise-limit regulations.

The EPA has recommended a maximum noise level of 55 A-weighted decibels (dBA) as the day-night average sound level (DNL) to protect against outdoor activity interference and annoyance; this is not a regulatory goal, but it is intentionally conservative to protect the most sensitive portion of the American population with an additional margin of safety (EPA 1974). For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an average noise level during a 24-hour period (L_{eq}/24 h) of 70 dBA or less.

The noise-producing activities within the Paducah Site are associated with remediation and construction activities and local traffic, similar to those at any other industrial site. During site operations, noise levels near the cooling towers are relatively high, but most noise sources are enclosed in the buildings. Another noise source is associated with train traffic in and out of the Paducah Site. In particular, train whistle noise, at a typical noise level of 95 to 115 dBA, is high at public grade crossings. Currently, train traffic noise is not a factor in the local noise environment because of infrequent traffic (DOE 2015b).

The Paducah Site is in a rural setting, and no residences or other sensitive receptor locations (e.g., schools, hospitals) are located in the immediate vicinity of any noisy on-site operations. The nearest sensitive receptor is located about 1 mile (2 kilometers) from the Paducah Site. Ambient noise levels around the Paducah Site are relatively low. Measurements taken at the nearest residence ranged from 44 to 47 dBA when the Paducah GDP was in operation (DOE 2004a). At nearby residences, noise emissions from the plant were reported as undetectable from background noise. While more recent noise data at nearby residences is not available, it is highly likely that current noise levels resulting from Paducah Site operations would be in a similar range (PPPO 2018). In general, the background environment is typical of rural areas; DNL is estimated to be about 52 dBA (EPA 1974) based on the population density in McCracken County.

3.1.3 Geology and Soil

3.1.3.1 Geology

Western Kentucky geology has gently rolling terrain between 330 and 500 feet (101 and 152 meters) above mean sea level. Within the boundaries of the Paducah Site security fence, the maximum variation in elevation is about 10 feet (3 meters) (DOE 2004a).

The stratigraphic sequence found beneath the Paducah Site is as follows (from oldest to youngest): limestone and shale bedrock; Clayton and McNairy Formations, sand with frequent lenses of silt and clay in its upper portions; Porters Creek Clay, silt with sand and clay interbeds (only beneath the southern portion of the Paducah Site); Continental Deposits, lower gravel or sandy gravel unit and an upper clay-sand unit; and loess, wind-blown silt. The combined thickness of the upper Continental Deposits and loess at Paducah is commonly about 60 feet (18 meters) (DOE 2004a, 2015b)

The Paducah Site is in the New Madrid Seismic Zone. No known faults underlie the Paducah Site (PPPO 2018). The largest recorded earthquakes in this seismic zone occurred in 1811 and 1812 in and near New Madrid, Missouri. The town of New Madrid, about 70 miles (113 kilometers) southwest of Paducah, was completely destroyed during these earthquakes. The largest earthquakes since the 1811 and 1812 events had magnitudes of 6.0 and 6.2 and occurred in 1843 and 1895, respectively. Seven additional events with magnitudes greater than 5.0 have occurred. Since 1895, the zone has experienced more than 4,000 earthquakes, most too small to be felt (DOE 2004a).

The U.S. Geological Survey reports 447 earthquakes occurred within 100 miles (161 kilometers) of Paducah between January 1973 and June 2016. The largest event occurred on September 26, 1990, with an epicenter approximately 2.5 miles (4 kilometers) southeast of Chaffee, Missouri (approximately 43 miles [69 kilometers] west of the Paducah Site) and an estimated magnitude of 4.8. Only 10 of the 447 earthquakes had a magnitude greater than 4.0 (USGS 2016a).

Earthquake-produced ground motion is expressed in units of percent *g* (force of acceleration relative to that of the Earth's gravity). Probabilistic peak (horizontal) ground acceleration (PGA) data from the U.S. Geological Survey were used to indicate seismic hazard. The PGA values cited are based on a 2-percent probability of exceedance in 50 years. This corresponds to an annual occurrence probability of about 1 in 2,500. At the Paducah Site, the calculated PGA is approximately 0.8 *g* (USGS 2014a, 2014b).

3.1.3.2 Soils

Soils within the industrialized portion of the plant have been heavily disturbed and have lost much of their original character. As such, they are classified as "Urban Land." Soils of the Calloway-Henry Association and Grenada-Calloway Association cover most of the remainder of the Paducah Site. Soils of the Calloway-Henry Association, which are nearly level and somewhat poorly drained soils of medium texture, occur on uplands. Soils of the Grenada-Calloway Association, which are nearly level to sloping and moderately well-drained, medium-textured soils, also occur on uplands. Calloway, Henry, and Granada soils have a slight potential for erosion, a low shrink-swell potential, and permeabilities ranging from 0.51 to 5.1 centimeters/hour (0.20 to 2.0 inches/hour) (DOE 2004a).

As part of ongoing CERCLA and Resource Conservation and Recovery Act (RCRA) investigations of Paducah Site operable units, soils in several areas have been identified as contaminated with radionuclides and chemicals. The prevalent contaminants are metals (including uranium), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) [benzo(a)pyrene equivalents], and radionuclides (including uranium radioisotopes). Five priority contaminants of concern based on a chemical-specific excess lifetime cancer risk (ELCR) > 1×10^{-4} or chemical-specific hazard quotient[24] (HQ) > 1 were identified based on results at one or more solid waste management units (SWMU) or areas of concern (AOC): total PCBs, arsenic, thallium, uranium, and uranium-238 (DOE 2016b). DOE is in the process of examining potential remedial actions for these contaminants.

3.1.4 Water Resources

3.1.4.1 Surface Water

The Paducah Site is situated in the western part of the Ohio River drainage basin. Surface water from the east side of the Paducah Site flows east-northeast toward Little Bayou Creek, an intermittent stream that flows north toward the Ohio River along a 7-mile (11-kilometer) course, while surface water from the west side of the plant flows west-northwest toward Bayou Creek, a perennial stream that flows toward the Ohio River along a 9-mile (14-kilometer) course. The two creeks converge 3 miles (5 kilometers) north of the plant before emptying into the Ohio River. Maps of the calculated 100-year flood elevations show that all three drainage systems have 100-year floodplains located within the DOE boundary at the Paducah Site, but only slightly within the industrialized area (DOE 2015b, 2017d). The cylinder storage yards are not within the 100-year floodplain (DOE 2015b). At present, DOE operates a nontransient, noncommunity water system

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[24] A hazard quotient is a ratio of the estimated intake versus the level below which adverse effects are not expected. A hazard quotient of less than one means no adverse health effects are expected.

at the Paducah Site and gets its water from the Ohio River at an intake north of the facility (DOE 2015b).

Flow in Bayou Creek and Little Bayou Creek fluctuates greatly as a result of precipitation; however, during most of the year, most of the flow in both streams is derived from plant effluents (DOE 2015b). All effluent discharges are regulated under permits from the Kentucky Pollutant Discharge Elimination System (KPDES). There are a total of 15 KPDES outfalls authorized to DOE and its contractors (DOE 2017a).

In 2016, as part of environmental surveillance monitoring, surface water was sampled quarterly at four locations for radiological parameters, and two background locations were sampled annually. Additionally, a location in the Ohio River immediately downgradient of Paducah, and a location near the nearest public water withdrawal location, Cairo, Illinois, were sampled (DOE 2017a). This sampling was performed to evaluate potential radiological effluents leaving the Paducah Site and to evaluate the effectiveness of the outfall sampling program. Threshold values were not exceeded during 2016 for the surface water environmental surveillance monitoring (DOE 2017a).

In addition to the environmental surveillance surface water sampling locations, samples are taken at the fifteen KPDES-permitted outfalls. The Paducah Site received three notices of violation in 2015 for alleged violations related to the KPDES permit. In September of 2015, a beaver dam caused exceedance of total suspended solids for one sampling event at Outfall 001; Outfall 006 exceeded the pH permitted limit for one sampling event; and Outfall 017 exceeded the toxicity permitted limit for four sampling events. Corrective actions were implemented, including removal of the beaver dam and preparation of a toxicity reduction plan. Efforts to maintain and monitor water quality standards and address toxicity continue to be implemented at the Paducah Site (DOE 2016a). However, two exceedances for toxicity were recorded for Outfall 020 in 2016: one in October and one in December. As of the end of 2016, no notice of violation had been received for either of these events (DOE 2017a).

Sediment sampling was conducted at the Paducah Site in June 2016 to measure concentrations of radiological and nonradiological constituents. An additional sampling for PCBs occurred in December 2016 (a list of constituents and background concentrations can be found in the *2016 Paducah Site Annual Site Environmental Report for the Calendar Year 2016*, DOE 2017a). Overall, radiological concentrations in sediment are near background concentrations with the exception of two locations, both of which are within or just downstream of the DOE boundary. Overall, uranium activity is above background in Little Bayou Creek and Bayou Creek near and downstream of the Paducah Site. Other radionuclides, although present, are not significantly above background levels (DOE 2017a). PCBs were detected in sediment in 2016, but were within the acceptable risk range (DOE 2017a). Warning signs along the Bayou and Little Bayou Creeks are posted to warn members of the public about the possible risks posed by recreational contact with these waters, stream sediments, and fish caught in the creeks (DOE 2017a).

3.1.4.2 Groundwater

The local groundwater flow systems at the Paducah Site include the following, from deepest to shallowest (DOE 2017a):

- The Bedrock Aquifer is 335 to 350 feet below the ground surface. There is no known contamination associated with the Paducah Site in the bedrock aquifer.

- The McNairy Flow System is about 225 feet thick and is first encountered about 100 feet below the surface. Groundwater flow in the McNairy Flow System is to the north and northwest. DOE has found minor amounts of Paducah Site associated contamination, in the upper portions of the McNairy flow system. The interface between the McNairy Flow System and the Bedrock Aquifier may include a thin and discontinuous layer of chert gravel rubble (Tuscaloosa Formation) but this layer is not considered a confining layer (PPPO 2018).

- The Regional Gravel Aquifer (RGA) is the uppermost and primary aquifer in the area. It is 30 to 70 feet thick and flows northward toward the Ohio River. This aquifer has been the most affected by contamination from past Paducah Site operations.

- The Porters Creek Clay pinches out the Regional Gravel Aquifer in the southern part of the DOE-owned property and is overlain by Terrace Gravel and Eocene sands. DOE has found contamination from past Paducah Site activities in these sands and gravels in the industrial portions of the site.

- Upper Continental Recharge System (UCRS) consists mainly of clay silt with interbedded sand and gravel and generally recharges the underlying Regional Gravel Aquifer. DOE has found contamination from past Paducah Site activities in the upper continental recharge system in the industrial portions of the site.

Groundwater flow originates south of the Paducah Site within Eocene Sands and the Terrace Gravel. Groundwater within the Terrace Gravel discharges to local streams and recharges the RGA. Groundwater flow through the UCRS is predominantly downward and also recharges the RGA. From the Paducah Site, groundwater generally flows northward in the RGA toward the Ohio River, which is the local base level for the system. The groundwater in the McNairy flow system beneath the Paducah Site also flows northward towards the Ohio River (DOE 2017a) as does groundwater in the bedrock aquifer (PPPO 2018).

Monitoring and protection of groundwater resources at the Paducah Site are required by DOE Orders and Commonwealth of Kentucky regulations, and groundwater programs continue to remediate contamination in off-site plumes and on-site source areas as outlined in the *Groundwater Protection Plan for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (FRNP 2018b) and the *Environmental Monitoring Plan, Fiscal Year 2018, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (FRNP 2018c). Data obtained from groundwater monitoring supports the decision-making process for the ultimate disposition of the contaminants. Groundwater monitoring serves to detect the nature and extent of contamination (i.e., types of contaminants and concentration of contaminants) and to determine the movement of groundwater near the Paducah Site (DOE 2017a).

Monitoring wells are used extensively at the Paducah Site to assess the effect of plant operations on groundwater quality. Over 200 monitoring wells and residential wells were sampled in 2016 in accordance with DOE Orders and Federal, state, and local requirements (DOE 2017a).

Groundwater monitoring activities at the Paducah Site include general environmental surveillance, current and inactive landfills, groundwater plume pump-and-treat operations, the C-400 Cleaning Building, Interim Remedial Action monitoring, and area residential wells (DOE 2017a). The primary contaminants in the RGA are trichloroethlyene (TCE) and technetium-99. Based on the 2014 results, the concentrations of technetium-99 in areas off DOE property do not exceed the technetium-99 maximum contaminant level (DOE 2015e). Known or potential sources of TCE and technetium-99 include former test areas, spills, leaks, buried waste, and leachate derived from contaminated scrap metal. Investigations of the source areas of TCE at the Paducah Site are ongoing with the main source of TCE contamination located near the C-400 Cleaning Building (DOE 2017a). Based on the results of monitoring, groundwater plume maps are created to depict the general footprint of the TCE and technetium-99 contamination in the RGA and convey the general magnitude and distribution of contamination within the plumes. The Paducah site groundwater plume maps are used to facilitate planning to optimize the site groundwater (DOE 2017a).

Historically, groundwater was the primary source of drinking water for residents and businesses in the vicinity of the Paducah Site. In areas near the Paducah Site where the groundwater either is known to be contaminated or has the potential to become contaminated in the future, DOE has provided water hookups to the West McCracken County Water District and pays water bills for affected residences and businesses. An annual educational mailer was developed in 2016 and was mailed to residents during the first quarter of 2016 and 2017 in an effort to ensure public awareness of the groundwater contamination. Residential wells have been capped, except for those that are used by DOE for monitoring (per license agreement between DOE and each resident), and all wells are locked (DOE 2017a).

3.1.5 Biotic Resources

3.1.5.1 Vegetation and Wildlife Habitats

Within the industrial area of the Paducah Site, buildings, roads, paved and graveled surfaces, and utility infrastructure cover large areas. The vegetation among the buildings consists mainly of maintained grassy areas and fields; shrubs are nearly absent and exist in only a few locations. The vegetation in the industrialized area outside the fence is a mixture of maintained grass fields, areas of second-growth forest, old fields, and wetlands. The vegetation in the area DOE licenses to Kentucky for the WKWMA, with the exception of a DOE-controlled landfill, has a high diversity of interspersed habitats including second-growth hardwood forest, riparian zones along Bayou Creek, palustrine wetlands, old fields, agricultural land, fencerows, and maintained grass fields. The Kentucky Department of Fish and Wildlife Resources (KDFWR) manages the WKWMA, including the DOE licensed land, primarily for early successional wildlife habitat. Common vegetation management practices include periodic mowing, field restoration, prescribed burning, discing, and tree and shrub control (physical removal or herbicide treatment) to maintain open areas and utility corridors (DOE 2015b).

Wildlife species indigenous to hardwood forests, scrub-shrub, and open grassland communities are present at the Paducah Site. Additionally, the Ohio River, which is 3 miles north of the Paducah Site, serves as a major flyway for migratory waterfowl (DOE 2017a). Common wildlife species of the WKWMA and undeveloped areas outside the Paducah GDP fence line include white-tailed deer, red fox, raccoon, opossum, coyote, turkey, and bobwhite quail. Ground-nesting species include the white-footed mouse, bobwhite, and eastern box turtle. Harvestable fish populations exist in Bayou Creek, especially near the mouth of the creek at the Ohio River. Harvestable fish populations do not exist in Little Bayou Creek (DOE 2016a). The abundance and diversity of aquatic organisms are generally lower near the Paducah Site outfalls than in upstream areas for both Little Bayou and Bayou Creeks (DOE 2004a). Warning signs along Bayou and Little Bayou Creeks are posted to warn members of the public about the possible risks posed by recreational contact with these waters, stream sediments, and fish caught in the creeks (DOE 2017a).

3.1.5.2 Wetlands

There are an estimated 400 acres (162 hectares) of wetlands characterized as forested wetlands, ponds, wet meadows, vernal pools, and wetlands converted to agriculture on the 3,556 acres (1,439 hectares) of the Paducah Site (DOE 2015b). Approximately 5 acres (2 hectares) of jurisdictional wetlands were identified in drainage ditches within the 750 acres (303 hectares) of the Paducah GDP. Palustrine forested wetlands occur extensively along the banks of Bayou and Little Bayou Creeks. A forested wetland dominated by tupelo trees in the WKWMA has been designated by the Kentucky Nature Preserves Commission and KDFWR as an area of ecological concern (DOE 2004a).

3.1.5.3 Threatened and Endangered Species

While there are potential habitats for endangered species on DOE property, none of the federally listed species has been found on the Paducah Site (DOE 2017a). Federally listed endangered and threatened species known to occur in the vicinity of the Paducah Site are identified in **Table 3-3**.

The Indiana bat (federally listed endangered) has been found near the confluence of Bayou Creek and the Ohio River 3 miles (5 kilometers) north of the Paducah Site. Indiana bats use trees with loose bark (such as shagbark hickory or standing dead trees) in forested areas as roosting sites during spring or summer. Potential roosting habitat for this species occurs on the Paducah Site outside the GDP and in adjacent wooded areas, but none has been observed on the site (DOE 2004a, 2017d). Unit RF 20 of the critical habitat designated for the Rabbitsfoot mussel (federally listed threatened) includes the portion of the Ohio River near the Paducah Site (USFWS 2015). No other critical habitat is in the vicinity of the Paducah Site (USFWS 2016).

The compass plant, listed by KDFWR as threatened, and cream wild indigo, listed by KDFWR as a species of special concern, are prairie species known to occur in several locations on the Paducah Site. State-listed species of special concern that occur on or near the Paducah Site include Bell’s vireo, great blue heron, and Northern crawfish frog. The lake chubsucker, listed by KDFWR as threatened, is known from early, but not recent, surveys of Bayou Creek and Little Bayou Creek (DOE 2004a).

Table 3-3 Federally Listed Endangered and Threatened Species near the Paducah Site

Scientific Name	Common Name	Status
Mammals		
Myotis grisescens	Gray bat	Endangered
Myotis sodalis	Indiana bat	Endangered
Myotis septentrionalis	Northern long-eared bat	Threatened
Birds		
Sterna antillarum	Least tern	Endangered
Clams		
Pleurobema clava	Clubshell	Endangered
Cyprogenia stegaria	Fanshell	Endangered
Potamilus capax	Fat pocketbook	Endangered
Plethobasus cooperianus	Orangefoot pimpleback (pearlymussel)	Endangered
Lampsillis abrupta	Pink mucket (pearlymussel)	Endangered
Quadrula cylindrical cylindrica	Rabbitsfoot	Threatened (CH)
Obovaria retusa	Ring pink (mussel)	Endangered
Pleurobema plenum	Rough pigtoe	Endangered
Plethobasus cyphus	Sheepnose mussel	Endangered
Cumberlandia monodonta	Spectaclecase mussel	Endangered

Key: CH = critical habitat.
Source: DOE 2017a

3.1.6 Public and Occupational Safety and Health

3.1.6.1 Radiation Environment

DOE has calculated the radiation exposures of on-site workers and members of the off-site general public resulting from operations of the Paducah Site. In 2015, the hypothetical maximum radiation dose to an off-site member of the public as a result of on-site facility operations was estimated to be 4.5 millirem per year (DOE 2017a**)** with no LCFs[25] expected (calculated value of 3×10^{-6}) (DOE 2017a), which is less than 2 percent of the average dose of 311 millirem per year from exposure to natural background radiation (e.g., cosmic gamma, internal, and terrestrial radiation) for an individual in the United States (NCRP 2009). The DOE dose limit for the general public is 100 millirem per year from all pathways, as prescribed in DOE Order 458.1. **Table 3-4** provides the contributions to the maximum individual dose by pathway. The hypothetical maximum dose was estimated by using the largest environmental media concentrations monitored at different off-site locations, emission data, and conservative exposure parameters.

The population dose is the sum of individual doses to the entire population within 50 miles (80 kilometers) of the Paducah Site. In 2015, the population dose from operations at the Paducah Site was 0.89 person-rem (DOE 2017a) with no LCFs expected (calculated value of 5×10^{-4}) which is approximately 5.4×10^{-4} percent of the total population dose (from natural background radiation) of 166,000 person-rem.

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[25] A latent cancer fatality (LCF) is a death from cancer resulting from and occurring sometime after exposure to ionizing radiation or other carcinogens. This DU Oxide SEIS focuses on LCFs as the primary means of evaluating health risk from radiation exposure. A risk factor of 0.0006 LCF per person-rem or rem is used, consistent with DOE guidance (DOE 2003).

The radiation environment is also impacted by operation of the Honeywell Metropolis Works (a uranium conversion facility under NRC license in Metropolis, Illinois). This facility is located approximately 5 miles to the Northeast of the Paducah site on the Ohio River. Based on an environmental analysis performed for a license renewal (NRC 2006), calculations indicate that the emissions from this facility result in a maximum dose to an off-site member of the public of 0.57 millirem per year with the population dose estimated to be 3.81 person-rem per year.[26]

Table 3-4 Sources of Maximum Individual Dose from Paducah Site Operations

Sources of Maximum Individual Dose	Dose (millirem per year)	LCF
Airborne radionuclides[a]	1.3×10^{-4}	8×10^{-11}
Waterborne radionuclides (Little Bayou Creek)[b]	0.09	5×10^{-8}
Incidental ingestion of surface water[c]	0.19	1×10^{-7}
Incidental ingestion of sediments	0.062	4×10^{-8}
Direct radiation[d]	4.2	3×10^{-6}
Total	4.5	3×10^{-6}

Key: LCF = latent cancer fatality.

[a] EPA limit for public dose from airborne radionuclides is 10 millirem per year (NESHAP, 40 CFR Part 61 subpart H)

[b] From sources (creeks and ditches) in the vicinity of the Paducah site.

[c] Drinking water is from the nearest (closest to the Paducah site) surface water intake for Cairo, IL.

[d] The Paducah 2016 ASER presents a direct radiation dose of 4.2mrem for the maximally exposed individual (MEI). However, it indicates that the calculation is unrealistic as site security protocols do not allow members of the public in the areas required to receive such a dose.

Source: Table 4.7 of DOE 2017a

Of the approximately 1,200 workers at Paducah (PPPO 2018), nearly 47 percent received a measureable dose (a dose of 1 millirem or more) during 2016 (DOE 2017b). These workers were primarily workers handling DU cylinders. The total worker dose for 2016 was 6.2 person-rem with no LCFs expected (calculated value of 0.004). Considering all 1,200 workers, the average worker dose was 5.2 millirem. However, considering only the workers who received a measurable dose (559 workers), the average dose to these workers was 11 millirem **(**DOE 2017b). To protect workers from impacts from radiological exposure, 10 CFR Part 835 imposes an individual dose limit of 5,000 millirem in a year. In addition, worker doses must be monitored and controlled below the regulatory limit to ensure that individual doses are less than an administrative limit of 2,000 millirem per year (DOE 2017f) and maintained as low as reasonably achievable (ALARA).

3.1.6.2 Chemical Environment

The chemical environment is described by the nonradiological effect of uranium when inhaled or ingested. This health effect is expressed as a hazard quotient, a ratio of the estimated intake versus the level below which adverse effects are not expected. A hazard quotient of less than one means no adverse health effects are expected. The hazard quotient for various exposure pathways (environmental medium) for members of the general public under existing environmental conditions near the Paducah Site are presented in **Table 3-5**. Since the on-site activities addressed in this *DU Oxide SEIS* at Paducah pertain primarily to the storage of DU oxide and handling of

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[26] The Honeywell Metropolis Works ceased operations in 2017 (PPPO 2018). Honeywell has indicated this shutdown is temporary due to reduced UF_6 demand. Operations are to resume once demand rebounds (Honeywell 2018).

DU oxide containers for off-site shipment, only uranium is addressed in this table, as that is the element most relevant to this *DU Oxide SEIS*.

Table 3-5 Chemical Hazard Quotient for Uranium

Environmental Medium	Assumed Exposure Concentration	Estimated Chronic Intake (mg/kg-d)[g]	Reference Level [f] (mg/kg-d)	Hazard Quotient
Air[a]	NA	NA	NA	NA
Soil[b]	17.5mg/g	2.5×10^{-4}	3.0×10^{-3}	0.083
Surface Water[c]	0.42 mg/L	2.4×10^{-4}	3.0×10^{-3}	0.081
Sediment[d]	9.7 µg/g	2.8×10^{-6}	3.0×10^{-3}	0.00092
Groundwater[e]	7.7 µg/L	2.2×10^{-4}	3.0×10^{-3}	0.07

Key: mg/g = milligrams per gram; µg/g = micrograms per gram; mg/L = milligrams per liter; ASER = annual site environmental report; NA = not applicable.

[a] Uranium emissions are approximately 120 grams per year (derived from Table 4.1 of DOE 2017a); chronic intake would be negligible.

[b] Concentration is the largest value for uranium in Table 4.5 of DOE 2017a

[c] Concentration is the largest value for uranium in Table 5.2 of DOE 2017a.

[d] Concentration derived from Table 4.9 of the 2015 Paducah ASER (DOE 2016a). Sediment concentrations were not analyzed in DOE 2017a.

[e] Concentration is the largest value for uranium in Table 6-2 of DOE 2017a.

[f] Reference levels are those included in DOE 2004a.

[g] Calculated based on an assumed inhalation/consumption rate (derived from DOE 2004a) for a representative person (weight of 70 kilograms)

Source: DOE 2017a

Safety and health requirements for DOE workers are governed by 10 CFR Part 851, which establishes requirements for a worker safety and health program to ensure that DOE workers have a safe work environment. Included are provisions to protect against hazardous chemicals. For worker protection from the toxic effects of uranium, DOE uses the Occupational Safety and Health Administration (OSHA) permissible exposure levels for workplace exposure to uranium of 0.25 milligram per cubic meter for insoluble and 0.05 milligram per cubic meter for soluble uranium (29 CFR 1910.1000, Table Z-1). Under the requirements of DOE's worker protection program, site worker exposures to airborne uranium are maintained below these levels.

3.1.7 Socioeconomics

The ROI for this socioeconomic analysis consists of six counties: Ballard, Carlisle, Graves, Marshall, and McCracken counties in Kentucky and Massac County in Illinois. The ROI is based on where socioeconomic impacts would be expected, if any were to occur, with a focus on McCracken County, where the majority of any impacts would be expected.

3.1.7.1 Population

In 2010, the population of the ROI was 141,585 people (Census 2010). Approximately 46.3 percent (65,565 people) of the total ROI resided in McCracken County. Between the 2010 U.S. Census and 2014 estimates, the total ROI population decreased by 94 people (approximately 0.02 percent). Over the same period, the population in Kentucky and Illinois grew at an average annual rate of 0.25 percent and 0.07 percent, respectively (see **Table 3-6**).

Table 3-6 Population in the Paducah Region of Influence, Kentucky and Illinois in 2010 and 2014

Location	2010 Census	2014 ACS 5-Year Estimate	Average Annual Growth Rate (%) 2010-2014
McCracken County	65,565	65,545	-0.01
Ballard County	8,249	8,274	0.08
Carlisle County	5,104	5,031	-0.36
Graves County	37,121	37,451	0.22
Marshall County	10,117	10,042	-0.19
Massac County	15,429	15,148	-0.46
ROI Total	**141,585**	**141,491**	**-0.02**
Kentucky	4,339,367	4,383,272	0.25
Illinois	12,830,632	12,868,747	0.07

Key: ACS = American community survey; ROI = region of influence.
Sources: Census 2010, 2014a

3.1.7.2 Employment and Income

Paducah Site employment was approximately 1,200 as of January 2018 (PPPO 2018). In 2014, total employment in the ROI was 91,232 people, representing an increase of 1,117 (1.24 percent) jobs since 2010. Major industries by employment in the ROI include retail trade, government and government enterprises, and health care and social assistance. In 2014, the total employment in McCracken County was 47,118 people, representing an increase of 1,320 jobs (3 percent) since 2010. The major industries by employment in the county include health care and social assistance, retail trade, and government and government enterprises (BEA 2015a).

Unemployment in McCracken County decreased from 9.1 percent in 2010 to 5.9 percent in 2015 (BLS 2016a). Unemployment in the ROI was 6.1 percent in 2015 (see **Table 3-7**). McCracken County had the highest per capita personal income in the six-county ROI, at $42,532 in 2014 (BEA 2015b).

Table 3-7 Employment in the Paducah Region of Influence in 2015

Location	Total Employment	Unemployment Rate (%)
McCracken County	47,118	5.9
Ballard County	3,793	7.1
Carlisle County	2,321	5.8
Graves County	17,003	6.3
Marshall County	15,629	5.7
Massac County	5,368	7.4
ROI Total	**91,232**	**6.1**
Kentucky	2,437,101	5.4
Illinois	7,595,648	5.9

Sources: Census 2014b; BEA 2015a; BLS 2016a

3.1.7.3 Housing

In 2014, total housing units in the six-county ROI totaled 77,279 units (Census 2014c). Over 40 percent of the total housing units in the ROI were in McCracken County. Approximately 15 percent of the total housing units were vacant, while the remaining 85 percent were occupied (see **Table 3-8**).

Table 3-8 Housing in McCracken County and the Paducah Region of Influence in 2014

Location	Total Housing Units	Occupied Housing Units	Vacant Housing Units
McCracken County	31,242	27,409	3,833
Ballard County	3,888	3,279	609
Carlisle County	2,448	2,075	373
Graves County	16,766	14,284	2,482
Marshall County	15,842	12,426	3,416
Massac County	7,093	6,013	1,080
ROI Total	**77,279**	**65,486**	**11,793**
Kentucky	1,938,836	1,702,235	236,601
Illinois	5,299,433	4,778,633	520,800

Source: Census 2014c

3.1.7.4 Community Resources

Emergency response services in the ROI include police, fire rescue, and emergency response. The Paducah Fire Department serves the city of Paducah and has 76 employees (City of Paducah 2016a, 2016b). The Paducah Police Department consists of 87 employees, which includes 9 civilians and 78 sworn officers (City of Paducah 2016a, 2016b). Lourdes Hospital and Baptist Health Paducah are the primary care facilities in the city of Paducah and McCracken County, with 359 beds and 379 beds, respectively (Lourdes 2016; Baptist Health Paducah 2016).

There are 13 schools in McCracken County, with a total enrollment of 6,923 students during the 2014–2015 school year (KDE 2016a). In 2015, there were 402 full-time equivalent (FTE) teachers in McCracken County, for a student-to-teacher ratio of approximately 17 to 1 (KDE 2016b).

3.1.8 Waste Management

A variety of wastes are generated at the Paducah Site as a result of differing activities, including management of DUF_6 cylinders in storage; conversion of DUF_6 to DU oxide and on-site storage of DU oxide cylinders pending their disposition; DD&D of excess facilities and structures; and environmental restoration of soil, groundwater, and surface water contamination. These wastes include LLW,[27] MLLW,[28] nonradioactive hazardous and toxic waste, solid nonhazardous waste, and wastewater. Current annual waste generation rates are summarized in **Table 3-9**.

Table 3-10 shows the waste expected to be generated during DD&D of the Paducah Site over the period 2018 through 2065. Approximately 3,238,000 cubic yards (2,476,000 cubic meters) of lightly contaminated LLW could be disposed of in the OSWDF (PPPO 2018).

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[27] Includes calcium fluoride generated during the oxide conversion process that may be disposed as low-activity LLW.

[28] Consisting of waste regulated for its radioactive content pursuant to the Atomic Energy Act of 1954, as amended, as well as for its chemical content pursuant to the RCRA, the TSCA, or other applicable statutes.

Table 3-9 Current Waste Generation Rates at Paducah

Waste Type		Annual Quantities
Solid LLW	Unusable empty DUF_6 cylinders[a]	29 cubic yards
	Debris	180 cubic yards
	Oversized debris	6.3 cubic yards
	Soil-like material	21 cubic yards
	Soil-like material with TSCA constituents	0.28 cubic yards
	Calcium fluoride[b]	24 metric tons (26 tons
Liquid LLW		690 gallons
MLLW	Debris	0.47 cubic yards
	Soil-like material	0.89 cubic yards
Liquid MLLW		59 gallons
Hazardous waste		5.5 cubic yards
Universal waste[c]		1.9 cubic yards
Solid nonhazardous waste		120 tons
Wastewater (not including sanitary wastewater)		1,200 gallons

Key: DUF_6 = depleted uranium hexafluoride; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; TSCA = Toxic Substances Control Act.

[a] Emptied cylinders determined to be unusable for containment of DU oxide are disposed of as LLW.

[b] From the oxide conversion process. The calcium fluoride may be shipped off site for disposal as low-activity LLW (also called exempt LLW). Low-activity LLW is waste that contains so little radioactive material that it can be disposed of at a facility other than a LLW disposal facility licensed under 10 CFR Part 61 or compatible Agreement State regulation. Disposal of low-activity LLW is licensed under 10 CFR 20.2002 or compatible Agreement State regulation.

[c] Universal waste refers to a category of hazardous waste having streamlined management procedures.

Source: PPPO 2018

Note: To convert cubic yards to cubic meters, multiply by 0.76456; tons to metric tons, multiply by 0.90718; gallons to liters, multiply by 3.7854.

Table 3-10 Estimate of Waste Generated During Deactivation, Decontamination, and Demolition of the Paducah Site

Waste Type	Disposal Location	Total Quantity (cubic yards)[a]
LLW	Off site	9,559
LLW	OSWDF	1,619,065
LLW – TSCA	OSWDF	1,619,065
MLLW	Off site	70,708
RCRA	Off site	761
TSCA	Off site	356
Solid waste	On-site U Landfill	272,039
Total		**3,591,554**

Key: LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; OSWDF = On-Site Waste Disposal Facility; RCRA = Resource, Conservation, and Recovery Act; and TSCA = Toxic Substance Control Act.

[a] Estimated to be generated over the period 2018 through 2065.

Source: PPPO 2018

Note: To convert cubic yards to cubic meters, multiply by 0.76456; tons to metric tons, multiply by 0.90718; gallons to liters, multiply by 3.7854.

Procedures for management of these wastes are summarized in **Table 3-11**.

Table 3-11 Current Procedures for Management of Wastes at the Paducah Site

Waste	Typical Content	Management Procedure[a]
Solid LLW	Refuse, sludge, or debris primarily containing uranium and technetium.	Temporary storage on-site pending shipment to off-site treatment and/or disposal facilities.
Solid and liquid MLLW	Similar materials as solid LLW but also containing RCRA hazardous components, such as lead, or toxic materials, such as PCBs.	Temporary on-site storage pending shipment to off-site permitted facilities for treatment and/or disposal. On-site storage capacity is 3,600 cubic yards (2,800 cubic meters).
Solid and liquid hazardous and toxic waste	Spent solvents, heavy-metal-contaminated waste and PCB-contaminated toxic waste.	Temporary on-site storage or on-site treatment pending shipment to off-site facilities for disposal. On-site capabilities include treatment units, tanks, container storage areas, and several additional 90-day storage areas.
Solid nonhazardous waste	Sanitary refuse, cafeteria waste, industrial waste, and construction and demolition debris.	Recycle or disposal off-site or in an on-site landfill permitted for disposal of 1 million cubic yards (764,000 cubic meters) of solid nonhazardous waste.
Wastewater	Nonradioactive sanitary and process-related wastewater streams, cooling water blowdown, and radioactive process-related liquid effluents	Nonradioactive wastewater is processed at on-site treatment facilities and discharged through eight permitted outfalls. The total capacity of the Paducah Site wastewater facilities is about 300 gallons (1,100 liters) per minute. Normal flow is between 200 and 300 gallons (800 to 1,100 liters) per minute (DOE 2012a). Radioactive liquid waste is shipped off site for treatment and disposal.

Key: PCB = polychlorinated biphenyl; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; RCRA = Resource Conservation and Recovery Act.

[a] In addition, the Paducah Site has an active program to minimize the generation of solid LLW, MLLW, hazardous waste, and solid nonhazardous waste.

Source: DOE 2004a

3.1.9 Land Use and Aesthetics

3.1.9.1 Land Use

The Paducah Site is in a generally rural area of McCracken County, Kentucky, about 10 miles (16 kilometers) west of the City of Paducah and 3.5 miles (5.6 kilometers) south of the Ohio River (see Figure 2-1). The predominant regional land uses in the vicinity of the Paducah Site are agricultural, industrial, and recreational. The area immediately surrounding the site generally features a combination of pasture, row crops, and deciduous forest (DOE 2004a).

The 2012 agricultural census recorded 447 farms in McCracken County, covering more than 67,192 acres (27,192 hectares), approximately 42 percent of the county (USDA 2014a). Residential land use occurs throughout much of McCracken County; however, most of it occurs in the eastern half of the county in the communities of Concord, Hendron, Lone Oak, Massac, Paducah, Reidland, and Woodlawn-Oakdale. The western half of the county, where the Paducah Site lies, consists primarily of pasture/hay and row crops (DOE 2004a).

The Paducah Site encompasses an area of 3,556 acres (1,439 hectares) (DOE 2017a). Approximately 837 acres (339 hectares) of the site are within a fenced security area, 600 acres (243 hectares) are located outside the security fence, 133 acres (54 hectares) are in acquired easements, and the remaining 1,986 acres (803 hectares) are licensed to the Commonwealth of Kentucky as part of the WKWMA (DOE 2004a, 2017d). The fenced area contains the Paducah

GDP and the Conversion Facility. The former Paducah GDP includes about 115 buildings with a combined floor space of about 8.2 million square feet (0.76 million square meters) with many support facilities. The areas between buildings consist primarily of mowed grassy areas. The developed lands outside the security fence contain roads, parking lots, grassy areas, utility infrastructure, water impoundments, landfills, and burial grounds (DOE 2015b).

The industrial area of the Paducah Site is surrounded by the WKWMA, including a 1,986-acre (803-hectare) parcel conveyed by DOE to the Commonwealth of Kentucky for use in wildlife conservation and for recreational purposes (DOE 2004a). According to a 1953 agreement granting the land to KDFWR, DOE can use any or all of this WKWMA whenever the need arises (DOE 2004a). The WKWMA contains access roads and multiple rights-of-way for electrical transmission lines but is otherwise a mixture of grass meadows, forested areas, and areas of diverse vegetation (DOE 2015b). Public activities in the WKWMA include bow hunting for deer, bird dog and retriever trials, youth turkey hunting, horseback riding, hiking, biking, and firearms hunting for small game (DOE 2015b).

The Paducah Site is currently zoned for heavy industry; therefore, industrial use of the site would be compatible with existing McCracken County zoning (DOE 2015b).

3.1.9.2 Aesthetics

The Paducah Site is in a generally rural area of McCracken County, Kentucky. The area is characterized by gently rolling terrain in the upland areas to a relatively flat floodplain near the Ohio River. The dominant viewshed (an area visible to the human eye from a fixed vantage point) at the Paducah Site consists of buildings, a water tower, cylinder storage yards, transmission lines, and open and forested buffer areas. Numerous buildings within the Paducah Site viewshed are in various stages of deactivation and decommissioning (KCREE 2016). There are no designated scenic areas near the Paducah Site.

The developed areas and utility corridors (transmission lines and aboveground pipelines) of the Paducah Site are consistent with a Visual Resource Management Class IV designation. The remainder of the Paducah Site is consistent with a Visual Resource Management Class II or Class III designation. Management activities within Class II and Class III areas may be seen, but do not dominate the view; management activities in Class IV areas dominate the view and are the focus of viewer attention (DOI 1986).

3.1.10 Cultural Resources

Human occupation in the vicinity of the Paducah Site dates to at least 10,000 years before the Common Era (BCE), and possibly longer. Archaeological sites reflect occupations from the Archaic period (10,000 to 3000 BCE), the Woodland period (3000 BCE to 1000 Common Era [CE]) and Mississippian period (1000 CE to 1700 CE). Western Kentucky was part of the Chickasaw Nation when first encountered by Euro-Americans, and the Chickasaw remained in the area as late as 1827. However, the land was purchased from the Chickasaw through the Jackson Purchase, a treaty negotiated by Andrew Jackson and Isaac Shelby in 1818. In addition to the Chickasaw Nation, the Peoria Tribe of Indians of Oklahoma has land claims in McCracken

County. Euro-American settlements centered on farmsteads established in the 19th century, as reflected in associated cemeteries. Families included Baldry, Owen, and Carneal (DOE 2015b).

The Federal Government purchased part of the Baldry farm in 1942 and began construction of the Kentucky Ordnance Works. The Kentucky Ordnance Works operated until the end of World War II. In 1950, the Atomic Energy Commission acquired the Kentucky Ordnance Works for conversion to a gaseous diffusion plant (BJC 2006).

Although not all of the Paducah Site has been surveyed for archaeological resources, there have been a number of investigations, finding numerous archaeological sites outside the security fencing. The results of a 20-percent, stratified, random sample archaeological survey were used to develop a sensitivity analysis for the unsurveyed portion of Paducah. Although the area outside the security fence is outside the ROI for the action, previous archaeological surveys of sample areas identified 34 archaeological sites. Inside the security fence, all areas are considered to have a "low" to "very low" sensitivity index for the presence of archaeological resources. As a result of this analysis, and because of the heavily disturbed nature of the facility inside the security fencing, this portion of Paducah was not investigated; existing disturbance greatly reduces the likelihood of finding any cultural resources with intact integrity (DOE 2015b).

The architectural resources at Paducah have been inventoried, with the result that 101 historic properties were identified, contributing to a NRHP-eligible historic district inside the security fencing. Although some of the historic properties have been demolished, the district retains its eligibility under NRHP Criterion A[29] for its military significance during the Cold War and its role in the development of commercial nuclear power (DOE 2015b).

As described in Chapter 2, Section 2.1.3, of this *DU Oxide SEIS*, DU storage cylinders are stored at several storage yards within the security fence at the Paducah Site. None of these locations has been identified as historic resources, nor are they likely to contain previously undiscovered or unrecorded cultural resources. No traditional cultural resources have been identified at Paducah.

Status of Consultation

In the course of various projects (DOE 2004a, 2015b), DOE has consulted with the following Native American tribes:

- Absentee-Shawnee Tribe of Oklahoma
- Cherokee Nation
- The Chickasaw Nation of Oklahoma
- Eastern Band of Cherokee Indians
- Eastern Shawnee Tribe of Oklahoma
- Miami Tribe of Oklahoma
- Peoria Indian Tribe of Oklahoma
- Quapaw Tribe of Indians
- Shawnee Nation, United Remnant Band

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[29] "Criterion A" applies to cultural resources "that are associated with events that have made a significant contribution to the broad patterns of our history" (36 CFR 60.4).

- Shawnee Tribe of Miami, Oklahoma
- United Keetoowah Band of Cherokee Indians

The Eastern Shawnee Tribe of Oklahoma and the Peoria Indian Tribe of Oklahoma responded that they had no concerns, but requested to be made aware of potential Native American Graves Protection and Repatriation Act issues should they arise. The Cherokee Nation responded by requesting that DOE conduct future coordination with the Eastern Band of Cherokee Indians. DOE did not receive responses from other tribes. No religious or sacred sites, burial sites, resources significant to Native Americans, or other Native American concerns have been identified at Paducah (DOE 2004a).

DOE also consulted with the following State Historic Preservation Offices (SHPO) when preparing NEPA documents for construction and operation of the conversion facility (DOE 2004a) and potential land and facilities transfers (DOE 2015b):

- Kentucky Heritage Council
- Ohio Historic Preservation Office
- Tennessee Historical Commission

The Ohio Historic Preservation Office did not respond to either consultation request. Tennessee Historical Commission requested additional consultation for construction and operation of the conversion facility (DOE 2004a). The Kentucky Heritage Council and DOE agreed that DOE would follow the 2006 *Paducah Gaseous Diffusion Plant Cultural Resources Management Plan* (BJC 2006), consulting with the SHPO as appropriate under the plan, relative to potential land and facilities transfers (DOE 2015b).

In terms of the potential impacts to cultural resources, DOE determined that the actions evaluated in this *DU Oxide SEIS* do not differ appreciably from those evaluated in the 2004 EIS (DOE 2004a), which resulted in the execution of a Programmatic Agreement (DOE 2004a) and the preparation and implementation of the *Paducah Gaseous Diffusion Plant Cultural Resources Management Plan* (BJC 2006). Therefore, DOE determined that the consultations completed for the 2004 EIS satisfy DOE’s obligation under NHPA Section 106 and that no further consultations are needed.

3.1.11 Environmental Justice

In 1994, Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority and Low-Income Populations (Environmental Justice),* was issued to focus the attention of Federal agencies on how their actions affect the human health and environmental conditions to which minority and low-income populations are exposed. This EO was also established to ensure that if there were disproportionately high and adverse human health or environmental effects from Federal actions on these populations, these effects would be identified and addressed. The environmental justice analyses in this *DU Oxide SEIS* address the characteristics of race, ethnicity, and poverty status for populations residing in areas potentially affected by implementation of the alternatives presented in this SEIS.

In 1997, EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks (Protection of Children)*, was issued to identify and address anticipated health or safety issues that affect children. The protection-of-children analyses in this *DU Oxide SEIS* address the distribution of population by age in areas potentially affected by implementation of the alternatives presented in this SEIS.

For the purpose of the environmental justice analysis, these populations are defined as follows:

Minority Populations: All persons identified by the U.S. Census Bureau to be of Hispanic or Latino origin, regardless of race, plus non-Hispanic persons who are Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, or members of some other (i.e., nonwhite) race or two or more races.

Low-Income Populations: All persons who fall within the statistical poverty thresholds established by the U.S. Census Bureau. For the purposes of this analysis, low-income populations are defined as persons living below the poverty level. Starting with the 2010 Decennial Census, poverty data will be provided through the annual American Community Survey rather than as part of the Decennial Census.

Children: All persons identified by the U.S. Census Bureau to be under the age of 18 years.

Table 3-12 provides a summary of the percentage of minority and low-income populations within 50 miles (80 kilometers) of the Paducah Site. There are 181 census tracts within 50 miles (80 kilometers) of the Paducah Site, collectively defined as the ROI. To identify census tracts with disproportionately high minority populations, this *DU Oxide SEIS* uses the percentage of minorities in each state containing a given tract as the Community of Comparison (COC). Using the individual states to identify “disproportionality” acknowledges that minority distributions in the state can differ from those found in the nation as a whole. As shown in **Figure 3-1**, in 2014, of the 181 census tracts within 50 miles (80 kilometers) of the Paducah Site, 40 census tracts had minority populations in excess of state-specific thresholds; a total of 49,862 minority persons. Of

Table 3-12 Environmental Justice Populations

Location	Minority		Low-Income[a]	
	Number	Percent	Number	Percent
United States	116,947,592	37.2	47,755,606	15.6
Kentucky	622,404	14.2	803,866	18.9
Illinois	4,780,117	37.1	1,810,470	14.4
Tennessee	1,612,415	25.0	121,344	17.8
Missouri	1,176,814	19.5	912,291	15.6

[a] Based on population for whom poverty status is determined[30] which may differ from the total population

Source: Census 2014a, 2014f

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[30] People whose poverty status cannot be determined includes people in college dormitories, military barracks, living situations without conventional housing, institutional group quarters, and unrelated invidivuals under age 15. However, these people may be included in the total population count; thus the total number of low-income individuals might differ if the percent of low-income individuals is taken from the total population.

the 181 census tracts within 50 miles of the Paducah Site, 98 census tracts had low-income populations in excess of state-specific thresholds; a total of 84,181 low-income persons (Census 2014d, 2014e).

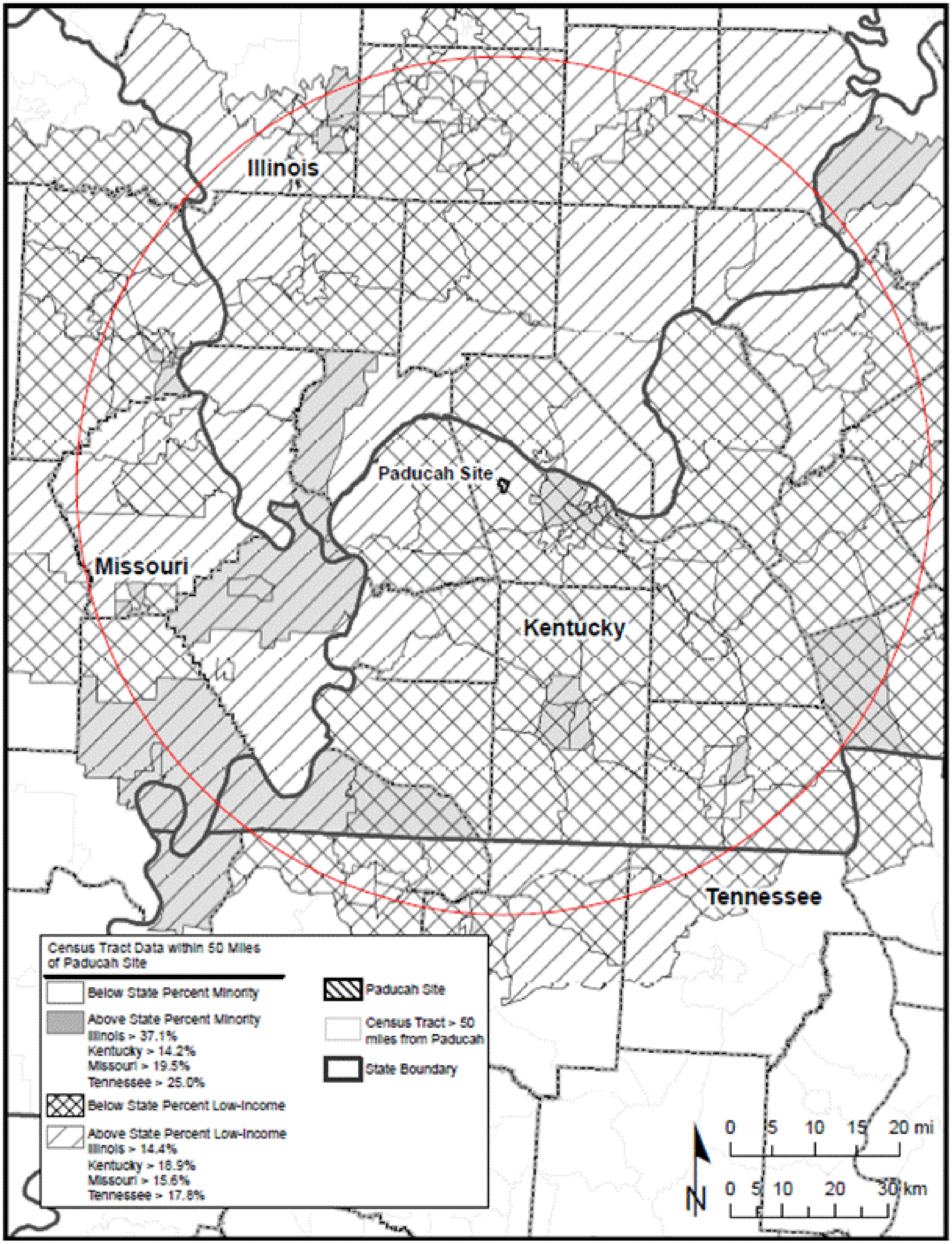

Figure 3-1 Environmental Justice Populations—Paducah Site (Source: Census 2014a–2014f)

Schools, childcare centers, parks, and hospitals represent areas where there would be high concentrations of children. There are two schools within a 5-mile (8-kilometer) radius of the Paducah Site: the ROE Safe School and the Metropolis Elementary School. Western Baptist Hospital and Lourdes Hospital are both located approximately 10 miles (16 kilometers) from the Paducah Site.

Table 3-13 provides a summary of the age distribution for the population in states containing a given census tract within 50 miles (80 kilometers) of the Paducah Site.

Table 3-13 Population Distribution by Age

Location	Total Population	Under 5 Years		Under 18 Years		Over 65 Years	
		Number	Percent	Number	Percent	Number	Percent
United States	314,107,084	19,973,711	6.4	73,777,658	23.5	43,177,961	13.7
Kentucky	4,383,272	277,776	6.3	1,018,350	23.2	614,496	14.0
Illinois	12,868,747	810,671	6.3	3,054,966	23.7	1,696,283	13.2
Tennessee	6,451,365	402,121	6.2	1,492,474	23.1	918,218	14.2
Missouri	6,028,076	379,273	6.3	1,406,494	23.3	882,552	14.6

Source: Census 2014a

3.2 PORTSMOUTH SITE

This section presents a brief description of the affected environment at the Portsmouth Site commensurate with the level of analysis required in this *DU Oxide SEIS*. Additional information on the affected environment at the Portsmouth Site (Portsmouth) is presented in the *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Portsmouth, Ohio, Site* (DOE 2004b) and the *Portsmouth Gaseous Diffusion Plant Annual Site Environmental Report – 2015, Piketon, Ohio* (DOE 2017c).

The Portsmouth Site is located in a rural area of Pike County, Ohio about 5 miles (8 kilometers) south of the town of Piketon, and approximately 22 miles (35 kilometers) north of the Ohio River and 2 miles (3 kilometers) east of the Scioto River (DOE 2017c) (see Chapter 2, Figure 2-2). The two largest cities in the vicinity are Chillicothe, located 26 miles (42 kilometers) north of the Portsmouth Site, and Portsmouth, 22 miles (35 kilometers) south (DOE 2004b).

The Portsmouth Site encompasses 3,777 acres (1,529 hectares). The three former GDP process buildings, the Conversion Facility, and most of the remaining buildings and structures, are situated within the approximately 1,000-acre (405 hectare) industrialized area that lies within Perimeter Road. The industrialized area includes a 750-acre (304-hectare) controlled access area (see Chapter 2, Figure 2-7). The Portsmouth Conversion Facility includes four major buildings with a combined floor space of about 87,693 square feet (8,147 square meters) (PPPO 2018). The portion of the DOE property outside of Perimeter Road, consisting of more than 2,500 acres (1,000 hectares), is used for a variety of purposes, including a water treatment plant, sediment ponds, sanitary and inert landfills, the On-site Waste Disposal Facility (OSWDF), cylinder storage yards, open fields, and forested buffer areas. Closed landfills and burial grounds account for approximately 101 acres (41 hectares) (DOE 2014a).[31]

3.2.1 Site Infrastructure

3.2.1.1 Transportation

The Portsmouth Site has direct access to major highway and rail systems, a nearby regional airport, and barge terminals on the Ohio River. Use of the Ohio River barge terminals requires transportation by public road from Portsmouth (DOE 2004b).

Two of southern Ohio's major highway systems, U.S. Route 23 and State Route 32/124, provide access to Portsmouth. Both routes are four lanes with U.S. Route 23 traversing north-to-south and State Route 32 traversing east-to-west. The Portsmouth Site is 3.5 miles (5.6 kilometers) from the U.S. Route 23 and State Route 32/124 interchange. State Route 32/124/50 runs 185 miles (298 kilometers) east-to-west from Cincinnati through Piketon to Parkersburg, West Virginia (DOE 2004b). The local road network is in generally good condition (DOE 2014a). Annual average daily traffic on U.S. Route 23 in proximity to the entrance to the Portsmouth Site is 14,490 vehicles; at the intersection of State Route 32 and U.S. Route 23, 7,700 vehicles (DOE 2014a).

The main access road for Portsmouth is a four-lane interchange with U.S. Route 23. The main access road is accessible to the public and connects to Perimeter Road, which encircles the fenced portion of the Portsmouth Site. Smaller roads that intersect with Perimeter Road from four directions provide access to inner portions of Portsmouth. The buildings and facilities are serviced with a system of roads and streets, which generally follow a north-to-south grid. This system is in generally good condition because of road repaving projects (DOE 2014a).

Two railroad carriers, CSX and Norfolk Southern, serve Pike County. Railroad track in the vicinity of Piketon allows a maximum train speed of 60 miles per hour (97 kilometers per hour) (DOE 2004b). A railroad system is located at the Portsmouth Site. The site railroad is connected to the CSX main rail system via a Norfolk Southern rail spur that enters the northwest portion of the site. Approximately 17 miles (27 kilometers) of track lie within the boundaries of Portsmouth; rail spurs lie in close proximity to the cylinder storage yards. However, only approximately one-third of the tracks are currently in service. The on-site railroad system is used infrequently (DOE 2004b).

The Portsmouth Site can be served indirectly by barge transportation on the Ohio River. However, use of the Ohio River barge terminals would require initial transportation of loads over public roads leading from the site to the barge terminal in the city of Portsmouth (DOE 2004b). All heavy-unit loading is done by mobile crane or barge-mounted crane at the open-air terminal. The Ohio River provides barge access to the Gulf of Mexico via the Mississippi River or the Tennessee-Tombigbee Waterway (DOE 2014a).

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[31] Centrus Energy Corp. (Centrus), formerly USEC, Inc., operated the American Centrifuge Plant, a small-scale demonstration centrifuge for uranium enrichment at Portsmouth starting 2006 (DOE 2017c). The American Centrifuge Plant is shut down (PPPO 2018). Because this is a relatively recent development, much of the affected environment information presented in Chapter 3 of this DU Oxide SEIS still reflects the impacts of operation of this facility. This will not have a substantive affect on the analysis or conclusions in this SEIS.

Because of the relatively isolated location of Portsmouth, commercial air service is limited. The nearest airport is the Greater Portsmouth Regional Airport, located approximately 15 miles (24 kilometers) south of the site. The airport mostly serves private aircraft owners and business travelers. There are no regularly scheduled commercial flights; however, charter service is available (DOE 2014a). Another nearby airport, the Pike County Airport, is located just north of Waverly. This facility is similar in size and makeup to the Greater Portsmouth Regional Airport. Three international airports are located within a 2-hour drive of Portsmouth: Cincinnati/Northern Kentucky International Airport, Dayton International Airport, and Port Columbus International Airport (DOE 2014a).

3.2.1.2 Water

The Portsmouth Site has access to large, reliable supplies of water (DOE 2017d). The site is the largest industrial user of water in the vicinity and obtains its water supply from the on-site X-611 Water Treatment Facility, which draws water from two well fields located along the Scioto River. The well fields draw groundwater from the Scioto River buried aquifer and are located in the Scioto River alluvium within the Scioto River floodplain. Recharge of the aquifer occurs from river and stream flow as well as precipitation. The maximum potential production associated with the well fields is 13 million gallons per day (49 million liters per day). Nominal capacity is approximately 4 million gallons per day (15 million liters per day). Current sitewide usage is approximately 707 million gallons (2.7 billion liters) annually (DOE 2017d).

3.2.1.3 Electricity

The Ohio Valley Electric Corporation supplies electricity to the Portsmouth Site (DOE 2017d). Its combined generating capacity is comparable to the site design load of 2,260 megawatts. Electrical power from the Ohio Valley Electric Corporation external 345-kilovolt power grid flowed through switchyards to substations around the site where the electrical power was stepped down in voltage to 13.8 kilovolts for distribution to the process and other support buildings. The plant currently uses between 20 and 40 megawatts hourly (DOE 2017d).

3.2.1.4 Natural Gas

A natural gas main (6-inch-diameter pipe rated to carry natural gas at 350 to 400 pounds per square inch) was installed from the main line near Zahn’s Corner to the East Access Road Reducing Station to support a hot water boiler system in the X-3002 building. Another line was installed for a natural gas boiler system that replaced the X-600 Steam Plant. Current sitewide usage is approximately 366,000 million standard cubic feet annually (DOE 2017d).

3.2.1.5 Steam

The X-690 Steam Plant was built in 2012 to provide a more reliable and cost-effective source of steam following the DD&D of the X-600 Steam Plant (DOE 2017d). The plant consists of the installation of two 42,000 pounds per hour natural gas-fired boilers and de-aerating feed tanks installed on a concrete pad located on the north side of the X-670 Dry Air Plant. The de-aerating feed tanks remove dissolved oxygen and other dissolved gases from the boiler feed water. Control system components and other auxiliary equipment for the boilers are located within the X-670 Dry Air Plant building. A 20,000-gallon, double-walled fuel oil tank, equipped with an electronic leak detection system, is mounted on a concrete pad just northeast of the boilers. The fuel oil is a contingency should the natural gas supply be disrupted. Current sitewide steam usage is approximately 235 million pounds annually (DOE 2017d).

3.2.2 Climate, Air Quality, and Noise

3.2.2.1 Climate

The Portsmouth Site is located in the humid continental climatic zone characterized by warm, humid summers and cold, humid winters (DOE 2017c). For the 1981 through 2010 period in Pike County, the annual average temperature was 54.8°F (12.7°C), with July the hottest month (average temperature of 87.0°F [30.6°C]) and January the coldest month (average temperature of 24.0°F [-4.44°C]). Annual precipitation averages about 40.9 inches (104 centimeters) primarily as rain. Precipitation is relatively evenly distributed throughout the year but is somewhat higher in spring and summer than in winter and fall. Snowfall in Portsmouth averages 9.0 inches (23 centimeters) per year, typically occurring from December to March (NWS 2016). The comfort index, which is based on humidity during the hot months, is 40 out of 100, where higher is more comfortable (Sperling 2016).

Wind data have been collected at an on-site meteorological tower. The data were collected at heights of 33, 98, and 197 feet (10, 30, and 60 meters) above the ground surface. An evaluation of data collected from 1995 through 2001 indicated that winds at the 33-foot (10-meter) level appear to be influenced by local topographical and/or vegetative features, while the wind data from the 98-foot (60-meter) level are believed to be more representative of actual prevailing wind direction and speed. About one third of the time, the wind blows from the south-southwest at an average speed of almost 6.5 miles per hour (10.5 kilometers per hour). Directional wind speed was highest from the south at approximately 8 miles per hour (13 kilometers per hour), while the lowest value was recorded in winds blowing from the east at 4 miles per hour (6 kilometers per hour) (DOE 2014a).

Tornadoes are rare in the area surrounding the Portsmouth Site, and those that do occur are less destructive in this region than those occurring in other parts of the Midwest. From 1997 through 2017, only 8 tornadoes were reported in Pike County, Ohio (NCDC 2018). Most of those were relatively weak, registering, at most, F1 on the Fujita tornado scale (73 to 112 miles per hour average wind speed).

3.2.2.2 Air Quality

The Portsmouth Site is located in the Wilmington-Chillicothe-Logan Intrastate AQCR, which includes eight counties in Ohio. **Table 3-14** provides baseline annual emissions data obtained from EPA's 2011 NEI for Pike County and the Wilmington-Chillicothe-Logan AQCR (EPA 2018a). The data include emissions from point sources, area sources, and mobile sources. *Point sources* are stationary sources that can be identified by name and location. *Area sources* are stationary sources from which emissions are too low to track individually, such as a home or small office building, or a diffuse stationary source, such as wildfires or agricultural tilling. *Mobile sources* are any kind of vehicle or equipment with gasoline or diesel engine, an airplane, or a ship. Currently, Pike County is in attainment for all NAAQS criteria pollutants (EPA 2018c). The Ohio

SAAQS for six criteria pollutants—SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and Pb—are the same as the NAAQS (OAC 2016). Ozone, is not emitted directly into the air, but is created by chemical reactions between NO_x and VOCs (EPA 2018b). Therefore, ozone is analyzed and reported as NO_x and VOCs throughout this document.

Table 3-14 Baseline Criteria Pollutant Emissions Inventory for Pike County and the Wilmington-Chillicothe-Logan Intrastate AQCR

Region	Criteria Pollutant Emissions (tons per year)					
	CO	NO_2	PM_{10}	$PM_{2.5}$	SO_2	VOC
Pike County	8,297	1,371	2,729	755	35	7,214
Wilmington-Chillicothe-Logan AQCR	70,303	13,768	30,082	7,658	18,694	51,552

Key: AQCR = air quality control region; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Source: EPA 2018a

For 2015, the following emissions of nonradiological air pollutants from the Portsmouth Site were reported as 11.03 tons (9.98 metric tons) of particulate matter, 1.96 tons (1.77 metric tons) of organic compounds, and 1.78 ton (1.61 metric ton) of nitrogen oxides. Emissions for 2015 are associated with the X-627 Groundwater Treatment Facility, X-330 Dry Air Plant Emergency Generator, and plant roads/parking areas.

The DUF_6 Conversion Facility emits only a small quantity of nonradiological air pollutants. Because of these small emissions, Ohio EPA requires a fee emissions report only once every two years. BWXT Conversion Services, the conversion facility operator at the time, reported less than 10 tons per year of specified nonradiological air pollutants for 2015 (DOE 2017c).

DOE operates under a Title V permit for operations that was issued by Ohio EPA in April 2014 (DOE 2017c). Title V Permit number P0109662 is a sitewide, federally enforceable operating permit that covers emissions of all regulated air pollutants at Portsmouth.

PSD regulations (40 CFR 52.21) limit the maximum allowable incremental increases in ambient concentrations of SO_2, NO_2, and PM_{10} above established baseline levels. The PSD regulations, which are designed to protect ambient air quality in Class I and Class II attainment areas, apply to major new sources and major modifications to existing sources. Class I areas are areas of special national or regional natural, scenic, recreational, or historic value for which the PSD regulations provide special protection. Class I and Class II areas are subject to maximum limits on air quality degradation called air quality increments (often referred to as PSD increments). Class II area air quality increments are more stringent than NAAQS, though less stringent than in Class I areas. The nearest Class I PSD areas are Otter Creek Wilderness Area in West Virginia, about 177 miles (285 kilometers) east of Portsmouth; Dolly Sods Wilderness Area in West Virginia, about 193 miles (311 kilometers) east of the site; and Mammoth Cave National Park in Kentucky, about 200 miles (322 kilometers) southwest of the site. These Class I areas are not located downwind of prevailing winds at the Portsmouth Site.

As discussed in Section 3.1.2.2 of this *DU Oxide SEIS*, the “natural greenhouse effect” is the process by which part of the terrestrial infrared radiation is absorbed by gases in the atmosphere, thereby warming the Earth's surface and atmosphere. This greenhouse effect and the Earth's radiative balance are affected largely by water vapor, CO_2, and trace gases, all of which are absorbers of infrared radiation and commonly referred to as "greenhouse gases" (GHGs). Other trace gases include nitrous oxide, chlorofluorocarbons, methane, and sulfur hexafluoride. Currently EPA reporting for the NEI does not include GHGs. CO_2, methane, and nitrous oxide annual GHG emissions data for the Portsmouth Site, Pike County, and the Wilmington-Chillicothe-Logan Interstate AQCR are provided in **Table 3-15**.

Table 3-15 Baseline Greenhouse Gas Emissions Inventory for Pike County and the Wilmington-Chillicothe-Logan Intrastate AQCR

Region of Interest	Greenhouse Gas (tons per year)			
	CO_2	CH_4	N_2O	Total CO_2e[a]
Portsmouth Site	15,105	0.29	0.029	15,120
Pike County	263,674	39	14	268,870
Wilmington-Chillicothe-Logan AQCR	2,796,109	236	139	2,847,831

Key: AQCR = air quality control region; CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; CO_2e = carbon dioxide equivalent.

[a] CO_2e is the internationally recognized measure of GHGs which weights GHGs based on their Global Warming Potential and the chemical's ability to impact global warming.

Source: DOE 2017c; EPA 2016d

3.2.2.3 Noise

The Noise Control Act of 1972, along with its subsequent amendments (Quiet Communities Act of 1978; 42 U.S.C. §§ 4901–4918), delegates authority to the states to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. The Commonwealth of Ohio and Pike County, where the Portsmouth Site is located, have no quantitative noise-limit regulations.

The EPA has recommended a maximum noise level of 55 dBA as the DNL to protect against outdoor activity interference and annoyance; this is not a regulatory goal, but it is intentionally conservative to protect the most sensitive portion of the American population with an additional margin of safety (EPA 1974). For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an average noise level over a 24-hour period (L_{eq} [24 h]) of 70 dBA or less.

The noise-producing activities within the Portsmouth Site are associated with processing and construction activities and local traffic, similar to those at any other typical industrial site. During Portsmouth Site operations, noise levels near the cooling towers are relatively high, but most noise sources are enclosed in the buildings. Another noise source is associated with train traffic in and out of the Portsmouth Site. In particular, train whistle noise, at a typical noise level of 95 to 115 dBA, is high at public grade crossings. Currently, train traffic noise is not a factor in the local noise environment because of infrequent traffic (DOE 2004b).

The Portsmouth Site is in a rural setting, and no residences or other sensitive receptor locations (e.g., schools, hospitals) exist in the immediate vicinity of any noisy on-site operations. The nearest sensitive receptor is located about 1 mile (2 kilometers) from the Portsmouth Site. Ambient sound level measurements around the Portsmouth Site are not currently available; however, the ambient noise level around the site is expected to be relatively low, except for infrequent vehicular noise. In general, the background environment is typical of rural areas; DNL from the population density in Pike County is estimated to be about 40 dBA (EPA 1974).

3.2.3 Geology and Soil

3.2.3.1 Geology

The topography of the Portsmouth Site area consists of steep hills and narrow valleys, except where major rivers have formed broad floodplains. Just east of the Scioto River, the summits of the main ridges rise to an altitude of more than 1,160 feet (354 meters) above mean sea level, with relief of up to 490 feet (149 meters) from the bottom of the valleys (DOE 2017d).

The stratigraphic sequence found beneath the Portsmouth Site is as follows (from oldest to youngest): Ohio Shale, thinly bedded black shale that may contain oil; Bedford Shale, interbedded thin sandstone and shale; Berea Sandstone, has a larger sand content than the Bedford Shale but is otherwise similar; Sunbury Shale, black carbonaceous shale (this unit thins from east to west and may be completely absent in western portions of the site); Cuyahoga Shale, thinly laminated shale with interbedded sandstone and siltstone (absent beneath the industrial portion of the Portsmouth Site); Gallia Sand, silty to clayey, coarse to fine-grained sand with a pebble base; Minford Clay, interbedded silts and clays divided into two zones, an upper zone of clay, and a lower zone of silty clay. The Gallia Sand and the Minford Clay form the Teays Formation (DOE 2004b, 2014c).

Geologic studies conducted to determine the potential seismic hazard for Portsmouth have determined that only one fault is located within 25 miles (40 kilometers) of the site. This fault lies approximately 18 miles (29 kilometers) to the west of the facility. No seismicity has been recorded on this fault (DOE 2017d).

Based on data from the U.S. Geological Survey, 29 earthquakes occurred within 100 miles (161 kilometers) of the site between June 1974 and June 2016. The largest event occurred on July 27, 1980, with an epicenter approximately 8.7 miles (14 kilometers) north of Mount Sterling, Kentucky (approximately 74 miles [119 kilometers] southwest of the Portsmouth Site) and an estimated magnitude of 5.1. Only 2 of the 29 earthquakes had a magnitude greater than 4.0 (USGS 2016b).

Earthquake-produced ground motion is expressed in units of percent *g* (force of acceleration relative to that of Earth’s gravity). Probabilistic peak (horizontal) ground acceleration (PGA) data from the U.S. Geological Survey were used to indicate seismic hazard. The PGA values cited are based on a 2 percent probability of exceedance in 50 years. This corresponds to an annual occurrence probability of about 1 in 2,500. At the Portsmouth Site, the calculated PGA is in the range of 0.06 to 0.08 *g* (USGS 2014a, 2014b).

3.2.3.2 Soils

Soils within the industrialized portion of the plant have been heavily disturbed and have lost much of their original character. As such, they are classified as “Urban Land.” Approximately 1,500 acres (600 hectares) of the Portsmouth Site consists of moderately drained soils of the Urban Land-Omulga silt loam complex. The Omulga soil at the site is a dark grayish brown silt loam about 10 inches (25 centimeters) thick. Beneath this layer is about 54 inches (137 centimeters) of yellowish-brown subsoil. This material is characterized by a friable silt loam, a silty clay fragipan (low-permeability layer), and, near the bottom, a friable silt loam. Other soils of Portsmouth include the Clifty and Wilbur silt loams, which occur in stream valleys. The uplands areas contain a mixture of Coolville, Blairton, Latham, Princeton, Shelocta, and Wyatt soils (DOE 2004b, 2014).

Soil samples are collected annually at 15 ambient air monitoring locations (on site, fence line, off site, and background locations) and analyzed for radionuclides. Soil samples are also collected and analyzed for radionuclides and chemicals in association with remediation activities (DOE 2017c). Soils at the Portsmouth Site have been contaminated by historical releases and practices. Contaminants include radionuclides (primarily uranium and technetium), metals, and organics. The only analytes exceeding screening levels are uranium-238, arsenic, chromium, and cobalt. Several organic compounds sporadically detected include TCE, PCBs, cis-1,2-dichloroethene, and PAHs (DOE 2014a)

3.2.4 Water Resources

3.2.4.1 Surface Water

The Portsmouth Site is located within the Lower Scioto River watershed about 2 miles (3 kilometers) east of the confluence of the Scioto River and Big Beaver Creek. The largest stream on the site is Little Beaver Creek, which drains the northern portion of the site and discharges into Big Beaver Creek, which then discharges into the Scioto River. The next largest stream, Big Run Creek, drains the east-central and southern portions of the site and flows off site to the southwest where it joins the Scioto River, approximately 4 river miles (6 river kilometers) from the site. The West Drainage Ditch, which drains the west-central portion of the site, flows for 4 stream miles (6 stream kilometers) before discharging into the Scioto River. The Southwest Drainage Ditch (also known as the DOE Piketon Tributary), which drains the southwestern portion of the site, is a small, intermittent watercourse (DOE 2017d). Flooding is not a problem for the majority of the Portsmouth Site. The facilities on the Portsmouth Site are located at a nominal elevation of 670 feet (204 meters) above mean sea level, which is about 100 feet (30 meters) above the historical flood level for the Scioto River in the area. The highest recorded flood elevation of the Scioto River in the vicinity of the site is 570 feet (174 meters) above mean sea level, occurring in January 1913. The entire Portsmouth Site is located outside of the 100-year floodplain, with the exception of a small area in the northwest portion of the site that is associated with Little Beaver Creek (DOE 2017d). The cylinder storage yards are not within the 100-year floodplain.

Discharges of chemicals and other parameters that measure water quality are regulated by the National Pollutant Discharge Elimination System (NPDES) under the Clean Water Act. Water from Portsmouth is monitored at 23 NPDES-permitted locations. Water from the NPDES outfalls is discharged or eventually flows to the Scioto River. Transuranic radionuclides were not detected in any of the samples collected from NPDES external outfalls in 2015. Uranium discharges from external outfalls were estimated at 8.9 kilograms. Total radioactivity (technetium-99 and isotopic uranium) released from the outfalls was estimated at 0.059 curie. Discharge limitations at the NPDES monitoring locations were exceeded on seven occasions in 2015 with these exceedances attributed to concentrations of chlorine or other chemicals in cooling tower or sanitary sewage discharges (DOE 2017c). Historically, all of the NPDES permits have maintained very high compliance rates (DOE 2017d).

Data collected in 2014 are consistent with data collected in previous years and indicate that radionuclides, metals, and other chemicals released by Portsmouth Site operations have a minimal effect on human health and the environment (DOE 2016a). In 2015, samples of surface water were collected semiannually from 14 locations upstream and downstream from Portsmouth at locations on the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek and background locations on local streams approximately 10 miles north, south, east, and west of Portsmouth. Uranium and uranium isotopes were detected at most of the surface water sampling locations. Technetium-99 was detected in samples collected from Little Beaver Creek and Big Beaver Creek downstream from Portsmouth. These detected concentrations of radionuclides were less than 1 percent of the DOE-derived concentration standards for drinking water; surface water around Portsmouth is not used for drinking water (DOE 2017c).

In 2015, samples of sediment were collected annually at 17 monitoring locations, which include the 14 locations sampled for the surface water monitoring program and three on-site NPDES outfalls on the east and west sides of Portsmouth. Samples were analyzed for radionuclides and PCBs. Neptunium-237 and/or plutonium-239/240 were detected in sediment from Little Beaver Creek, on site near NPDES Outfall 001, and Big Beaver Creek. Technetium-99 was detected in sediment collected from Big Beaver Creek, Big Run Creek, on site near NPDES Outfalls 010 and 013, and downstream locations on Little Beaver Creek. Uranium and uranium isotopes were also detected at each of the sediment sampling locations, including upstream and background sampling locations (DOE 2017c). Technetium-99, uranium, and uranium isotopes detected in the 2015 samples have been detected at similar levels in previous sampling events from 2002 through 2014. These radionuclides would yield a dose of 0.035 millirem per year to a hypothetical individual exposed to the maximum concentrations of all radionuclides; well below the DOE standard of 100 millirem per year in DOE Order 458.1 (DOE 2017c). PCBs were detected in Little Beaver Creek, Big Beaver Creek, Big Run Creek, and on site in the West Drainage. None of the detections of PCBs in sediment around Portsmouth were above the risk-based screening level of 240 micrograms per kilogram (DOE 2017c).

3.2.4.2 Groundwater

Five hydrogeological units are important for groundwater flow and contaminant migration at the Portsmouth Site. These units are, in descending order, Minford Clay, Gallia Sand, Sunbury Shale, Berea Sandstone, and Bedford Shale. The upper two units form an aquifer in unconsolidated Quaternary deposits; the lower three units form a Mississippian bedrock aquifer. The hydraulic conductivities of all of the units are very low at the Portsmouth Site (DOE 2004b). Two water-bearing zones are present beneath the industrialized portion of the Portsmouth Site: the Gallia and Berea formations. The Gallia is the uppermost water-bearing zone and contains most of the groundwater contamination at the Portsmouth Site. The Berea is deeper than the Gallia and is usually separated from the Gallia by the Sunbury shale, which acts as a barrier to impede groundwater flow between the Gallia and Berea formations, although the Sunbury shale may be absent in western portions of the site (DOE 2017c).

The direction of groundwater flow beneath the Portsmouth Site is controlled by a complex interaction between the Gallia and Berea units and is also affected by the presence of storm sewer drains and by the reduction in recharge caused by the presence of buildings and paved areas. The direction of groundwater flow is generally to the south in the southern sections of the Portsmouth Site and to the north in the northern sections. Three main discharge areas exist for the groundwater system beneath the Portsmouth Site: Little Beaver Creek to the north and east, Big Run Creek to the south, and two unnamed drainages to the west (DOE 2004b).

Groundwater monitoring at the Portsmouth Site is required by a combination of state and Federal regulations, legal agreements with the Ohio EPA and U.S. EPA, and DOE Orders. More than 400 monitoring wells are used to track the flow of groundwater and to identify and measure groundwater contaminants including VOCs, radionuclides, metals, and other parameters (DOE 2017c). The *Integrated Groundwater Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* describes the groundwater monitoring program for the Portsmouth Site (DOE 2014b).

Five groundwater contamination plumes have been identified at the Portsmouth Site. Groundwater contamination consists of VOCs (primarily TCE) and radionuclides such as technetium-99. Four groundwater treatment facilities are operated by the DOE Environmental Restoration Program to treat contaminated groundwater from the on-site groundwater plumes that are contaminated with industrial solvents. The groundwater treatment facilities remove TCE from the water so it can be safely discharged to Little Beaver Creek or the Scioto River in accordance with NPDES permits issued by Ohio EPA (DOE 2017c). In general, concentrations of contaminants detected within the groundwater plumes at Portsmouth were stable or decreasing in 2015. No VOCs were detected in any of the seven off-site monitoring wells that monitor the groundwater plume near the southern boundary of Portsmouth (DOE 2017c).

DOE has filed a deed notification at the Pike County Auditor's Office that restricts the use of groundwater beneath the Portsmouth Site. Groundwater directly beneath the Portsmouth Site is not used as a domestic, municipal, or industrial water supply, and contaminants in the groundwater do not affect the quality of the water in the Scioto River Valley buried aquifer (DOE 2017c).

Monitoring of four private residential drinking water sources is routinely performed at the Portsmouth Site to determine whether the site has had any impact on the quality of drinking water sources. The Portsmouth water supply is also sampled as part of this program. The Portsmouth Site is the largest industrial user of water in the area and obtains water from water supply well fields north or west of the site in the Scioto River Valley buried aquifer. Results of groundwater monitoring indicate that Portsmouth has not affected drinking water wells outside the site boundaries (DOE 2017c).

3.2.5 Biotic Resources

3.2.5.1 Vegetation and Wildlife Habitat

The most common type of vegetation on the Portsmouth Site is managed grassland (making up approximately 30 percent of the total site area), oak-hickory forest (17 percent), old field

(11 percent), and upland mixed hardwood forest (11 percent).[32] Oak-hickory forest occurs on well-drained upland areas, and old-field communities occur in disturbed areas. Riparian forest occurs in low, periodically flooded areas near streams. Within the area surrounded by Perimeter Road, the Portsmouth Site consists primarily of open grassland (including areas maintained as lawns) and developed areas consisting of buildings, paved areas, and storage yards (DOE 2017c).

Habitats on the Portsmouth Site support a relatively high diversity of terrestrial and aquatic wildlife species, including 27 mammal species, 114 bird species, 11 reptile species, and 6 amphibian species (DOE 2017d). Various species of reptiles and amphibians are associated with streams and other surface water on the site and migrating waterfowl use site retention ponds (DOE 2004b).

Little Beaver Creek fish communities are described as fair upstream and good to exceptional downstream of the Portsmouth Site. Little Beaver Creek has lower water levels upstream of the Portsmouth Site where stream flow is intermittent. Upstream macroinvertebrate communities are poor, while downstream communities range from poor to exceptional. The fish community in West Ditch is marginally good, while the macroinvertebrate community is fair (DOE 2004b).

3.2.5.2 Wetlands

The aquatic habitats on Portsmouth include the various holding ponds; streams that flow through the site and include Little Beaver Creek, Big Run Creek, the West Drainage Ditch; and the DOE Piketon Tributary, all of which discharge into the Scioto River. Little Beaver Creek, Big Run Creek, and the West Drainage Ditch are designated warm water habitats (DOE 2017d). Of these aquatic habitats, 34 acres (14 hectares) of wetlands, excluding retention ponds, occur on the Portsmouth Site; 41 (of the 45 total) wetlands meeting the U.S. Army Corps of Engineers criteria for jurisdictional wetlands. The jurisdictional wetlands primarily support emergent vegetation with palustrine forested wetlands occurring along Little Beaver Creek. The Ohio State Division of Natural Areas and Preserves has listed two wetland areas near the site as significant wetland communities: (1) a palustrine forested wetland, about 5 miles (8 kilometers) east of the site, and (2) Givens Marsh, a palustrine wetland with persistent emergent vegetation, about 2.5 miles (4 kilometers) northeast of the site (DOE 2004b).

3.2.5.3 Threatened and Endangered Species

Federally and state-listed endangered and threatened species known to occur in the vicinity of the Portsmouth Site are identified in **Table 3-16**.

Suitable habitat has been identified for the federally and state-listed endangered Indiana bat (*Myotis sodalis*) and the federally listed threatened northern long-eared bat (*Myotis septentrionalis*). Potential summer habitat for the Indiana bat was identified on the site. Mist net surveys were conducted on the Portsmouth site in May of 2011 and July and August of 2013; no Indiana bats were found. However nine northern long-eared bats were captured (and released) (DOE 2017d).

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[32] Approximately half of this upland mixed hardwood forest was recently removed for construction of the OSWDF (DOE 2017d).

Table 3-16 Federally and State-Listed Endangered, Threatened, and Special Concern Species near the Portsmouth Site

Scientific Name	Common Name	Status	
		Federal	State
Faunal Species			
Myotis sodalis	Indiana bat	Endangered	Endangered
Myotis septentrionalis	Northern long-eared bat	Threatened	Threatened
Opheodrys aestivus	Rough green snake	Not Listed	Species of Concern
Accipiter striatus	Sharp-shinned hawk	Not Listed	Species of Concern
Tyto alba	Barn owl	Not Listed	Threatened
Crotalus horridus	Timber rattlesnake	Species of Concern	Endangered
Floral Species			
Rhexia virginica	Virginia meadow-beauty	Not Listed	Potentially Threatened
Xyris difformis	Carolina yellow-eyed grass	Not Listed	Endangered
Juncus secundus	Lopsided rush	Not Listed	Potentially Threatened
Packera paupercula	Balsam groundsel	Not Listed	Threatened
Piptochaetium avenaceum	Blackseed speargrass	Not Listed	Endangered
Trifolium stoloniferum	Running buffalo clover	Endangered	Endangered

Source: DOE 2017d

The sharp-shinned hawk and the rough green snake, both species of concern in Ohio, have been observed on the Portsmouth Site. Both of these species inhabit moist woods. The timber rattlesnake, listed by the State of Ohio as endangered, occurs in the vicinity of the Portsmouth Site but has not been found on the site. Habitat for the timber rattlesnake is found on and near high, dry ridges.

No occurrence of federally listed endangered or threatened plant species have been documented on the Portsmouth Site. Of the state-listed plant species, only the Virginia meadow-beauty (listed as potentially threatened) has been identified on site, and the Carolina yellow-eyed grass (listed as endangered) has been tentatively identified on Portsmouth. Thirteen additional state-listed rare, threatened, and endangered plant species were preliminarily identified on the Portsmouth Site during a 2012 Ohio University habitat study. These plant species identifications did not meet the multi-level criteria (three-season survey) necessary to definitively identify the presence of a listed plant species (DOE 2017d).

3.2.6 Public and Occupational Safety and Health

3.2.6.1 Radiation Environment

DOE has calculated the radiation exposures of on-site workers and members of the off-site general public from operation of the Portsmouth Site. In 2014, the hypothetical maximum radiation dose to an off-site member of the public as a result of on-site facility operations was estimated to be 1.1 millirem per year (DOE 2017c) with no LCFs expected (calculated value of 7×10^{-7}), which is less than one percent of the average dose of 311 millirem per year from exposure to natural background radiation (e.g., cosmic gamma, internal, and terrestrial radiation) for an individual in the United States (NCRP 2009). The calculation of this maximum dose limit assumes that the same representative person works near the Portsmouth Site and lives in the immediate vicinity of the Portsmouth Site. The DOE dose limit for the general public is 100 millirem per year from all pathways, as prescribed in DOE Order 458.1. **Table 3-17** provides the contributions to the maximum individual dose by pathway. The hypothetical maximum dose was estimated by using the largest environmental media concentrations monitored at different off-site locations, emission data, and conservative exposure parameters.

The population dose is the sum of individual doses to the entire population within 50 miles of the Portsmouth Site. In 2015, the population dose from operations at the Portsmouth Site was 0.224 person-rem (DOE 2017c) with no LCFs expected (calculated value of 1×10^{-4}), which is approximately 1.1×10^{-4} percent of the total population dose (from natural background radiation) of 210,000 person-rem.

Table 3-17 Sources of Maximum Individual Dose

Source of Dose	Dose (millirem per year)	LCF
Airborne radionuclides[a]	0.037	2×10^{-8}
Waterborne radionuclides (Scioto River)[b]	0.0017	1×10^{-9}
External radiation[c]	0.96	6×10^{-7}
Radionuclides detected by environmental monitoring programs[d]	0.082	5×10^{-8}
Total	**1.1**	$\mathbf{1\times10^{-6}}$

Key: LCF = latent cancer fatality.

[a] EPA limit for public dose from airborne radionuclides is 10 millirem per year (NESHAP, 40 CFR Part 61, Subpart H).

[b] Dose calculated from measured radionuclide discharges from the plant outfalls and the annual flow rate of the Scioto River.

[c] From the off-site monitoring station resulting in the highest calculated dose.

[d] Includes all sources (e.g., sediment, soil, residential drinking water, biota) not specifically identified in the first three entries in this table.

Source: DOE 2017c (Table 4.1)

Less than 2 percent of the 2,527 workers at Portsmouth received a measureable dose (a dose of 1 millirem or more) in 2016. These workers were primarily handling DU cylinders. The total worker dose for 2016 was 2.5 person-rem with no LCFs expected (calculated value of 0.002). Considering all 2,527 workers, the average worker dose was 0.99 millirem (DOE 2017b). However, considering only the workers who received a measurable dose (40 workers), the average dose to these workers was 63 millirem (DOE 2017b). To protect workers from impacts from radiological exposure, 10 CFR Part 835 imposes an individual dose limit of 5,000 millirem in a year. In addition, worker doses must be monitored and controlled below the regulatory limit to ensure that individual doses are less than a DOE administrative limit of 2,000 millirem per year (DOE 2017f) and maintained to achieve ALARA goals.

3.2.6.2 Chemical Environment

The chemical environment is described by the nonradiological effect of uranium when inhaled or ingested. This health effect is expressed as a hazard quotient, a ratio of the estimated intake versus the level below which adverse health effects are not expected. A hazard quotient of less than one means no adverse health effects are expected. The hazard quotient for various exposure pathways (environmental medium) for members of the general public under existing environmental conditions near the Portsmouth Site are presented in **Table 3-18**. Since the on-site activities addressed in this *DU Oxide SEIS* pertain only to the storage of DU oxide and not the DUF_6 conversion process nor the source material for that process, only uranium is addressed in this table, as that is the element most relevant to this SEIS.

Safety and health requirements for DOE workers are governed by 10 CFR Part 851, which establishes requirements for a worker safety and health program to ensure that DOE workers have a safe work environment. Included are provisions to protect against hazardous chemicals. For worker protection from the toxic effects of uranium, DOE uses the OSHA permissible exposure levels for workplace exposure to uranium of 0.25 milligram per cubic meter for insoluble and 0.05 milligram per cubic meter for soluble uranium (29 CFR 1910.1000, Table Z-1). Under the requirements of DOE's worker protection program, site worker exposures to airborne uranium are maintained below these levels.

Table 3-18 Chemical Hazard Quotient for Uranium

Environmental Medium	Assumed Exposure Concentration	Estimated Chronic Intake (mg/kg-d)[a]	Reference Level[b] (mg/kg-d)	Hazard Quotient
Air[c]	2.4×10^{-3}μg/m^3	2.1×10^{-6}	3.0×10^{-4}	6.9×10^{-3}
Soil[d]	3.49 μg/g	15.0×10^{-5}	3.0×10^{-3}	1.7×10^{-2}
Surface Water[e]	5.04 μg/L	2.9×10^{-6}	3.0×10^{-3}	9.6×10^{-4}
Sediment[f]	6.49 μg/g	1.9×10^{-6}	3.0×10^{-3}	6.2×10^{-4}
Groundwater[g]	35.6 μg/L	1.0×10^{-3}	3.0×10^{-3}	3.4×10^{-1}

Key: μg/m^3 = micrograms per cubic meter; μg/g = micrograms per gram; μg/L = micrograms per liter; mg/m^3 = milligrams per cubic meter.

[a] Calculated based on an assumed inhalation/consumption rate (derived from DOE 2017c) for a representative person (weight of 70kg)

[b] Air reference level derived from the OSHA permissible exposure limits (PELs) for soluble uranium compounds (0.05 mg/m^3) instead of the higher limit for insoluble uranium. The other environmental medium reference level is EPA's oral reference dose (RfD) from EPA Integrated Risk Information System for uranium.

[c] Concentration is the largest value for uranium in Table 2-10 of DOE (2017c).

[d] Concentration is the largest value for uranium in Table 2-16 of DOE (2017c).

[e] Concentration is the largest value for uranium in Table 2-14 of DOE (2017c).

[f] Concentration is the largest value for uranium in Table 2-15 of DOE (2017c).

[g] Concentration is the largest value for uranium in Table 4-9 of DOE (2017c).

Source: DOE 2017c

3.2.7 Socioeconomics

The ROI for this socioeconomic analysis consists of four counties: Jackson, Pike, Ross, and Scioto counties in Ohio. The ROI is based on where socioeconomic impacts would be expected, if any were to occur, with a focus on Pike County and Scioto County, where the majority of any impacts would be expected.

3.2.7.1 Population

In 2010, the population of the ROI was 219,497 people (Census 2010). Approximately 49.3 percent (108,208 people) of the total ROI resided in Pike County and Scioto County. Between the 2010 U.S. Census and 2014 estimates, the total four-county ROI population decreased by 1,969 people (approximately -0.23 percent annually). Over the same period, the population in Ohio grew at an average annual rate of 0.05 percent (see **Table 3-19)**.

Table 3-19 Population in the Portsmouth Region of Influence and Ohio in 2010 and 2014

Location	2010 Census	2014 Estimate	Average Annual Growth Rate (%) 2010–2014
Jackson County	33,225	32,952	-0.21
Pike County	28,709	28,504	-0.18
Ross County	78,064	77,552	-0.16
Scioto County	79,499	78,520	-0.31
ROI Total	**219,497**	**217,528**	**-0.23**
Ohio	11,536,504	11,560,380	0.05

Key: ROI = region of influence.
Sources: Census 2010, 2014a

3.2.7.2 Employment and Income

The number of personnel supporting Portsmouth was 2,612 non-DOE government personnel including 116 Centrus personnel as of January 2018 (PPPO 2018). In 2014, total employment in the ROI was 93,493, representing an increase of 1,673 (1.82 percent) jobs since 2010. Major industries by employment in the ROI include health care and social assistance, government and government enterprises, and retail trade. In 2014, total employment in Pike County was 12,785, representing a decrease of 282 jobs (2 percent) since 2010. The major industries by employment in the county include administrative and support and waste management, health care and social assistance, and government and government enterprises. In 2014, total employment in Scioto County was 31,016, representing a decrease of 373 jobs (1.2 percent) since 2010. The major industries in the county include health care and social assistance, government and government enterprises, and retail trade (BEA 2015a).

Unemployment in Pike County and Scioto County decreased between 2010 and 2015 from 14.8 percent to 7.4 percent in Pike County and from 13.3 percent to 7.7 percent in Scioto County (BLS 2016a). Unemployment in each county and the total ROI was greater than the unemployment rate in the state of Ohio during 2015 (see **Table 3-20**). Scioto County had the lowest per capita personal income in the four-county ROI with $31,627 in 2014 and Jackson County had the highest with $32,701. Pike County had a per capita personal income of $32,093. All counties had a lower per capita personal income compared to the state of Ohio with $42,236 in 2014 (BEA 2015c).

Table 3-20 Employment in the Portsmouth Region of Influence in 2015

Location	Total Employment	Unemployment Rate (%)
Jackson County	14,400	7.5
Pike County	12,785	7.4
Ross County	35,292	5.3
Scioto County	31,016	7.7
ROI Total	**93,493**	**6.7**
Ohio	6,753,002	4.9

Sources: Census 2014b; BEA 2015a; BLS 2016a

3.2.7.3 Housing

In 2014, housing units in the four-county ROI totaled 93,141 units (Census 2014c). More than 36 percent of the total housing units in the ROI were in Scioto County. Approximately 12 percent of the total housing units were vacant, while the remaining 88 percent were occupied (see **Table 3-21**).

Table 3-21 Housing in the Portsmouth Region of Influence in 2014

Location	Total Housing Units	Occupied Housing Units	Vacant Housing Units
Jackson County	14,574	13,204	1,370
Pike County	12,534	10,944	1,590
Ross County	31,933	28,209	3,724
Scioto County	34,100	29,558	4,542
ROI Total	**93,141**	**81,915**	**11,226**
Ohio	5,135,173	4,570,015	565,158

Key: ROI = Region of Influence.
Source: Census 2014c

3.2.7.4 Community Resources

Emergency response services in the ROI include police, fire rescue, and emergency response. Law enforcement in the ROI consists of state, county, and local police departments. There are 16 officers in Pike County, 14 in Jackson County, 44 in Ross County, and 43 in Scioto County (DOE 2017d). The Portsmouth Fire Department serves the city of Portsmouth and Sciotoville and has 36 sworn officers and 6 emergency dispatchers (Portsmouth Ohio 2016a, 2016b). There is an on-site fire department on Portsmouth with the capabilities and equipment to contain most fires that would occur on site; however, the on-site fire department has a mutual assistance agreement with off-site fire departments for situations that are beyond the on-site fire department's capabilities (DOE 2017d).

Southern Ohio Medical Center (Portsmouth) and Adena Pike Medical Center (Waverly) are the primary care facilities with 222 beds and 25 beds, respectively (SOMC 2016; Adena 2016). Both medical centers operate an urgent care facility approximately 8 miles north of Portsmouth. In addition, there is an on-site medical center at Portsmouth. There is also a first aid room maintained by the X-1007 Fire Station (DOE 2017d).

There are 33 public school districts throughout the four-county ROI. During the 2013–2014 school year, there were 33,286 students enrolled throughout the 86 schools in the ROI (DOE 2017d). There are four school districts in Pike County with a total enrollment of 4,689 students and 271 full-time teachers during the 2014–2015 school year, for a student-to-teacher ratio of 17.3 to 1 (ODE 2016a, 2016b). There are 10 school districts in Scioto County with a total enrollment of 11,530 students and 723 full-time teachers during the 2014–2015 school year, for a student-to-teacher ratio of 15.9 to 1 (ODE 2016a, 2016b).

3.2.8 Waste Management

A variety of wastes are generated at the Portsmouth Site as a result of differing activities including the management of DUF_6 cylinders in storage; conversion of DUF_6 to DU oxide with on-site storage of DU oxide cylinders pending their disposition; DD&D of excess facilities and structures; and environmental restoration of soil, groundwater, and surface-water contamination. These wastes include LLW,[33] MLLW,[34] nonradioactive hazardous and Toxic Substances Control Act (TSCA) waste, solid nonhazardous waste, and wastewater. Current annual generation rates for these wastes are summarized in **Table 3-22**.

Table 3-22 Current Waste Generation Rates at Portsmouth

Waste Type		Annual Quantities
Solid LLW	Unusable empty DUF_6 cylinders[a]	22 cubic yards
	Debris	140 cubic yards
	Oversized debris	4.8 cubic yards
	Soil-like material	16 cubic yards
	Soil-like material with TSCA constituents	0.21 cubic yards
	Calcium fluoride[b]	18 metric tons/20 tons
Liquid LLW		510 gallons
MLLW	Debris	0.35 cubic yards
	Soil-like material	0.67 cubic yards
Liquid MLLW		44 gallons
Hazardous waste		4.1 cubic yards
Universal waste[c]		1.4 cubic yards
Solid nonhazardous waste		87 tons
Wastewater (not including sanitary wastewater)		920 gallons

Key: DUF_6 = depleted uranium hexafluoride; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; TSCA = Toxic Substances Control Act.

[a] Emptied cylinders determined to be unusable for containment of DU oxide are disposed of as LLW.

[b] From the oxide conversion process. The calcium fluoride would be shipped off site for disposal as low-activity LLW (also called exempt LLW). Low-activity LLW is waste that contains so little radioactive material that it can be disposed of at a facility other than a LLW disposal facility licensed under 10 CFR Part 61 or compatible Agreement State regulation. Disposal of this waste is licensed under 10 CFR 20.2002 or compatible Agreement State regulation.

[c] Universal waste refers to a category of hazardous waste having streamlined management procedures.

Source: PPPO 2018

Note: To convert cubic yards to cubic meters, multiply by 0.76456; tons by metric tons, multiply by 0.90718; gallons to liters, multiply by 3.7854.

Table 3-23 shows the waste expected to be generated during DD&D of the Portsmouth Site. Approximately 1,357,000 cubic yards (1,038,000 cubic meters) of waste is expected to be generated by DD&D (PPPO 2018). It is anticipated that the large majority of the lightly contaminated waste will be disposed of in the OSWDF. It is also anticipated that 107,000 cubic yards (81,800 cubic meters) of the waste will be sent off site for disposal, and another 110,000 cubic yards (84,100 cubic meters) of material may be a candidate for recycling and/or reuse. The OSWDF will have a capacity of 5 million cubic yards (3,823,000 cubic meters) to factor in uncertainties in the underlying assumptions of the original capacity calculations (DOE 2015g). **Table 3-24** summarizes methods for management of these wastes.

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[33] Includes calcium fluoride generated during the oxide conversion process that would be disposed as low-activity LLW.

[34] Consisting of waste regulated for its radioactive content pursuant to the Atomic Energy Act of 1954, as amended, as well as its chemical content pursuant to RCRA, TSCA, or other applicable statutes.

Table 3-23 Estimate of Waste Generated During Deactivation, Decontamination, and Demolition of the Portsmouth Site

Waste Type	Total Quantity (cubic yards)[a]
Solid LLW	437,500
LLW – construction and demolition debris	786,800
LLW – TSCA	37,000
MLLW	100
RCRA	53,400
Construction and demolition debris	32,000
Solid Waste	10,200
Total	1,357,000

Key: LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; OSWDF = On-Site Waste Disposal Facility; RCRA = Resource, Conservation and Recovery Act; and TSCA = Toxic Substance Control Act.

[a] This waste could be generated, depending upon funding, over a 10- to 12-year period (DOE 2014a).

Source: PPPO 2018

Table 3-24 Current Methods for Management of Wastes at the Portsmouth Site

Waste	Typical Content	Management Procedure[a]
Solid LLW	Refuse, sludge, or debris primarily containing uranium and technetium.	Temporary storage on-site pending shipment to off-site treatment and/or disposal facilities.[b]
Solid and liquid MLLW	Similar materials as solid low-level radioactive waste but also containing RCRA hazardous components such as lead, or toxic materials such as PCBs.	Temporary on-site storage pending shipment to off-site permitted facilities for treatment and/or disposal.[b]
Solid and liquid hazardous and toxic waste	Spent solvents, heavy-metal-contaminated waste and PCB-contaminated toxic waste.	Temporary on-site permitted storage pending shipment to off-site facilities for treatment and or storage disposition. Principal storage areas are the X-330 and X-345 RCRA storage areas. Several 90-day storage areas are also available.[b]
Wastewater	Sanitary and process-related wastewater streams, cooling water blowdown, radioactive process-related liquid effluents, discharges from groundwater treatment systems, and storm water runoff from plant areas. Radioactive process-related liquid.	Nonradioactive wastewater is processed at several on-site treatment facilities and discharged through permitted outfalls. Treatment facilities include an activated sludge sewage treatment plant; facilities that apply waste-specific pretreatment technologies (e.g., pH adjustment, activated carbon adsorption, metals removal, denitrification, and ion absorption); and basins to facilitate solids settling, oil collection, and chlorine dissipation. The Portsmouth Site wastewater facilities have a capacity of about 5.3 million gallons (20 million liters) per day. Radioactive liquid is shipped off site for treatment and disposal.
Solid nonhazardous waste	Sanitary refuse, cafeteria waste, industrial waste, disinfected medical waste, and construction and demolition debris.	Recycle or disposal in an off-site permitted nonhazardous waste landfill.[b]

Key: LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; PCB = polychlorinated biphenyl; RCRA = Resource Conservation and Recovery Act.

[a] In addition, the Portsmouth Site has an active program to minimize the generation of solid LLW, MLLW, hazardous waste, and solid nonhazardous waste.

[b] In the future, Portsmouth plans to dispose of waste from DD&D activities within an OSWDF, provided the waste meets the waste acceptance criteria for the OSWDF. Waste not meeting the OSWDF waste acceptance criteria will be transported off site for disposal (DOE 2015g).

Sources: DOE 2004b; PPPO 2018

3.2.9 Land Use and Aesthetics

3.2.9.1 Land Use

The Portsmouth Site is located in south-central Ohio, in the southern portion of rural Pike County, and encompasses an area of 3,777 acres (1,528 hectares). Land use in the general vicinity of the Portsmouth Site includes urban land, residential areas, private and commercial farms, light industries, and transportation corridors (highways and railroads) (DOE 2014a). In Pike County the land use is approximately 66 percent forest, 23 percent cropland, and 8 percent pasture. The remaining 3 percent is classified as urban land, open water, and bare/mines areas (DOE 2014a). The latter classification refers to largely unvegetated areas of nonurban land, some of which may be associated with mining. Two public recreational areas are located in the vicinity of the Portsmouth Site: Brush Creek State Forest (approximately 15 miles [24 kilometers] to the southwest), and Lake White State Park (approximately 6 miles [10 kilometers] to the north) (DOE 2014a).

In the immediate area surrounding the Portsmouth Site, land is used primarily for farms, pastures, forests, and rural residences; however, the dominant land use is farming. The 2012 agricultural census recorded 490 farms in Pike County, covering more than 97,446 acres (39,370 hectares), approximately 34 percent of the county (USDA 2014b).

Human settlement is sparse throughout most of Pike County; the largest communities (Piketon and Waverly) are located near the Scioto River, north of the Portsmouth Site; the village of Jasper is northwest of the site; and the village of Wakefield is south of the site (DOE 2004b).

Within the 3,777-acre (1,528-hectare) DOE land holdings at the Portsmouth Site, Perimeter Road surrounds a 1,300-acre (526-hectare) developed industrial use area, which includes the Conversion Facility and former Portsmouth GDP in a 750-acre (304-hectare) controlled access area. The Portsmouth Conversion Facility includes multiple buildings supporting the site mission, located in proximity to three large process buildings with a combined floor space of about 9,680,000 square feet (900,000 square meters) (DOE 2018c). The portion of the plant outside of Perimeter Road has approximately 2,500 acres (1,010 hectares) of land. Land uses outside of the central industrial area include a water treatment plant, holding ponds, sanitary and inert landfills, cylinder storage yards, parking areas, open fields, and forested buffer areas (DOE 2014a).

Currently, DOE has two real property leases with the Southern Ohio Diversification Initiative (SODI) (DOE 2014a). The first lease between DOE and SODI was signed in April 1998 for 7 acres (3 hectares) of land on the north side of the DOE property. This tract is used as a right-of-way for a railroad spur that connects to the existing DOE north rail spur. SODI subleases a portion of this property to the Glatfelter Corporation to allow access to the rail line for a wood-grading operation. In October 2000, a second lease between DOE and SODI was signed to allow concurrent SODI access to and use of the existing north rail spur (DOE 2014a). In July 2018, DOE transferred 80 acres of additional site property to SODI (DOE 2018d).

3.2.9.2 Aesthetics

The Portsmouth Site is located in a rural area of Pike County, Ohio. The area is characterized by gently rolling terrain. The dominant viewshed (an area visible to the human eye from a fixed vantage point) at the Portsmouth Site consists of buildings, cylinder storage yards, transmission lines, and open and forested buffer areas. Numerous buildings within the Portsmouth Site viewshed are in various stages of deactivation and decommissioning.

A visual impact study was conducted at the Portsmouth Site (DOE 2014a). This study evaluated the visibility of various components of the Portsmouth Site from the surrounding community. In the immediate area surrounding the Portsmouth Site there are no environmentally sensitive areas, including areas of recreational, scenic, or aesthetic importance (DOE 2014a).

The developed areas and utility corridors (transmission lines and aboveground pipelines) of the Portsmouth Site are consistent with a Visual Resource Management Class IV designation. The remainder of the site is consistent with a Visual Resource Management Class II or Class III designation. Management activities within Class II and Class III areas may be seen, but do not dominate the view; management activities in Class IV areas dominate the view and are the focus of viewer attention (DOI 1986).

3.2.10 Cultural Resources

Although southern Ohio has been home to humans from at least the Paleoindian period, prior to 11,000 BCE, there is very little evidence in the vicinity of the Portsmouth Site. More common are sites dating to the Archaic Period (11,000 BCE to 3000 BCE), followed by the Woodland Period (3000 BCE to 900 CE). The latter period is particularly notable for the mound complexes found throughout the region. Most recently, prior to Euro-American contact, the Fort Ancient culture period extended from 900 CE to 1600 CE. At the time of Euro-American contact, the Shawnee lived in southern Ohio, including the Scioto Valley. Euro-American settlements took hold in the early 1800s, consisting primarily of agricultural ventures (DOE 2004b; Miller et al. 2014).

The Atomic Energy Commission chose the Scioto Valley as the location for a gaseous uranium diffusion facility to work in concert with facilities at Paducah, Kentucky and Oak Ridge, Tennessee. With construction starting in 1952, the plant became operational in 1954 (DOE 2004b; Miller et al. 2014).

Portsmouth fulfilled its cultural resource inventory obligations under Section 110 of the National Historic Preservation Act through numerous cultural resources surveys and consultation with the Ohio SHPO between 1996 and 2013. As a result of these efforts, 117 archaeological resources, 196 architectural resources (buildings and structures), and 2 cemeteries were identified. Of the archaeological resources, three prehistoric sites and two historic era sites (the Holt Cemetery and Mount Gilead Church and Cemetery) are eligible for listing on the NRHP, and the rest are not NRHP-eligible (DOE 2017d). Additionally, based on the results of those surveys, it has been determined that all of the area within Perimeter Road was significantly disturbed during plant construction (DOE 2015b).

Thirty-three of the 196 Portsmouth buildings are considered historic properties, all of which are considered eligible for the NRHP based upon their relationship with the historic Cold War mission of Portsmouth (DOE 2017d). The final comprehensive mitigation measures are included in the *Final Record of Decision for the Site-Wide Waste Disposition Evaluation Project at the Portsmouth Gaseous Diffusion Plant* (DOE 2015g). None of the cylinder storage locations has been identified as historic resources. No traditional cultural resources have been identified at the Portsmouth Site.

Status of Consultation

For the 2004 EIS (DOE 2004b), DOE initiated Section 106 consultation with the following Native American tribes:

- Absentee Shawnee Tribe of Oklahoma
- Chickasaw Nation of Oklahoma
- Eastern Band of Cherokee Indians, Quallah Boundary
- Eastern Shawnee Tribe of Oklahoma
- Peoria Tribe of Oklahoma
- Seneca-Cayuga Tribe of Oklahoma
- Shawnee Nation, United Remnant Band
- Shawnee Tribe

The Eastern Shawnee Tribe of Oklahoma and Peoria Tribe of Oklahoma had no concerns and requested consultation in the event of any North American Graves Protection and Repatriation Act-related finds or issues. No other tribes responded. No religious or sacred sites, burial sites, resources significant to Native Americans, or other Native American concerns have been identified at the Portsmouth Site (DOE 2004b).

In 2009, DOE transmitted a letter, “Interest as a Consulting Party in NHPA Section 106 Consultation Process,” to the following Native American tribes:

- Citizen Potawatomi Nation
- Delaware Nation
- Eastern Shawnee Tribe of Oklahoma
- Forest County Potawatomi Community
- Hannahville Indian Community Council
- Miami Tribe of Oklahoma
- Ottawa Tribe of Oklahoma
- Peoria Tribe of Indians of Oklahoma
- Pokagon Band of Potawatomi Indians
- Prairie Band of Potawatomi Nation
- Shawnee Tribe
- Turtle Mountain Band of Chippewa
- Wyandotte Tribe of Oklahoma

For the *Conveyance of Real Property at the Portsmouth Gaseous Diffusion Plant EA* (DOE 2017d) DOE initiated Section 106 consultation with the following Native American tribes:

- Shawnee Tribe of Oklahoma
- Eastern Shawnee Tribe of Oklahoma
- Seneca-Cayuga Tribe of Oklahoma

- Shawnee Nation, United Remnant Band
- Shawnee Tribe

At this time, the Portsmouth NHPA Officer is in contact with the following tribes:

- Absentee-Shawnee Tribe of Oklahoma
- Eastern Shawnee Tribe of Oklahoma
- Seneca-Cayuga Tribe of Oklahoma
- Shawnee Tribe

DOE also consulted with the following SHPOs on the 2004 Portsmouth EIS (DOE 2004b):

- Kentucky Heritage Council
- Ohio Historic Preservation Office
- Tennessee Historical Commission

The Ohio and Kentucky offices indicated, by not responding, that they had no concerns. Although the Tennessee Historical Commission had some concerns at the time of consultation for the 2004 action (DOE 2004b), no elements of the current project involve resources that are regulated by the State of Tennessee. DOE also consulted with the Ohio Historic Preservation Office for the *Conveyance of Real Property at the Portsmouth Gaseous Diffusion Plant EA* (DOE 2017d).

In terms of the potential impacts to cultural resources, DOE determined that the actions evaluated in this *DU Oxide SEIS* do not differ appreciably from those evaluated in the 2004 EIS (DOE 2004b). Therefore, DOE determined that the consultations completed for the 2004 EIS satisfy DOE's obligation under NHPA Section 106 and that no further consultations are needed.

3.2.11 Environmental Justice

In 1994, EO 12898, *Federal Actions to Address Environmental Justice in Minority and Low-Income Populations (Environmental Justice)*, was issued to focus the attention of Federal agencies on how their actions affect the human health and environmental conditions to which minority and low-income populations are exposed. This EO was also established to ensure that if there were disproportionately high and adverse human health or environmental effects from Federal actions on these populations, these effects would be identified and addressed. The environmental justice analyses in this *DU Oxide SEIS* address the characteristics of race, ethnicity, and poverty status for populations residing in areas potentially affected by implementation of the alternatives presented in this SEIS.

In 1997, EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks (Protection of Children)*, was issued to identify and address anticipated health or safety issues that affect children. The protection-of-children analyses in this *DU Oxide SEIS* address the distribution of population by age in areas potentially affected by implementation of the alternatives presented in this SEIS.

For the purpose of the environmental justice analysis, these populations are defined as follows:

Minority Populations – All persons identified by the U.S. Census Bureau to be of Hispanic or Latino origin, regardless of race, plus non-Hispanic persons who are Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, or members of some other (i.e., nonwhite) race or two or more races.

Low-Income Populations – All persons who fall within the statistical poverty thresholds established by the U.S. Census Bureau. For the purposes of this analysis, low-income populations are defined as persons living below the poverty level. Starting with the 2010 Decennial Census, poverty data will be provided through the annual American Community Survey rather than as part of the Decennial Census.

Children – All persons identified by the U.S. Census Bureau to be under the age of 18 years.

Table 3-25 provides a summary of the percentage of minority and low-income populations within 50 miles (80 kilometers) of the Portsmouth Site. The 225 census tracts within 50 miles of the Portsmouth Site are defined as the ROI. To identify census tracts with disproportionately high minority populations, this *DU Oxide SEIS* uses the percentage of minorities in each state containing a given tract as the COC. Using the individual states to identify "disproportionality" acknowledges that minority distributions in the state can differ from those found in the nation as a whole.

Table 3-25 Environmental Justice Populations

Location	Minority		Low-Income[a]	
	Number	Percent	Number	Percent
United States	116,947,592	37.2	47,755,606	15.6
Ohio	2,248,817	19.5	1,790,564	15.9
Kentucky	622,404	14.2	803,866	18.9
West Virginia	135,010	7.3	326,225	18.1

[a] Based on population for whom poverty status is determined[35] which may differ from the total population
Sources: Census 2014a, 2014f

Table 3-26 provides a summary of the age distribution for the population in states containing a given census tract within 50 miles (80 kilometers) of the Portsmouth Site.

Table 3-26 Population Distribution by Age

Location	Total Population	Under 5 Years		Under 18 Years		Over 65 Years	
		Number	Percent	Number	Percent	Number	Percent
United States	314,107,084	19,973,711	6.4	73,777,658	23.5	43,177,961	13.7
Ohio	11,560,380	700,088	6.1	2,673,661	23.1	1,704,599	14.7
Kentucky	4,383,272	277,776	6.3	1,018,350	23.2	614,496	14.0
West Virginia	1,853,881	103,044	5.6	383,727	20.7	311,625	16.8

Source: Census 2014a

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[35] People whose poverty status cannot be determined includes people in college dormitories, military barracks, living situations without conventional housing, institutional group quarters, and unrelated invidivuals under age 15. However, these people may be included in the total population count; thus the total number of low-income individuals might differ if the percent of low-income individuals is taken from the total population.

Schools, childcare centers, parks, and hospitals represent areas where there would be high concentrations of children. There are three schools approximately 4 to 6 miles from the Portsmouth Site: Jasper Elementary School, Piketon Junior/Senior High School, and Zahn's Middle School. Adena Pike Medical Center and Southern Ohio Medical Center are located 5 miles and 17 miles (8 kilometers and 27 kilometers) from the Portsmouth Site, respectively.

As shown in **Figure 3-2**, in 2014, of the 225 census tracts within 50 miles (80 kilometers) of the Portsmouth Site, 17 census tracts had min3-48ority populations in excess of state-specific thresholds; a total of 11,555 minority persons. Of the 225 census tracts within 50 miles of the Portsmouth Site there were 147 census tracts with low-income populations in excess of state-specific thresholds; a total of 144,420 low-income persons (Census 2014d, 2014e).

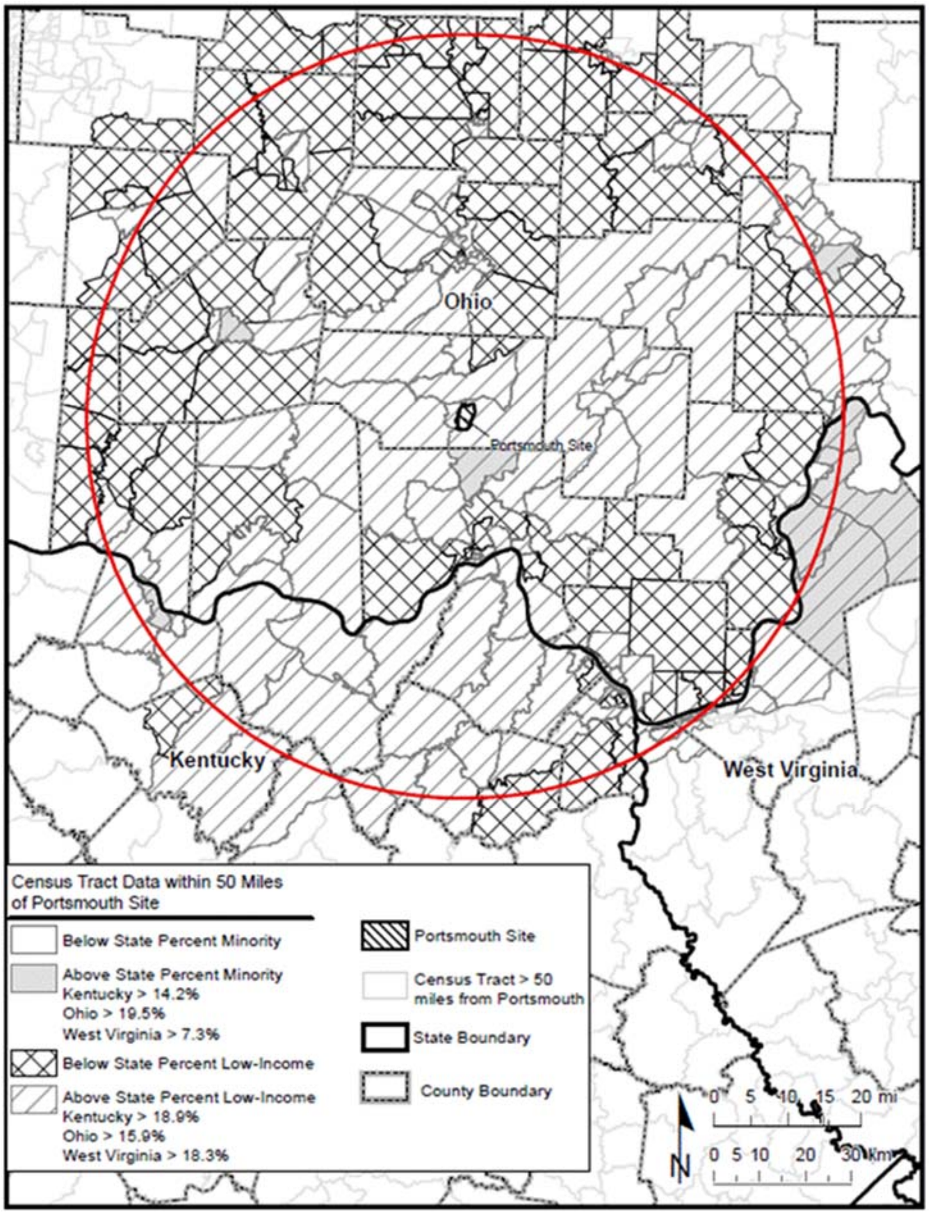

Figure 3-2 Environmental Justice Populations—Portsmouth Site (Sources: Census 2014a–2014f)

3.3 ENERGY*SOLUTIONS*

The Energy*Solutions* site is located on a 640-acre (260-hectare) parcel of land in western Utah, in the northwestern portion of Tooele County, about 60 miles (100 kilometers) west of Salt Lake City, on the eastern edge of the Great Salt Lake Desert (ES 2016b) (**Figure 3-3**). Energy*Solutions* owns the property, with the exception of 100 acres (40.5 hectares) owned by DOE (ES 2016a).

Figure 3-3 Location of the Energy*Solutions* Site near Clive, Utah

The Energy*Solutions* site is located in the Intermountain Plateau climatic zone, which is classified as a middle-latitude dry climate or steppe (ES 2016a). From 1992 to 2009, the average monthly temperatures at the site ranged from 80°F (26°C) in July to 28°F (-2.4°C) in December. Site data indicate that, from 1992 to 2004, the average annual rainfall was approximately 8.6 inches (22 centimeters) per year. On average, April has the highest amount of precipitation (1.3 inches [3.2 centimeters]), while August has the lowest (0.32 inches [0.8 centimeters]). Snowfall does occur during the winter months (Neptune 2015).

The Energy*Solutions* site is located in the Basin and Range Province of North America, which predominantly consists of block-faulted mountain ranges generally trending north to south. The soils primarily consist of sediments originating from Quaternary lacustrine Lake Bonneville deposits and Quaternary and Tertiary colluvial and alluvial materials eroded from adjacent mountains (ES 2016c).

The upper aquifer systems below the Energy*Solutions* site consists of a shallow unconfined aquifer that extends through the upper 40 feet (12 meters) of lacustrine deposits and a confined aquifer that begins around 40 to 45 feet (12 to 14 meters) and continues through the valley fill to depths of about 500 feet (160 meters) (ES 2016b, 2016c). Little or no precipitation reaches the upper unconfined aquifer as direct vertical infiltration due to low precipitation and high evapotranspiration rates. Most groundwater recharge occurs from infiltration at bedrock and alluvial fan deposits followed by lateral and vertical movement through the unconfined and confined aquifers (ES 2016b, 2016c). The groundwater in the upper aquifer system at the site is considered saline and contains several chemicals with concentrations above EPA's secondary drinking water standards. Therefore, the groundwater in the upper aquifer system is not considered potable (ES 2016b, 2016c).

In 2010, Tooele County had a total population of 58,218 people and a population density of 8.4 persons per square mile (3.2 persons per square kilometer) (Census 2015a). The closest resident to the Energy*Solutions* site is approximately 7 miles (11 kilometers) to the northeast (ES 2016c). As of October 2016, there were approximately 100 employees working on site (Shrum 2016c).

The Energy*Solutions* site can accept waste by truck and train and has direct access to major highway and rail systems in the region. Vehicular access is provided by Interstate 80, Exit 49, and an all-weather road to the site that Energy*Solutions* maintains. Rail access is provided by a rail system owned and operated by the Union Pacific Railroad. Energy*Solutions* owns over 5 miles (8 kilometers) of track and operates two locomotives at the disposal site (ES 2016c).

The Energy*Solutions* site is licensed and permitted to dispose of Class A LLW as defined in the NRC's regulation at 10 CFR Part 61, MLLW,[36] and uranium mill tailings (defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended [42 U.S.C. § 2014] as a byproduct material)[37] (**Figure 3-4**). Waste disposal occurs in above-grade disposal units (embankments) using low-permeable clay as a liner on top of a foundation of compacted indigenous clay and soil. In addition,-high density polyethylene liners were installed in the MLLW disposal units (NDR 2016). Although most waste is emplaced in shallow (2-foot) "lifts," larger waste such as discarded equipment is disposed of using controlled low-strength material, a "flowable" grout material to reduce the presence of voids and air pockets (Shrum 2016b). Wastes having higher radiation levels are disposed of in concrete vaults with voids in the vaults filled with controlled low-strength material. Filled disposal units are covered with layers of clay, gravel, soil, and rock designed to promote evapotranspiration (NDR 2016). A summary of the treatment and disposal services provided, and waste disposal capacity, is provided in **Table 3-27**.

The disposal unit proposed by Energy*Solutions* to receive DU waste would be constructed separately from the disposal units for other wastes. The DU disposal unit would be located in the

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[36] Consisting of waste regulated for its radioactive content pursuant to the Atomic Energy Act of 1954, as amended, as well as for its chemical content pursuant to RCRA, TSCA, or other applicable statutes.

[37] 11e.(2) byproduct material is defined as the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.

area labeled "Federal Cell" on Figure 3-4. This disposal unit has been partially constructed and would be completed following completion of the State regulatory review process for the proposed license amendment. The disposal unit is designed[38] to accept approximately 378,000 cubic yards (289,000 cubic meters) of DU (Shrum 2016a). The ultimate capacity of this disposal unit would depend on the quantities of DU waste that would be received from Paducah, Portsmouth, and other sources, and in accordance with any limits on waste acceptance imposed through the licensing and permitting process.

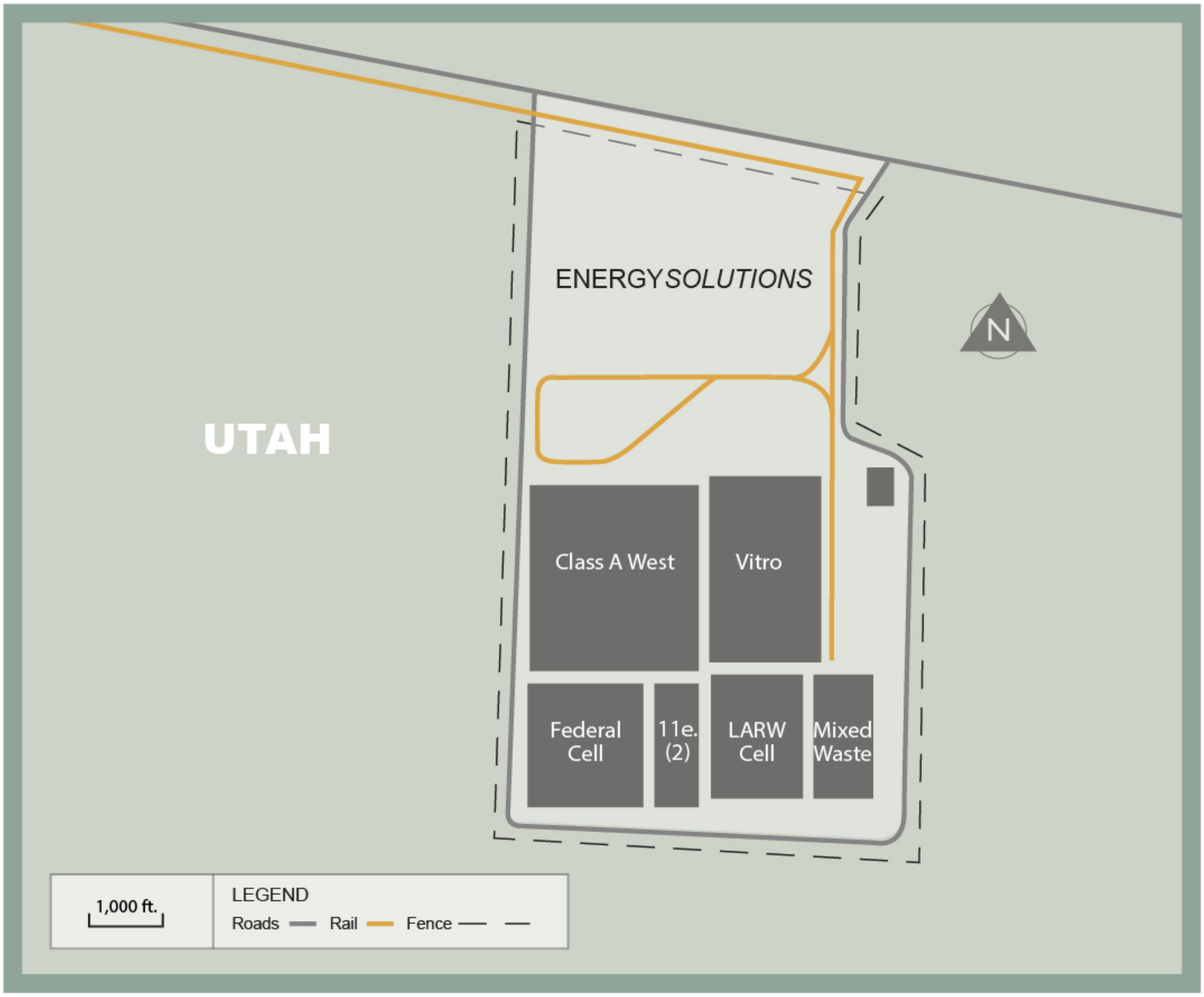

Figure 3-4 Energy*Solutions* Disposal Facilities (Source: ES 2015a)[39]

In June 2010, the Utah Department of Environmental Quality (UDEQ) issued revised radioactive waste disposal regulations addressing disposal of DU at disposal facilities in Utah. These revised regulations require the preparation for review and approval of a performance assessment with a quantitative compliance period for comparison against regulatory dose limits for a minimum of

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[38] The design of the disposal unit (designated the Federal Cell) has not been finalized and the final design features, including design capacity, are subject to change.

[39] **Key:** 11e(2) = uranium processing byproduct waste; DU = depleted uranium; LARW = low-activity radioactive waste; Vitro = uranium mill tailings from the inactive Vitro Mill site located near Salt Lake City, Utah.

10,000 years, with additional qualitative analyses for the period of peak radiation dose. Energy*Solutions* then prepared a technical analysis to support a proposed license amendment to authorize disposal of DU at its Utah disposal facility and submitted the analysis and proposed amendment to UDEQ for review. Energy*Solutions* prepared several responses to UDEQ interrogatories with the final response submitted on April 2, 2018. The UDEQ review of the final responses is underway (ES 2018).

Table 3-27 Waste Management Services Provided at Energy*Solutions* Site

Waste Types Accepted and Services	Disposal Capacities		
	Waste Type	Disposal Capacity (cubic yards)	
		Permitted	Remaining
Accepts Class A LLW, Class A MLLW, 11e.(2) byproduct material, NORM waste, and NARM waste for disposal, and proposes to accept DU for disposal (a form of Class A LLW), principally in the form of DU oxide. Waste types include decommissioning debris, metal, soil and debris, PCBs, asbestos, and liquids. Treatment services include metal shredding, thermal desorption, oxidation/reduction, macro-encapsulation, chemical stabilization, mercury amalgamation, chemical stabilization, neutralization and deactivation, and debris spray washing. The facility can accept waste by truck and train.	LLW	8,724,000	4,172,000 as of August 2016
	DU	378,000 proposed	NA
	MLLW	1,353,000	358,000 as of August 2016

Key: DU = depleted uranium; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NA = not applicable; NARM = naturally occurring and accelerator produced radioactive material; NORM = naturally occurring radioactive material; PCB = polychlorinated biphenyl.

Sources: ES 2015b, 2016a, 2016c; Halstrom 2014; Shrum 2016a

Note: Capacities are rounded to the nearest thousand cubic yards.

3.4 NEVADA NATIONAL SECURITY SITE

The NNSS is located on an 870,400-acre (352,200-hectare) parcel of land in southern Nevada, in the southern portion of Nye County, about 57 miles (92 kilometers) northwest of downtown Las Vegas (DOE 2013a; NNSS 2016) (

The NNSS is surrounded by thousands of additional acres of land withdrawn from the public domain, creating an unpopulated area of nearly 6,500 square miles (16,830 square kilometers). The area around NNSS consists of sparsely vegetated basins or flats (Jackass Flats in the southwestern quadrant, Frenchman Flats in the southeastern quadrant, and Yucca Flats in the northwestern quadrant) and mountains separated by canyons (northeastern quadrant) (DOE 2013a).

Most of the NNSS is located in the southwestern corner of the Great Basin Desert with a portion located in the Mojave Desert (southern third of the site). The NNSS is located in the rain shadow of the southern Sierra Nevada mountain range and has the general climatic characteristics of a mid-latitude desert area. From 1983 to 2002, average summer temperatures range from a maximum of 90 to 100°F (32 to 38°C) to a minimum of 55 to 70°F (13 to 21°C), while average winter temperatures range from a maximum of 50 to 60°F (10 to 16°C) to a minimum of 20 to 35°F (-6.7 to 1.7°C) (DOE 2013a). Annual average precipitation at the site varies from 5 inches (13 centimeters) to 13 inches (33 centimeters) depending on the elevation, with higher elevations receiving more precipitation. Precipitation falls most often during winter and early spring and during mid to late summer (DOE 2013a).

Figure 3-5 Nevada National Security Site Location

The region is characterized by complex stratigraphic and structural elements that combine Basin and Range faulted bedrock, Mesozoic thrust faults, volcanic uplands and calderas, and modern alluvial basins. These features overlay a basement complex of highly deformed Proterozoic- and Paleozoic-age sedimentary and metasedimentary rocks (DOE 2013a).

The NNSS is located within the Death Valley regional groundwater flow system, which encompasses approximately 16,000 square miles (41,400 square kilometers) of the Great Basin.

The three primary hydrogeologic water-bearing units of the Death Valley regional groundwater flow system are grouped into three types of aquifers: basin-fill alluvium (alluvial aquifers), volcanic aquifers, and carbonate aquifers. Groundwater flow through these units is mainly controlled by faults and fractures with the flow system extending from the water table to a depth that may exceed 4,900 feet (1,490 meters) (DOE 2013a). The depth to groundwater at the NNSS varies from approximately 30 feet (9.1 meters) to more than 2,000 feet (610 meters). Most groundwater recharge occurs from precipitation and from interbasin underflow from upgradient areas. Groundwater is the only source of potable water at the NNSS and is withdrawn from deep wells installed in the alluvial, volcanic, and carbonate aquifers (DOE 2013a).

In 2010, Nye County had a total population of 43,945 people and a population density of 2.4 persons per square mile (0.93 persons per square kilometer) (Census 2015b). Because of the low population density and most of the land surrounding NNSS is withdrawn from the public domain, there are few residents near the site. As of 2013, there were approximately 1,849 employees working at NNSS (DOE 2013a).

The NNSS can only accept waste by truck and has direct access to major highways in the region. The main entrance to the NNSS (Gate 100) is located on Mercury Highway, which originates at U.S. Route 95. There are other access points around the site; however, their use is restricted and they are usually barricaded. The NNSS has 640 miles (1,030 kilometers) of on-site roadways (340 miles [550 kilometers] of paved roads and 300 miles [480 kilometers] of unpaved roads) that are used to transport personnel and materials around the site (DOE 2013a).

NNSS is divided into numbered operational areas to facilitate management; communications; and distribution, use, and control of resources. Waste disposal currently occurs at the RWMC in Area 5, northwest of Frenchman Lake (**Figure 3-6**).[40] NNSS receives waste from DOE and DoD facilities throughout the United States; NNSS does not accept commercially generated waste (DOE 2013b). Operations at the Area 5 RWMC include LLW and MLLW examination, repackaging if necessary, and disposal; temporary hazardous and MLLW storage; treatment of some on-site generated MLLW before disposal; and temporary storage of in-state-generated TRU waste pending off-site shipment. The Area 5 RWMC covers about 740 acres (300 hectares) of land and is surrounded by a 1,000-foot- (300-meter-) wide buffer zone. The Area 5 RWMC includes several equipment storage yards, as well as structures that are used for offices, laboratories, utilities, and routine operations. The total area used to date for waste disposal, including operational disposal units, covers about 200 acres (80 hectares) (DOE 2013a).

LLW disposal at the Area 5 RWMC occurs in unlined cells, while MLLW disposal occurs in lined cells permitted by the State of Nevada (DOE 2013b). A summary of the treatment and disposal services provided, and remaining waste disposal capacity, is provided as **Table 3-28**.

DOE has performed technical analyses (performance assessments) that address potential impacts far into the future and in support of disposal authorizations at NNSS by DOE pursuant to DOE Order 435.1. DOE Order 435.1 requires performance assessments that demonstrate compliance

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[40] Another disposal area is located in Area 3, which opened in 2018. As required, it would be used, subject to consultation with the State of Nevada, for disposal of wastes from environmental restoration and other activities at DOE/National Nuclear Security Administration sites within the state of Nevada.

with prescribed radiation dose limits for a period of 1,000 years following disposal, along with sensitivity analyses that address peak doses that could occur beyond 1,000 years. In addition, DOE Order 435.1 requires analyses that demonstrate compliance with prescribed limits on the long-term gaseous release of radon-isotopes from LLW disposal facilities.[41] Approved analyses are summarized in the NNSS SWEIS (DOE 2013a). In 2012, DOE prepared an analysis addressing disposal of DU at NNSS (NSTec 2012). This analysis showed compliance with the DOE Order.

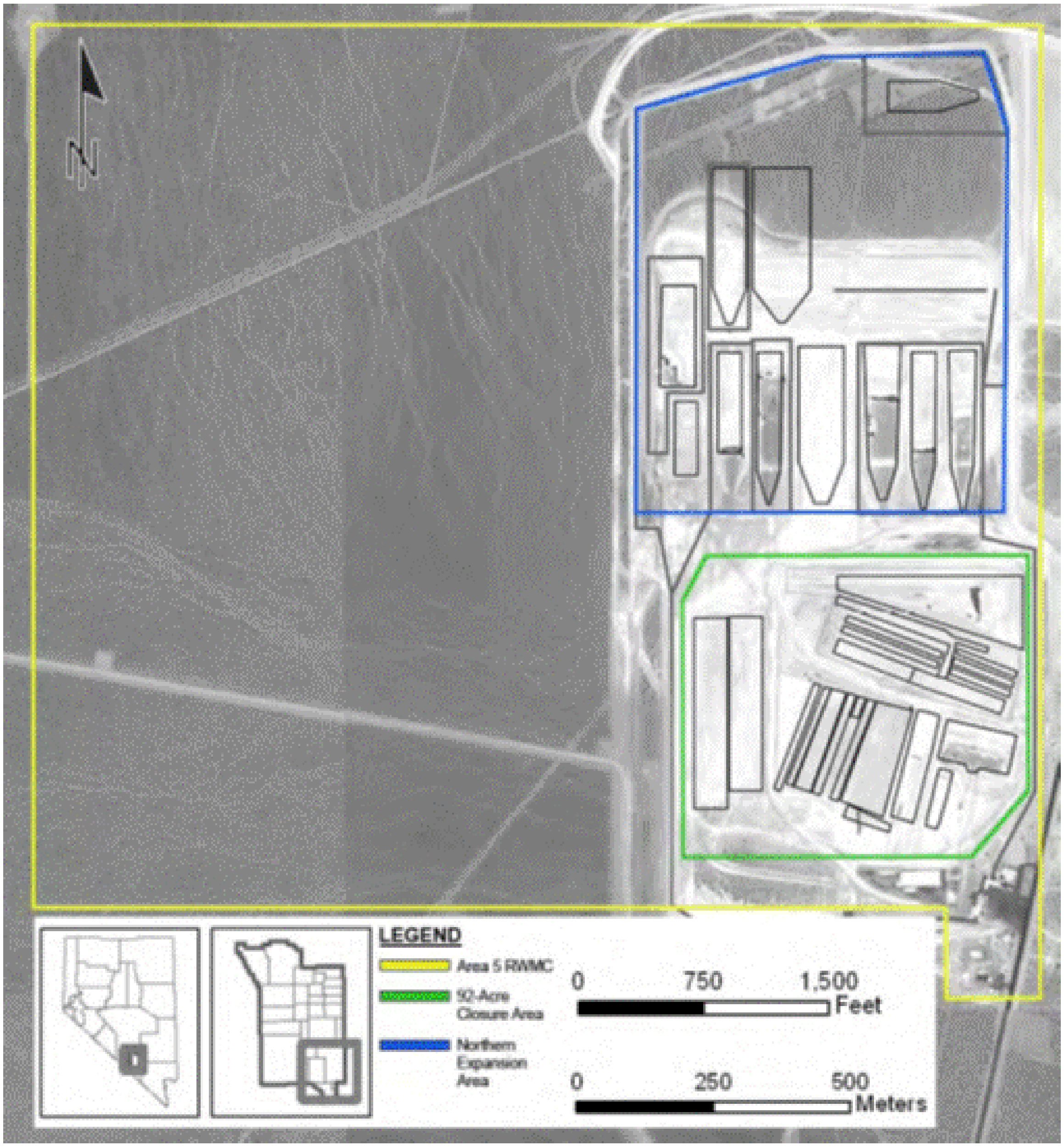

Figure 3-6 Nevada National Security Site Area 5 Radioactive Waste Management Complex (Source: DOE 2013a)

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[41] One of the principal concerns for disposal of large quantities of DU as waste is the long-term gaseous release of radon isotopes

Table 3-28 Waste Management Services Provided at Nevada National Security Site

	Disposal Capacities	
Waste Types Accepted and Services	**Waste Type**	**Disposal Capacity (cubic yards)**
Accepts LLW and MLLW for disposal, including wastes containing or contaminated with asbestos or PCBs, from approved DOE and DoD waste generators. All MLLW must meet RCRA land disposal restrictions prior to disposal at NNSS. The NNSS RCRA permit does not include provisions for treatment of MLLW generated off-site. The facility can accept waste only by truck.	LLW	1,778,000[a]
	MLLW	148,000[a]

Key: LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; PCBs = polychlorinated biphenyls; RCRA = Resource Conservation and Recovery Act; RWMC= Radioactive Waste Management Complex.

[a] In DOE's December 30, 2014, ROD (79 FR 78421) for the NNSS SWEIS (DOE 2013a), DOE decided to dispose of up to 1.78 million cubic yards (48 million cubic feet) of LLW and up to 148,000 cubic yards (4 million cubic feet) of MLLW at the NNSS Area 5 RWMC. As of April 2014, disposal units had been constructed providing about 237,000 cubic yards (6.4 million cubic feet) of disposal capacity.

Sources: DOE 2013a; Gordon 2014

Note: Capacities are rounded to the nearest thousand cubic yard.

3.5 WASTE CONTROL SPECIALISTS LLC

WCS owns a 14,000-acre (5,670-hectare) property in western Texas, in the northwestern portion of Andrews County, about 30 miles (50 kilometers) west of the City of Andrews on the border between Texas and New Mexico (**Figure 3-7**). The waste management facility encompasses 1,338 acres (541 hectares) of the WCS site (WCS 2016a, 2016b).

The WCS site is located in a semi-arid continental climate. From 1962 to 2010 in Andrews County, the annual average temperature was 63°F (17°C), with July the hottest month (average temperature of 81°F [27°C]) and January being the coldest month (average temperature of 44°F [6.7°C]) (WRCC 2016). The Western Regional Climate Center records indicate that the average annual precipitation is approximately 15 inches (38 centimeters), primarily as rain, with a low of 2.0 inches (5.1 centimeters) in 2011 and a maximum of 32 inches (82 centimeters) in 1941 (WRCC 2016, WCS 2016a). Precipitation is relatively evenly distributed throughout the year but is somewhat higher in spring and summer than in winter and fall. Snowfall in Andrews County averages 3.3 inches (8.4 centimeters) per year, typically occurring from November to February (WRCC 2016).

The WCS site is located on the southwestern edge of the Southern High Plains (DOE 2011) on a gently southeastward-sloping plain with a natural slope of approximately 8 to 10 feet (3.4 to 3.0 meters) per mile. Soils primarily consist of well-drained, fine sandy loam and fine sand underlain by gravelly loam and cemented material (WCS 2016a).

Groundwater occurs in two principal aquifer systems in the vicinity of the WCS site: the High Plains Aquifer and the Dockum Aquifer (DOE 2011). The High Plains Aquifer of west Texas, the principal aquifer in west Texas, consists of water bearing units within the Tertiary Ogallala Formation and underlying Cretaceous rocks. On the WCS site, the formations that comprise the High Plains Aquifer consists of the Ogallala-Antlers-Gatuna (OAG) unit, which includes the Antlers and Gatuna formations as well as the Ogallala. The OAG unit is not water bearing in the

Figure 3-7 Waste Control Specialists Site Location

WCS licensed area. The 225-foot (69-meter) zone of the Dockum Group is considered the uppermost regulated groundwater zone at WCS. The nearest downgradient drinking water well is approximately 6.5 miles (10 kilometers) to the east of the site (WCS 2016a). In 2010, Andrews County had a total population of 14,786 people and a population density of 9.9 persons per square mile (3.8 persons per square kilometer) (Census 2015c). The nearest population center is Eunice, New Mexico, located approximately 6 miles (10 kilometers) west of the WCS site (DOE 2011). Andrews, Texas, is located approximately 30 miles (50 kilometers) to the east of the site (WCS 2016a). As of 2015, there were approximately 204 employees working on site, with approximately 50 percent of the site employees living in Texas and 50 percent living in New Mexico (WCS 2015).

The WCS site can accept waste by truck and train and has direct access to major highway and rail systems in the region. Vehicular access to the site is provided by Interstate 20 to Highway 176 from the east and by U.S. Highway 62 to Highway 176 from the west. Rail access to WCS is provided by a rail system that is owned and operated by the Texas-New Mexico Railroad (GE 2009). The Texas-New Mexico Railroad connects to the WCS rail system that travels around the perimeter of the site.

The WCS site is licensed and permitted by the State of Texas for disposal of LLW, MLLW, hazardous waste, and byproduct material (**Figure 3-8**). Disposal operations include the following (WCS 2016c):

- **Compact Waste Facility:** Licensed to dispose of LLW generated by State Compacts formed pursuant to the Low-Level Radioactive Waste Policy Amendments Act of 1985.
- **Federal Waste Facility (FWF):** Licensed and permitted to dispose of LLW and MLLW generated by the Federal Government.
- **Hazardous Waste Facility:** Permitted to dispose of hazardous waste as defined by the RCRA, toxic waste such as PCBs and asbestos as defined by TSCA, and exempted low-activity radioactive waste.[42]
- **Byproduct Disposal Facility:** Licensed to dispose of 11e(2) byproduct material.

Figure 3-8 Waste Control Specialists Waste Management Facilities (Source: WCS 2016d)

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[42] Exempted low-activity radioactive waste contains less than 10 percent of the Class A limits as defined by the NRC in 10 CFR Part 61.

Waste disposal typically occurs in large disposal units with multilayer liner systems totaling about 7 feet (2 meters) thick and consisting of layers of clay, geosynthetic material, and concrete. The planned final covers for the disposal units would be up to 45 feet (14 meters) thick and consist of layers of concrete, clay, soil, sand, and rock, topped by an evapotranspiration layer. The depth to the waste would be at least 25 feet (7.6 meters) below the final ground surface (WCS 2016d, 2016e).

In addition, the WCS site is authorized to process and store a variety of wastes, as well as for the non-thermal treatment of radioactive and nonradioactive wastes. For example, WCS is capable of storing greater-than-Class C LLW, TRU waste, sealed sources, and byproduct material, and provides a variety of waste treatment services. A summary of the treatment, storage, and disposal services provided, and remaining waste disposal capacity, is provided as **Table 3-29**. DU oxide from Paducah and Portsmouth would be disposed of in the FWF.

Table 3-29 Waste Management Services Provided at Waste Control Specialists Site LLC

		Disposal Capacities	
		Disposal Capacity (cubic yards)	
Waste Types Accepted and Services	**Waste Type**	**Permitted**	**Remaining**
Accepts LLW, MLLW, hazardous waste and 11e(2) byproduct material for disposal. Treatment services include chemical oxidation/reduction, deactivation, micro- and macro-encapsulation, neutralization, stabilization, controlled reaction, stabilization, shredding, repackaging, and dewatering. Accepts LLW, TRU waste, sealed sources, byproduct material, and RCRA/TSCA waste for storage. The site can accept waste by truck and/or train.	LLW and MLLW (in the FWF)	963,000	955,000 as of August 2016

Key: LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; RCRA = Resource Conservation and Recovery Act; TRU = transuranic; TSCA = Toxic Substances Control Act.
Note: Capacities are rounded to the nearest thousand cubic yards.
Sources: WCS 2016b

As discussed in Section 3.1 of this *DU Oxide SEIS*, in recent years, Federal and state regulators have reviewed existing LLW disposal requirements for DU, which is classified as Class A LLW. The TCEQ required that WCS prepare a technical analysis specifically addressing the potential long-term impacts that could result from disposal of DU at WCS. In August 2014, informed by the required technical analysis (performance assessment) prepared by WCS which addressed the radiological impacts that could occur over a 1-million-year period following waste disposal, TCEQ approved an amendment to the LLW disposal license providing WCS authority to dispose of DU (WCS 2014).

4 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

This chapter discusses the potential impacts on the environment, including impacts on workers and members of the general public, under the No Action Alternative for the long-term storage of DU oxide at Paducah and Portsmouth (Section 4.1) and the Action Alternatives for disposal of DU oxide at Energy*Solutions* near Clive, Utah (Section 4.2), NNSS in Nye County, Nevada (Section 4.3), and WCS near Andrews, Texas (Section 4.4). The alternatives are described in Chapter 2. Chapter 4 also describes the potential cumulative impacts of the alternatives (Section 4.5), potential mitigation measures (Section 4.6), unavoidable adverse impacts of the alternatives (Section 4.7), irreversible and irretrievable commitments of resources (Section 4.8), the relationship between short-term use of the environment and long-term productivity (Section 4.9), and pollution prevention and waste minimization (Section 4.10).

This *DU Oxide SEIS* does not reevaluate the impacts of storage of DUF_6 cylinders, conversion of DUF_6 to DU oxide, or the management and disposition of HF. These activities were evaluated in the 2004 EISs (DOE 2004a, 2004b) and decisions announced in the associated RODs (69 FR 44654; 69 FR 44649). The impacts of these activities are considered as part of potential cumulative impacts (Section 4.5).

The impacts assessment methodologies and assumptions are described in Chapter 4 and Appendix F of the *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Paducah, Kentucky, Site* (Paducah EIS) (DOE 2004a), and the *Final Environmental Impact Statement for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Portsmouth, Ohio, Site* (Portsmouth EIS) (DOE 2004b) (referred to collectively as the 2004 EISs). Changes from the 2004 EISs' impact assessment methodologies and assumptions are described in this chapter and related appendixes.

The analysis uses a sliding-scale approach, which is consistent with DOE's *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 2004c). This guidance implements the CEQ regulations directing agencies preparing EISs to focus on significant environmental issues and alternatives (40 CFR 1502.1) and on impacts in proportion to their significance (40 CFR 1502.2[b]).

For example, because there would be no land disturbance at Paducah and Portsmouth, there would be no impacts on land use, geology and soils, water resources, biotic resources, and cultural resources related to land disturbance. Also, because there would be no routine releases of hazardous or radioactive materials, there would be no impacts on public health, biotic resources, air quality, and environmental justice related to exposure to hazardous or radioactive materials from normal operations. Therefore, this *DU Oxide SEIS* discusses these impacts in less detail.

As discussed in Chapter 2, Section 2.2.2, as another shipping option, DOE could ship 12 cylinders per railcar using an ABC railcar. This would result in half the number of annual train shipments while transporting the same number of DU oxide cylinders. The same number of cylinders would be handled each year and in total. Therefore, for impacts related to the annual or total number of shipments and impacts related to the number of cylinders handled, shipping in gondola railcars would be similar to or bound the impacts of shipping in ABC railcars, and this topic is not discussed further. This topic is only discussed in more detail in relation to transportation impacts. For nonradiological transportation impacts (e.g., air emissions from the train engine, traffic fatalities) transporting DU oxide cylinders in ABC railcars would have approximately half the impacts of shipping in gondola railcars. For radiological transportation impacts, annual and total impacts would remain similar, but per-shipment impacts could increase due to the higher quantity of DU oxide per shipment

4.1 NO ACTION ALTERNATIVE

A No Action Alternative is evaluated in accordance with CEQ regulations at 40 CFR 1502.14. As described in Chapter 2, Section 2.2.1 of this *DU Oxide SEIS*, under the No Action Alternative, DU oxide would be stored at Paducah and Portsmouth and would not be disposed of as LLW. In accordance with the RODs for the 2004 EISs (69 FR 44654; 69 FR 44649), the empty and heel cylinders, CaF_2, and ancillary LLW and MLLW would be shipped to off-site disposal facilities.

The No Action Alternative would not meet the purpose and need for agency action as described in Chapter 1, Section 1.3, and would only defer a final decision on the ultimate disposition of the DU oxide. Because the No Action Alternative defers a disposition decision, it is possible that at some future time the cylinders of DU oxide would be transported off site for disposal or some undetermined future use. Transportion and disposal of the DU oxide would likely be similar to the activities described under the Action Alternatives.

4.1.1 Impacts at Paducah and Portsmouth

For purposes of analysis, the duration of the No Action Alternative at Paducah and Portsmouth is 100 years beginning with storage of the first DU oxide containers in 2011 and ending in 2110.[43] Based on the rate of conversion of DUF_6 to DU oxide, and the current inventory of DUF_6, DOE believes that conversion activities will be completed and the last DU oxide produced, between 2044 and 2054 at Paducah and 2032 and 2042 at Portsmouth (PPPO 2018).

The long-term storage of DU oxide containers are considered under the No Action Alternative. Long-term storage includes monitoring and maintenance of the containers, and repair of any containers that are damaged or breached during the storage period.

4.1.1.1 Site Infrastructure

Impacts on infrastructure at Paducah and Portsmouth could occur from new significant construction or changes in operations. Under the No Action Alternative, there would be no new significant construction and no substantial change in DU container storage and maintenance activities at Paducah and Portsmouth, and therefore, no adverse impacts on site infrastructure.

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[43] Storage under the No Action Alternative could extend beyond the 100 years analyzed in this DU Oxide SEIS. Storage for longer than 100 years would not change the maximum reasonably foreseeable annual impacts of operations, but would extend the impacts described in this DU Oxide SEIS further out in time. The contributions attributable to those facilities to total life-cycle impacts, such as those for total worker and population dose and LCFs, and total waste generation, would increase in proportion to the extended period. These impacts can be estimated from the analyses provided in this DU Oxide SEIS under the No Action Alternative by multiplying the additional years of operation by the annual impacts.

There would be adequate capacity to store all the DU oxide containers and therefore no adverse impacts on the storage infrastructure.

As shown in **Table 4-1**, the utility infrastructure needs for storage and maintenance of DU oxide containers under the No Action Alternative would be small when compared to current use and site capacity. Therefore, impacts on the utility infrastructure at both Paducah and Portsmouth would be minor.

The container storage and maintenance activities and loading of wastes at Paducah and Portsmouth for transport to a disposal facility would consume minimal amounts of water and electricity. Support vehicles (i.e., cars and light trucks) at each site are expected to use 2,080 gallons per year (7,870 liters per year) of gasoline. Waste package handling is expected to use 15,600 gallons per year (59,050 liters per year) of diesel fuel at both Paducah and Portsmouth. Fuel consumed by support vehicles and container loading equipment would be supplied by off-site sources and would not adversely affect the infrastructure at Paducah or Portsmouth.

Table 4-1 Infrastructure Comparison for the No Action Alternative

Resource	Paducah			Portsmouth		
	No Action Alternative[a]	**Current Use[b]**	**Capacity[b]**	**No Action Alternative[a]**	**Current Use[c]**	**Capacity[c]**
Electricity	0.167 MWh	7 to 12 MWh [d]	3,040 MW	0.167 MWh	20 to 40 MWh	2,260 MW
Water (mgd)	0.23	3.4	30 to 32 [e]	0.073	1.9	4 to 13
Natural gas (mcf/year)	Minimal	154,000	876,000 [f]	Minimal	366,000	NR
Steam (lbs/hour)	Minimal	100,000 [g]	135,000	Minimal	26,835 [h]	84,000

Key: gal = gallons; lbs = pounds; mcf = million cubic feet; mgd = million gallons per day; MW = megawatt; MWh = megawatt hours; NR = not reported.

[a] Usage estimates from PPPO 2018, unless otherwise noted.

[b] Paducah current use and capacity from Chapter 3, Section 3.1.1, unless otherwise noted.

[c] Portsmouth current use and capacity from Chapter 3, Section 3.2.1, unless otherwise noted.

[d] Source: DOE 2012a

[e] Peak withdrawal reported in DOE 2012a.

[f] Annual natural gas capacity is calculated based on an hourly capacity of 100 mcf per hour.

[g] Current use of steam is identified as an estimate of demand.

[h] Use estimate is an extrapolation of hourly use based on reported annual use of 235 million pounds per year.

Note: To convert gallons to liters multiply by 3.785.

Table 4-2 presents a summary of the potential off-site shipments from the Paducah and Portsmouth Sites. This table does not include the small number of shipments of ancillary LLW and MLLW (one shipment per year from both Paducah and Portsmouth), but does include the option of shipping CaF_2 (converted from HF) off site for disposal. This table shows an annual maximum of 1,080 truck or 28 train shipments from Paducah and 742 truck or 20 train shipments from Portsmouth. Assuming 250 shipping days per year, this equates to approximately four daily truck shipments or two to three monthly train shipments from Paducah, and 3 daily truck shipments or one or two monthly train shipments from Portsmouth. Therefore, the loading of wastes and off-site shipments using either truck or train, would not require new significant construction or changes in infrastructure at Paducah and Portsmouth, and would likely result in minor impacts on the transportation infrastructure at Paducah and Portsmouth.

Table 4-2 Summary of Off-Site Shipments under the No Action Alternative

Location		Container Type and Estimated Number of Shipments[a]				Maximum Total Shipments	
		14,000 Intact Empty and Heel Cylinders (volume-reduced)[b]		CaF_2 in Bulk Bags Option[c]			
		Truck	Train	Truck	Train	Truck	Train
Paducah	Total	4,242 (848)	141 (42)	32,400	811	36,700	952
	Annual	125 (25)	4 (1)	953	24	1,080	28
Portsmouth	Total	2,759 (552)	92 (28)	13,600	339	16,300	431
	Annual	125 (25)	4 (1)	616	15	742	20

[a] Estimates of annual truck, rail and total shipments are based on total number of shipments divided by the number of years of conversion facility operation, in this case, 34 years for Paducah and 22 years for Portsmouth. Use of the shorter timeframe for completion of conversion operations would result in the most conservative estimate of annual impacts, as the total impacts would be spread across fewer years.

[b] The 14,000 empty and heel cylinders would be shipped intact,2 per truck or 6 per gondola railcar with 10 railcars per train, or volume-reduced, and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar with 10 railcars per train.

[c] The CaF_2 in bulk bags would be shipped 1 per truck or 4 per railcar with 10 railcars per train.

Note: Shipment numbers are derived from PPPO (2018) or calculated based on the assumptions described in the table notes.

4.1.1.2 Air Quality, Climate, and Noise

This *DU Oxide SEIS* generally follows the methodologies described in the 2004 EISs (DOE 2004a, 2004b) for the air quality and noise analysis. The 2004 EISs did not evaluate greenhouse gas (GHG) emissions and the effects of climate change. This *DU Oxide SEIS* evaluates potential climate change impacts in terms of context and intensity as defined in 40 CFR 1508.27. This requires the analysis of significance of the action with respect to the setting of the Proposed Action and the severity of the impact.

Impacts on air quality and climate change could occur from the combustion of fossil fuels associated with DU oxide storage and maintenance activities. These activities would involve no significant construction and little painting or other industrial processes requiring fossil fuel combustion or other emissions of criteria air pollutants or GHGs above those from normal daily operations. In addition, there would be no routine releases of hazardous air pollutants.

The vehicles and equipment used for loading of wastes at Paducah and Portsmouth for truck or train transport to a disposal facility would emit air pollutants. Support vehicles (i.e., cars and light trucks) at each site are expected to use 2,080 gallons per year (7,870 liters per year) of gasoline. Waste package handling is expected to use 15,600 gallons per year (59,050 liters per year) of diesel fuel at both Paducah and Portsmouth. Annual emissions of criteria pollutants produced by consumption of this fuel would be similar to ongoing cylinder yard activities at Paducah and Portsmouth, and would result in minimal impacts on air quality.

Further, container storage and maintenance and waste loading activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be no significant construction, little painting, and little or no increase in other activities above normal daily operations that would contribute to the noise environment. Therefore, potential impacts on air quality, climate, and noise at both Paducah and Portsmouth would be minor.

In addition, container storage and maintenance and truck- and train-loading activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be little or no increase above current daily operations that would contribute to the noise environment. Off-site shipments via train could increase by one to three shipments per month per site, and truck shipments could increase by three or four per day (see Section 4.1.1.1). This increase is unlikely to be perceptible on public roadways and existing railways in comparison to existing traffic in the region around the sites and the millions of annual shipments already occurring on public highways (3.68 million trucks travelling 2.74 billion miles annually [ATA 2018]) and railways. Therefore, because the increase is small and would occur in areas, roads, and/or railways already used for these purposes, potential impacts on noise levels near Paducah and Portsmouth would be minor.

4.1.1.3 Geology and Soil

Impacts on geology and soils could occur from the disturbance or use of geologic and soil materials, and from contamination by radioactive or hazardous materials via air or water borne pathways. Container storage and maintenance and waste loading activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be no significant construction, no use of geologic and soils materials, and no routine releases of DU oxide or hazardous materials. Soil contaminated by the release of uranium oxide from a potential cylinder breach would be removed, packaged, and disposed of at an off-site radioactive waste disposal facility. In addition, the release of uranium from a potential cylinder breach was evaluated in the 2004 EISs and found to result in soil concentrations considerably below the U.S. Environmental Protection Agency (EPA) health-based value for residential exposure (DOE 2004a, 2004b). Therefore, potential impacts on geology and soils would be minor at both Paducah and Portsmouth.

4.1.1.4 Water Resources

Impacts on water resources could occur from changes in water use, surface water discharge, groundwater recharge, or impacts on surface water or groundwater quality due to contamination by radioactive or hazardous materials associated with long-term container storage and maintenance, waste loading, or a potential container breach. Under the No Action Alternative, container storage and maintenance and waste loading activities would occur within the industrialized areas of both Paducah and Portsmouth in areas outside the 100-year floodplain. Primary impacts to floodplains in 2004 were expected to be related to construction of the conversion facilities. The ongoing operational, storage and maintenance, and transportation-related activities are not appreciably different than in 2004, and these activities had negligible impact, as shown in the 2004 EISs and *Floodplain/Wetland Assessment of the Effects of Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Paducah Kentucky Site* (Floodplain/Wetland Assessment) (ANL 2004a). At that time, DOE determined that a floodplain assessment was not required for Portsmouth because the site was outside maximum historic flooding levels (see Chapter 3, Section 3.2.4 of this SEIS). Therefore, no additional floodplain assessment is necessary.

There would be no significant construction, no increases in water use and wastewater discharge, no change to groundwater recharge, and no routine releases of DU oxide or hazardous materials. As described in Section 4.1.1.1, Table 4-1, water usage under the No Action Alternative would be 0.23 million gallons per day (0.87 million liters per day) at Paducah and 0.073 million gallons per day (0.28 million liters per year) at Portsmouth. This is a small percentage of the daily water use of 3.4 million gallons (13 million liters) at Paducah and 1.9 million gallons (7.2 million liters) at Portsmouth. Therefore, potential impacts on water resources at both Paducah and Portsmouth would be minor.

Potential impacts on surface and groundwater quality as a result of a DU release associated with a potential container breach was evaluated in the 2004 EISs. For both Paducah and Portsmouth, impacts on surface water and groundwater quality from hypothetical releases of uranium would result in uranium concentrations below radiological benchmark levels (i.e., Safe Drinking Water Act maximum contaminant levels) (DOE 2004a, 2004b).

4.1.1.5 Biotic Resources

Impacts on biotic resources could occur from removal or degradation of vegetation, wildlife habitats, wetlands, and federally and state-listed species, and contamination by radioactive or hazardous materials via air or water borne pathways. Container storage and maintenance and waste loading activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be no significant construction and no routine releases of DU oxide or hazardous materials. Container storage and maintenance and waste-loading activities would not disturb wetlands, sensitive habitats, or threatened, endangered, or sensitive species. Therefore, potential impacts on biotic resources would be minor at both Paducah and Portsmouth. Primary impacts to wetlands in 2004 were expected to be related to construction of the conversion facilities. The ongoing operational, storage and maintenance, and transportation-related activities are not appreciably different than in 2004, and these activities had negligible impact as shown in the 2004 EISs and the Paducah Floodplain/Wetland Assessment (ANL 2004a), and *Wetland Assessment of the Effects of Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Portsmouth, Ohio, Site* (ANL 2004b). Therefore, no additional wetlands assessment is necessary.

Potential impacts on biotic resources due to a potential container breach were evaluated in the 2004 EISs. At both Paducah and Portsmouth, groundwater uranium concentrations from such a release could exceed ecological screening values for water. However, most plants and animals would not have direct access to the groundwater and contaminants in the groundwater discharging to a surface water body, such as a stream or river, are likely to be quickly diluted to negligible concentrations (DOE 2004a, 2004b).

4.1.1.6 Public and Occupational Safety and Health

This section presents radiological impacts on workers and the public from normal operations and postulated accidents at Paducah and Portsmouth, as well as impacts from potential chemical exposures and accidents and intentional destructive acts. This *DU Oxide SEIS* generally follows the methodology described in the 2004 EISs (DOE 2004a, 2004b) with two primary differences. The 2004 EISs used risk factors of 0.0004 LCF per person-rem of exposure for workers and 0.0005 LCFs per person-rem of exposure for members of the general public. This *DU Oxide SEIS* uses a more conservative risk factor of 0.0006 LCF per person-rem for both workers and the public, consistent with current DOE guidance (DOE 2003). In addition, this *DU Oxide SEIS* uses updated population data from the 2010 Census.

Health risks are considered for involved and noninvolved workers, the off-site population, and a maximally exposed individual (MEI).[44] Workers and members of the public are protected from exposure to radioactive material and hazardous chemicals by facility design and administrative procedures. Major DOE design criteria include those in DOE Order 420.1C, Change 2 "*Facility Safety*," and DOE Order 430.1C, "*Real Property Asset Management*." DOE regulation 10 CFR Part 830, "*Nuclear Safety Management*," requires documented safety analyses and technical safety requirements that provide the safety basis and controls for facility design and operation.

Other regulations and DOE directives include 10 CFR Part 820, "*Procedural Rules for DOE Nuclear Facilities*," DOE Order 458.1, Change 3 "*Radiation Protection of the Public and the Environment*," 10 CFR Part 835, "*Occupational Radiation Protection*," and 10 CFR Part 851, "*Worker Safety and Health Program*." See Chapter 5 for more information on health and safety requirements.

To protect the public from impacts from radiological exposure, DOE Order 458.1 imposes an annual individual dose limit to members of the public of 10 millirem from airborne pathways, 4 millirem from the drinking water pathway, and 100 millirem total from all pathways. Public doses from all pathways must be maintained to achieve ALARA goals. To protect workers from impacts from radiological exposure, 10 CFR Part 835 imposes an individual dose limit of 5,000 millirem in a year. In addition, worker doses are monitored and controlled below the regulatory limit to ensure that individual doses are less than an administrative limit of 2,000 millirem per year and maintained to achieve ALARA goals (DOE 2017f).

Rem – A unit of radiation dose used to measure the biological effects of different types of radiation on humans. The dose in rem is estimated by a formula that accounts for the type of radiation, the total absorbed dose, and the tissues involved. One thousandth of a rem is a millirem.

Person-rem – A unit of collective radiation dose applied to a population or group of individuals. It is calculated as the sum of the estimated doses, in rem, received by each individual of the specified population. For example, if 1,000 people each received a dose of 1 millirem, the collective dose would be 1 person-rem (1,000 persons×0.001 rem).

Latent cancer fatalities (LCFs) – Deaths from cancer resulting from and occurring sometime after exposure to ionizing radiation or other carcinogens. This supplemental environmental impact statement focuses on LCFs as the primary means of evaluating health risk from radiation exposure. A risk factor of 0.0006 LCF per person-rem or rem is used, consistent with DOE guidance (DOE 2003b). The values reported for an LCF are (1) the increased risk of an MEI or other individual developing a fatal cancer, or (2) the number of LCFs projected to occur in an identified population. For a population, if the calculated LCF value is less than 0.5, the number of LCFs is reported as zero.

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[44] An involved worker is directly or indirectly involved with operations at a facility who receives an occupational radiation exposure from direct radiation (i.e., neutron, x-ray, beta, or gamma) or from radionuclides released to the environment from normal operations. A noninvolved worker is a site worker outside of a facility who is unlikely to be subjected to direct radiation exposure, but could be exposed to emissions from that facility, particularly during postulated accidents. The off-site population comprises members of the general public living within 50 miles (80 kilometers) of a facility. The maximally exposed individual (MEI) is a hypothetical member of the public at a location of public access that would result in the highest exposure, which is assumed to be at the site boundary during normal operations and postulated accidents.

Nonradiological public health impacts may occur primarily through inhalation of air containing hazardous chemicals released to the atmosphere; risks from other pathways such as ingestion of contaminated drinking water are generally lower. Impacts are minimized through design, construction, and administrative controls that limit hazardous chemical releases to the environment and achieve compliance with National Emissions Standards for Hazardous Air Pollutants and National Pollutant Discharge Elimination System requirements. The effectiveness of these controls is verified through the use of environmental monitoring information and inspection of mitigation measures.

Nonradiological impacts on workers at Paducah and Portsmouth could occur through exposure to hazardous materials by inhaling contaminants in the workplace atmosphere or by direct contact. Workers are protected from workplace hazards through appropriate training, protective equipment, monitoring, materials substitution, and engineering and management controls. They are also protected by adherence to Federal and state laws, DOE orders and regulations, and OSHA and EPA guidelines. Monitoring that reflects the frequency and quantity of chemicals used in the operational processes ensure that these standards are not exceeded. DOE requires that conditions in the workplace be as free as possible from recognized hazards that cause, or are likely to cause, illness or physical harm.

Public Safety and Health Under Normal Operations

Containers of DU oxide emit very low levels of gamma and neutron radiation, resulting in a dose rate of about 2 millirem/hour at 30 centimeters (PPPO 2018). Public health impacts could result from the release of DU oxide due to container breaches. The uranium could be transported through the environment as an airborne release or as a groundwater or surface water release. As indicated in Chapter 2, Section 2.2.1, the numbers of DU oxide cylinder breaches have been estimated based on two scenarios. The more conservative "uncontrolled corrosion" scenario assumes that the historical rate of breaches would continue throughout the duration of the No Action Alternative. In the second "controlled corrosion" scenario, improved storage conditions are assumed to result in lowered breach rates. No new cylinder breaches have occurred at Paducah and Portsmouth since improved storage conditions have been implemented (PPPO 2018).

The 2004 Paducah EIS and the 2004 Portsmouth EIS (DOE 2004a, 2004b) estimated the public health impacts from the storage of DUF_6 at Paducah and Portsmouth. After conversion, any exposure to stored uranium would be from DU oxide. The chemical form of the uranium does not appreciably impact the radiological characteristics of the material. Therefore, the dose estimates from the 2004 EISs for DUF_6 were used in this *DU Oxide SEIS* to estimate the effects of exposure to DU oxide.

The 2004 Paducah EIS (DOE 2004a) estimated that if all DU annually assumed to be released in cylinder breaches each year were released to the atmosphere (a very conservative assumption), the dose to the general public would be 0.008 person-rem. When scaled for the increased number of cylinders being stored under the No Action Alternative, this results in an annual population dose of 0.01 person-rem.[45] For the 100 years of DU oxide storage assumed for the No Action Alternative, this population dose rate would correspond to a total population dose of 1.0 person-rem. This population dose would result in an estimated 0 (6×10^{-4}) LCF.[46] For comparison, the average natural background radiation level in the United States is 310 millirem per year; this means that during the 100 years of DU oxide storage, the population within 50 miles of Paducah would receive a background dose of 16 million person-rem based on a population of 534,000 (DOE 2017a**)**. The population dose associated with natural background radiation could result in an estimated 9,600 LCFs.

The 2004 Portsmouth EIS (DOE 2004b) estimated that if all DU annually assumed to be released in cylinder breaches each year were released to the atmosphere (a very conservative assumption), the dose to the general public would be 0.002 person-rem. For the 100 years of DU oxide storage assumed for the No Action Alternative, this population dose rate would correspond to a total population dose of 0.2 person-rem.[47] This population dose would result in an estimated 0 (1×10^{-4}) LCF. For comparison, over the same period, the 677,000 people (DOE 2017c**)** living within 50 miles of Portsmouth would receive a background dose of 21 million person-rem. The population dose associated with natural background radiation could result in an estimated 12,600 LCFs.

The Paducah Annual Site Environmental Report for mentions that the effective dose potentially received by a member of the public passing through accessible portions of the Paducah Site would likely be 4.24 millirem/year in a scenario where areas of highest exposure are visited 80 hours/year" (DOE 2017a). Measurements at one of the locations used in developing this estimate of a direct radiation dose are from monitors located just outside the controlled (security fenced) area near the cylinder yards. The Paducah Annual Site Environmental Report also states "Because security protocols prohibited the public from gaining prolonged access to the Paducah Gaseous Diffusion Plant (GDP) boundary fence in CY 2016, the potential radiation doses calculated at or in close proximity to the fence are not realistic." However unrealistic, this estimate has been included to produce a conservative estimate of the MEI dose from cylinder storage. The MEI doses identified in the 2004 Paducah EIS (DOE 2004a) resulted from cylinder breaches and were approximately 0.1 millirem per year from airborne releases of uranium and less than 0.5 millirem per year from ingestion of contaminated water. Scaling for the increase in the annual cylinder breach rate (see footnote 43), the combined doses would correspond to an MEI dose of

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[45] The annual number of cylinder breaches assumed in this DU Oxide SEIS (Table 2-2) for Paducah is higher than that assumed in the 2004 EIS for storage of uranium hexafluoride (approximately 14 versus 11 breaches per year for the conservative case and 1.14 versus 0.9 breaches per year for the improved storage condition scenario). This scaling is required due to the larger number of cylinders assumed to be stored in this DU Oxide SEIS versus the 2004 Paducah EIS. Estimates for population doses at Paducah from the 2004 EIS (DOE 2004a) are scaled up by 25 percent to account for the greater number of breaches and corresponding increase in the amount of uranium released per year assumed in this DU Oxide SEIS.

[46] A latent cancer fatality (LCF) is a death from cancer resulting from and occurring sometime after exposure to ionizing radiation or other carcinogens. This DU Oxide SEIS focuses on LCFs as the primary means of evaluating health risk from radiation exposure. A risk factor of 0.0006 LCF per person-rem or rem is used, consistent with DOE guidance (DOE 2003).

[47] The annual number of cylinder breaches assumed in this DU Oxide SEIS (Table 2-2) for Portsmouth is similar to that assumed in the 2004 EIS for the storage of uranium hexafluoride (approximately 1.9 per year for the conservative case and 0.4 per year for the improved storage condition scenario). This number of cylinders assumed to be stored in this DU Oxide SEIS is within 10 percent of that assumed in the 2004 Portsmouth EIS and the breach rates developed in the 2004 EISs are used in this DU Oxide SEIS. Therefore, no scaling of the estimates for population doses from the 2004 EIS (DOE 2004a) were performed for this DU Oxide SEIS.

approximately 0.75 millirem per year from potential cylinder breaches. Assuming, conservatively, that the same individual receives all of the MEI doses, combining the direct radiation dose from the Annual Site Environmental Report and the 2004 EIS results in an MEI dose of less than 5.0 millirem per year. These doses are well below regulatory limits established by EPA and DOE for radiation exposure to a member of the public. EPA has set radiation dose limit to a member of the general public of 10 millirem per year from airborne sources (40 CFR Part 61). In DOE Order 458.1, DOE established a limit on the dose to a member of the public of 100 millirem per year from all sources combined. The 5.0 millirem per year dose to the MEI results in an incremental increase in an annual risk of an LCF for this individual of 3×10^{-6}, or 1 chance in about 330,000 of an LCF. Although it is extremely unlikely that the same individual would be the MEI every year over the 100 years of DU oxide storage, the total dose during this period would be 500 millirem. The likelihood of the individual receiving this MEI dose during that period and contracting an LCF is less than 1 chance in about 3,300 (calculated risk of 3×10^{-4} LCF).

The Portsmouth Annual Site Environmental Report for 2015 states that a member of the public that drives on Perimeter Road past the cylinder yards, on a daily basis, could receive a direct radiation dose from storage of DU in the cylinder yard (DOE 2017c). In 2015, this hypothetical individual received a dose of 0.77 millirem from direct radiation. The MEI doses identified in the 2004 Portsmouth EIS (DOE 2004b) resulted from cylinder breaches and were less than 0.1 millirem per year from airborne releases of uranium and less than 0.4 millirem per year from ingestion of contaminated water. Assuming the same individual receives all of the MEI doses, combining the direct radiation dose from the Annual Site Environmental Report and the 2004 EIS results in an MEI dose of less than 1.3 millirem per year. These doses are well below regulatory limits established by EPA and DOE for radiation exposure to a member of the public. This 1.3 millirem per year dose to the MEI results in an incremental increase in the annual risk of an LCF for this individual of 8×10^{-7}, or 1 chance in about 1.3 million of an LCF. Although it is extremely unlikely that the same individual would be the MEI every year over the 100 years of DU oxide storage, the total dose during this period would be 130 millirem. The likelihood of an LCF for this individual receiving this MEI dose during that period is less than 1 chance in 12,000 (calculated risk of 9×10^{-5} LCF).

Hazard Index

The hazard index (HI) is the sum of the hazard quotients for all chemicals to which an individual is exposed. A value less than 1 indicates that the exposed person is unlikely to develop adverse human health effects.

The hazard quotient is a comparison of the estimated intake level of a chemical with its adverse effects level. It is expressed as a ratio of estimated intake level to adverse effects level.

The 2004 EISs (DOE 2004a, 2004b) also provide an estimate of the nonradiological impacts of uranium releases on the public. Both of the 2004 EISs estimated that the hazard index (HI) associated with airborne releases of uranium would be less than 0.1 and that for releases into the waters around Paducah and Portsmouth the HI would be less than 0.05. Therefore, no adverse impacts are expected from chemical exposure.

Data presented in the Paducah Annual Site Environmental Report for 2016 (DOE 2017a**)** suggests that the HI for water releases may be smaller than that presented in the 2004 Paducah EIS (DOE 2004a). This report indicates that groundwater is not used as a source of drinking water in the area downstream of Paducah; all well water systems have been replaced by city water. Assuming all of the uranium released from cylinder breaches would be released into surface water and not ultimately reach groundwater, the potential HI to an individual that uses Ohio River surface water as a source of drinking water would be less than 0.05.

Data presented in the Portsmouth Annual Site Environmental Report for 2015 (DOE 2017c**)** suggests that the HI for water releases may be smaller than that presented in the 2004 Portsmouth EIS (DOE 2004b). This report indicates that groundwater monitoring has not detected uranium above background levels in drinking (well) water in the area surrounding Portsmouth. Assuming all of the uranium released from cylinder breaches would be released into surface water and not ultimately reach groundwater, the potential HI to an individual that uses Scioto River surface water as a source of drinking water would be less than 0.05. For both Paducah and Portsmouth, the concentrations of uranium within the rivers, based on concentrations of less than 20 micrograms per liter in the tributaries to the rivers (DOE 2004a, 2004b), would be well below 30 micrograms per liter, the EPA maximum contaminant level for drinking water (EPA 2001).

Noncancer health effects from exposure to possible groundwater contamination are not expected; the estimated maximum HI for an individual assumed to use groundwater is less than 0.05 (DOE 2004a, 2004b).

Occupational Safety and Health Under Normal Operations

Workers would be exposed to low levels of gamma and neutron radiation while working in the DU oxide cylinder storage yards performing activities that include routine cylinder inspections, radiological monitoring and valve maintenance, and cylinder repair and relocations. At Paducah, a total of 16 workers would be required for these activities during the 100 year period evaluated for the No Action Alternative, while at Portsmouth, a total of 12 workers would be required (PPPO 2018).

The average annual dose to Paducah and Portsmouth cylinder yard workers, are provided in the DOE's 2014 and 2016 Occupational Radiation Exposure Reports (DOE 2015h, 2017b). In 2014 the average dose (considering only those workers that received a measurable dose) was 74 millirem at Paducah[48] and in 2016 the average dose was 63 millirem at Portsmouth. These reported doses are well below the worker exposure limit of 5,000 millirem per year as required by 10 CFR 835, "*Occupational Radiation Protection*," and correspond to an annual risk of about 4×10^{-5} LCF. These workers performed duties similar to those expected of workers during the implementation of this alternative and these historical doses were used as estimates of cylinder yard worker doses for this analysis. Therefore, it is estimated that at Paducah the collective dose would be approximately 1.2 person-rem per year for the 16 cylinder yard workers, and would total 120 person-rem during the 100 years of DU oxide storage. No LCFs (calculated value of 0.07) would be expected from this exposure. Similarly, it is estimated that the collective dose for the 12 Portsmouth cylinder yard workers would be approximately 0.76 person-rem per year and total 76 person-rem during the 100 years of DU oxide storage. No LCFs (calculated value of 0.05) are expected to result from this exposure.

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[48] As noted in Chapter 3, in 2016 over 500 workers received a measurable dose at Paducah. The higher average dose calculated from the 2014 occupational exposure data (versus the 11-millirem value from the 2016 data) was used in this section because Paducah data for 2014 was deemed more representative of cylinder yard worker doses.

The 2004 Paducah and Portsmouth EISs (DOE 2004a, 2004b) calculated a maximum noninvolved worker dose of 0.15 millirem per year from storage of DUF_6. The dose, primarily from direct radiation, was estimated based on the uranium in the cylinders in the conversion facility and cylinder storage yards and the cylinders moved to and from the conversion facility. Because the amount of uranium that will be stored as an oxide would be similar to that previously being stored as DUF_6, the dose to the noninvolved worker would be similar for the storage and handling of DU oxide.

The 2004 Paducah and Portsmouth EISs (DOE 2004a, 2004b) also calculated a total worker dose for noninvolved workers. The collective noninvolved worker dose at both facilities was estimated to be 0.003 person-rem per year at Paducah and 0.001 person-rem per year at Portsmouth for workforces, which is somewhat different[49] than that predicted for each site during the storage of DU oxide; these doses, therefore, provide a reasonable estimate for the total noninvolved worker dose. During the 100 years of DU oxide storage, the total noninvolved worker dose would be 0.3 person-rem at Paducah and 0.1 person-rem at Portsmouth. No LCFs (calculated values are less than 0.0002 LCF at Paducah and 0.00006 LCF at Portsmouth) would be expected at either site.

For worker protection from the toxic effects of uranium, DOE uses the OSHA permissible exposure levels for workplace exposure to uranium of 0.25 milligram per cubic meter for insoluble and 0.05 milligram per cubic meter for soluble uranium (29 CFR 1910.1000, Table Z-1). Under the requirements of DOE's worker protection program, site worker exposures to airborne uranium are maintained below these levels. Adherence to these limits would result in no adverse health effects to workers at either site from the toxic effects of uranium exposure.

Nonradiological accidents also pose a risk to site workers. All on-site work would be performed in accordance with best management practices and in accordance with applicable OSHA requirements and DOE Orders and regulations. In particular, worker safety practices would be governed by worker safety requirements in 10 CFR 851, "*Worker Safety and Health Program*." DOE Order 450.2, "*Integrated Safety Management,"* integrates safety into management and work practices at all levels ensuring protection of workers, the public, and the environment.

The estimated number of accidental worker injuries and fatalities were based on the number of workers in the cylinder storage yard (16 at Paducah and 12 at Portsmouth) and national worker injury and fatality rates. During the assumed 100 years of DU oxide storage there would be no expected fatalities at either site based on an average worker fatality rate of 3.4 fatalities per 100,000 worker years (BLS 2014). In 2016, the national average across all industries for accidents resulting in lost worker days was 3.0 accidents per 100,000 worker-years (BLS 2016b). This accident rate results in an estimated 0.48 annual cylinder yard worker injury at both Paducah and 0.36 worker injury at Portsmouth. During the 100 years of assumed DU oxide storage, there could be a total of 48 worker injuries at both Paducah and 36 worker injuries at Portsmouth.

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[49] The size of the workforces used in the 2004 EISs were 1,727 at Portsmouth and 1,799 at Paducah. In 2016 the size of the workforce at each site was 2,612 workers at Portsmouth and approximately 1,200 workers at Paducah (PPPO 2018). Noninvolved worker doses were not scaled due to these differences.

Public and Occupational Safety and Health Under Accident Conditions

The potential impacts of accidents associated with continued DU oxide container storage operations have been extensively examined in NEPA and safety analyses for the respective Sites, including the DUF_6 PEIS (DOE 1999), the 2004 EISs (DOE 2004a, 2004b), and the 2016 documented safety analyses (DSAs) for the cylinder storage yards for each site (BWXT 2016a, 2016b). The 2004 EISs and 2016 DSAs identified similar accidents and impacts from cylinder storage and maintenance activities. The accident analyses in these documents indicate that the physical hazards associated with handling large, heavy cylinders were such that workers could be injured or killed as a result of on-the-job accidents unrelated to radiation or chemical exposure. The potential for accidental injuries and deaths are similar to other industries that use heavy equipment or manipulate heavy objects.

DU oxide cylinders and drums would be stored for an assumed 100 years in the cylinder storage yards as described in Chapter 2, Section 2.1.3. DU oxide cylinders would be stored in the open, but DU oxide stored in 55-gallon (208-liter) drums would be protected from the elements by storing the drums in intermodal containers (BWXT 2016b).

Accidents could release radionuclides or chemicals to the environment, potentially affecting workers and members of the general public. If released to the atmosphere, DU oxide may become airborne as a function of particle size. Inhalation of fine uranium particles presents increased radiation hazards; uranium particles in the lungs may be a long-term cancer hazard. The lung is the critical organ (i.e., the part of the body most vulnerable to damage from the uranium) for insoluble respirable dusts or fines such as oxide powders; the more soluble uranium compounds are considered most toxic to the kidneys. Uranium dusts are also respiratory irritants, with coughing or shortness of breath as possible results of exposure.

In both the NEPA and safety documents, a range of operational and natural-phenomena-initiated accidents were considered, including cylinder handling equipment fires, fires involving cylinder(s) in a pool of fuel or oil, small vehicle or transport truck fires, tornadoes and high winds, seismic events, and small and large aircraft impacts followed by fires. The assessment considered accidents ranging from those that would be reasonably likely to occur (estimated to occur one or more times in 100 years on average) to those that would be extremely rare (estimated to occur less than once in 1 million years on average).[50]

The previous NEPA analyses indicate that of all the operational accidents considered during handling and storage area operations, those involving DUF_6 cylinders would have the largest potential effects. These analyses indicated that accidents involving DUF_6 cylinders would present higher potential impacts on workers and the public than DU oxide cylinders because the DUF_6 cylinders were more likely to rupture when exposed to fire. In addition, if a cylinder ruptured, DUF_6 would undergo chemical reactions and release HF in addition to various uranium compounds, thus presenting additional chemical hazards when compared to a DU oxide release. The previous NEPA analyses indicated that impacts from handling and storage area accidents involving DUF_6 cylinders would bound the impacts from any accidents involving DU oxide containers. Therefore, specific analyses for accidents involving DU oxide containers in the storage

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[50] Container breaches as a result of corrosion are expected to occur and are analyzed as part of "Normal Operations."

areas were not performed in the previous NEPA analyses since the potential impacts were considered bounded by the impacts from potential accidents involving DUF_6 cylinders.

The hazards analyses in the Paducah and Portsmouth cylinder yard DSAs concluded that fire events at the storage yards could potentially involve several cylinders or drums containing DU oxide. However, the densified (i.e., packed) oxide powder in the cylinders or drums is not easily dispersible under fire conditions because the oxide is difficult to deagglomerate and DU oxide does not liquefy or vaporize and would not over-pressurize a container to the point of rupture. These events are not expected to result in significant radiological and chemical consequences (BWXT 2016b). In addition, the DSAs indicated that a non-fire related breach of a cylinder or drum containing DU oxide is not expected to have significant radiological or chemical consequences.

The hazards analyses in the Paducah and Portsmouth cylinder yard DSAs involving handling and storage of cylinders of DU oxide concluded that the hazards associated with DU oxide evaluated in the respective hazards analyses result in acceptable-risk events. No accident scenarios or mechanisms were identified that could result in the airborne dispersion of substantial quantities of DU oxide. All of the operational and natural phenomena initiated events identified in the hazard evaluation tables in the DSAs that involved DU oxide were found to have low unmitigated (without preventive or mitigative features) radiological and chemical consequences to facility (involved) or collocated (noninvolved) workers, and negligible radiological and chemical consequences to the public. As a result, no DU oxide events were evaluated in detail in the Paducah and Portsmouth cylinder storage yard DSAs; the DSAs instead concentrate on DUF_6 accidents as the bounding cylinder storage yard accidents (BWXT 2016b).

The detailed technical basis for a hypothetical, worse-case, that is, more conservative than the NEPA standard of maximum reasonably foreseeable, accident within the conversion facility involving drums and cylinders of DU oxide is described in the DUF_6 Conversion Facility DSAs (BWXT 2016c). The modeled release is a full hopper containing 20,000 kilograms (44,100 pounds) of DU oxide resulting from a broken discharge chute. The release is modeled as a free-fall spill of DU oxide powder from 3 meters (9.8 feet) with a total airborne respirable release fraction of 6×10^{-4}. Because the DU oxide powder is assumed to become suspended, a damage ratio of 0.5 is assigned and about 6.0 kilograms (13 pounds) is assumed to be released. This is extremely conservative for a spill of this size and bounds other release mechanisms.

Acute Exposure Guideline Levels (AEGLs)

Threshold values published by the National Research Council and National Academy of Sciences for use in chemical emergency planning, prevention, and response programs. AEGLs represent threshold exposure limits for the general population, including susceptible individuals. AEGL values are defined for varying degrees of severity of toxic effects, as follows:

AEGL-1 – The airborne level of concentration of a substance above which the exposed population could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects would not be disabling and would be transient and reversible upon cessation of exposure.

AEGL-2 – The airborne level of concentration of a substance above which the exposed population could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3 – The airborne level of concentration of a substance above which the exposed population could experience life-threatening health effects or death.

A cylinder contains 9,000 to 12,000 kilograms (20,000 to 26,000 pounds) of DU oxide, and a bulk bag would contain about 11,000 kilograms (22,000 pounds) of DU oxide. No physical mechanisms were identified involving cylinders or bulk bags of DU oxide during handling or storage that would result in as high a fraction of the total amount of DU released as the hypothetical full hopper failure and a free-fall spill modeled for the conversion facilities. Therefore, the full hopper failure and a free-fall spill modeled for the conversion facilities was used as the bounding DU oxide accident.

The dose conversion factor for DU oxide (insoluble uranium) is approximately 0.083 rem per milligram. For an accident involving the contents of a DU oxide powder hopper (20 metric tons [22 tons] of DU oxide), the largest estimated dose for both Sites is approximately 6.5×10^{-3} rem for an off-site MEI and 1.3 rem for an on-site noninvolved worker at a distance of 100 meters (330 feet). These doses correspond to risks of 4×10^{-4} LCF and 8×10^{-4} LCF, respectively. For both Sites, uranium uptake is estimated to be 0.08 milligrams for an off-site individual and 15.4 milligrams for an on-site noninvolved worker at a distance of 100 meters (330 feet) (BWXT 2016c). The consequences of the modeled unmitigated release from a DU oxide powder hopper resulted in low consequences for both the off-site public and on-site noninvolved workers in terms of radiological dose and uranium uptake. No quantitative evaluation of dose consequences was performed for the facility worker; however, based on qualitative considerations, the hazard is assumed to be low. This is because the hazard from DU oxide is low and the worker would have to remain in the area for an extended time to receive a substantial exposure (BWXT 2016c).

Uptake by an off-site member of the public of 0.08 milligram of uranium would be less than 1 percent of Acute Exposure Guideline Level-1 (AEGL-1) (10 milligrams), which is considered acceptable for members of the public in a chemical accident. A noninvolved worker uptake of 15.4 milligrams is less than the 50 milligrams uranium AEGL-2 value considered acceptable to workers (BWXT 2016c).

The radiological and chemical impacts on noninvolved workers and the public from this 6.0 kilograms (13 pounds) DU oxide airborne release are expected to bound any other credible storage yard accidents associated with DU oxide container handling operations at Paducah or Portsmouth.

Other accidents evaluated in the Paducah and Portsmouth EISs include a DU oxide drum spill in which a single DU oxide drum is damaged by a forklift and spills its contents onto the ground outside a storage facility. For that accident a release of 1.1 kilograms (2.4 pounds) was postulated (DOE 2004b).

Fires and other events at the DU oxide container staging area could potentially involve several cylinders or drums. However, the packed DU oxide powder in the cylinders or drums would not be easily dispersible under fire conditions because it would not vaporize and would be very difficult to deagglomerate. Thus, the full hopper failure and a free-fall spill accident bounds the potential consequences of events for DU oxide container storage.

The handling for disposal of CaF_2 is unlikely to present any substantial risks from an accident involving this material. CaF_2 is not a hazardous material and would likely contain very low level of radionuclides such that it could be handling and disposed of as a solid waste. Therefore, no credible accident scenarios were evaluated that would result in a substantial health risk.

A seismic-initiated earthquake was also evaluated in which a DU oxide storage building was damaged and 10 percent of the contents of the stored containers were breached, resulting in a spill of 61 kilograms (135 pounds) (DOE 2004b). Because the DU oxide will not be stored in a building, there would be no risk of damage to the cylinders from falling debris; thus, this storage building accident is not applicable. Severe, natural phenomena events, including earthquakes, do not have the potential to substantially damage stored DU oxide containers, and releases larger than the 6 kilograms (13 pounds) of DU oxide evaluated above would not be expected.

Public and Occupational Safety and Health—Intentional Destructive Act Scenarios

Because of the low hazard posed by DU oxide, the material would not be an attractive target for a terrorist attack or other intentional destructive acts. The 2004 EISs (DOE 2004a, 2004b) demonstrated that other hazardous chemicals and cylinders of other forms of uranium (including DUF_6) present a higher potential impacts to workers and the public than DU oxide when released. The releases caused by intentional destructive acts during the management of DU oxide were not expressly calculated in the 2004 EISs (DOE 2004a, 2004b) and this *DU Oxide SEIS*. In both the NEPA and safety documents, a range of operational, external events, and natural-phenomena-initiated accidents were considered, including cylinder handling equipment fires, fires involving cylinder(s) in a pool of fuel or oil, small vehicle or transport truck fires, tornadoes and high winds, seismic events, and small and large aircraft impacts followed by fires. As discussed in the 2004 EISs and this *DU Oxide SEIS*, releases for and the consequences from severe accidents involving the DU oxide were derived using conservative assumptions. Therefore, any releases caused by and the consequences from potential intentional destructive events are likely to either be bounded by or be comparable to the releases and consequences presented in the 2004 EISs (including operational accidents, tornados, seismic events, and aircraft crashes) and this *DU Oxide SEIS* for severe operational, external, and natural phenomena-initiated accidents. Substantial security measures would be in place to reduce the likelihood of a successful intentional destructive act.

4.1.1.7 Socioeconomics

The socioeconomic analysis covers the effects on population, employment, income, regional growth, housing, and community resources in the ROI of Paducah and Portsmouth. At Paducah, 16 workers would be required for DU oxide container storage and maintenance and waste loading activities, while at Portsmouth, 12 workers would be required (PPPO 2018). There would be no significant construction activities at Paducah or Portsmouth.

Table 4-3 compares the employment for DU oxide monitoring and maintenance to estimated future site employment at Paducah and Portsmouth. The employment associated with DU oxide container monitoring and maintenance and waste loading activities would be less than 2 percent of total site employment, and approximately 6 percent of conversion facility employment at each location. During the post-conversion period, employment for DU oxide container monitoring and maintenance and waste loading activities would likely constitute most of the remaining employees at Paducah and Portsmouth. This does not consider the possible extension of current activities or future activities that could locate at these Sites. In addition, management of large quantities of CaF_2 would only be required if DOE was unable to sell HF; in which case, staff assigned to manage HF could manage the CaF_2. Therefore, because of the small number of employees involved, no in-migration or out-migration is expected that would impact population, employment, income, regional growth, housing, or community services in the Paducah and Portsmouth ROIs.

Table 4-3 Comparison of Site Employment Against Employment for DU Oxide Container Management under the No Action Alternative

Site	Employment for DU Oxide Container Monitoring and Maintenance	Site Employment (Percent of Employment)	
		Estimated for Conversion Facility	Total Site
Paducah	16	250 (6)	1,200 (2)
Portsmouth	12	210 (6)	2,612 (<1)

Key: DU = depleted uranium.
Source: PPPO 2018

4.1.1.8 Waste Management

Storage and maintenance of DU oxide containers at Paducah and Portsmouth would annually generate small quantities of solid LLW (exclusive of empty and heel cylinders and CaF_2), and MLLW (**Table 4-4**). These annual waste quantities would represent small fractions of the same types of waste that are currently generated and managed during other site activities such as conversion of DUF_6 to DU oxide, environmental restoration, and building demolition.

Therefore, generation of waste during storage and maintenance of DU oxide containers would not impact waste management capabilities at Paducah or Portsmouth. All LLW and MLLW generated during storage and maintenance of DU oxide containers would be transported to off-site facilities for treatment and/or disposal.

In addition, some of the cylinders would not be usable for storage and potential future shipment of DU oxide or may be excess, and would be shipped off site for disposal as LLW. DOE estimates that 8,483 empty and heel cylinders would be generated at Paducah and 5,517 empty and heel cylinders would be generated at Portsmouth. Assuming each cylinder is 4 feet (1.2 meters) in diameter and 12 feet (3.7 meters) long, and no volume reduction occurs at either site, about 1,400 cubic yards (1,070 cubic meters) per year of empty and heel cylinders would be generated at Paducah and Portsmouth. In addition, if the HF cannot be recycled into commerce, CaF_2 would be generated. Although these empty and heel cylinders and CaF_2 would be very large percentages of current LLW generation, the site waste management infrastructure has been modified under the 2004 EISs and associated RODs to handle these volumes of wastes. Therefore, managing these waste would not adversely affect the waste management infrastructure. Nonhazardous waste (general trash) and sanitary wastewater would be generated at both Paducah and Portsmouth by the 16 and 12 employees involved in DU oxide container storage and maintenance activities, respectively (PPPO 2018). At both Portsmouth and Paducah, nonhazardous waste would be disposed of on site or sent to off-site permitted recycle or disposal facilities, while sanitary wastewater would be treated on-site (see Sections 3.1.8 and 3.2.8). Any nonhazardous waste or sanitary wastewater that would be generated would represent small fractions of the same types of waste generated by current site personnel and would be managed with no impacts on capacities at either site.

Table 4-4 Percent of Annual Waste Generation at Paducah and Portsmouth under the No Action Alternative

	Paducah			Portsmouth		
Waste Type	**Waste Volume (cubic yards)[a]**	**Current Waste Generation[b]**	**Percent of Current Waste Generation**	**Waste Volume (cubic yards)[a]**	**Current Waste Generation[b]**	**Percent of Current Waste Generation[b]**
LLW [c]	2.1	210	1.0	1.6	160	1.0
LLW – empty and heel cylinders[d]	1,400	NWS	NA	1,400	NWS	NA
LLW – CaF_2	4,600	NWS	NA	3,100	NWS	NA
MLLW	0.014	1.4	1.0	0.010	1.0	1.0

Key: LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NA = not applicable; NWS = new waste stream.

[a] Source: PPPO 2018.

[b] Waste from current activities at Paducah is described in Section 3.1.8, while waste from current activities at Portsmouth is described in Section 3.2.8.

[c] The comparisons against current LLW generation rates are for LLW other than empty and heel cylinders.

[d] The listed volume of the empty and heel cylinders is the envelope volume of the cylinders. Waste volumes may be significantly reduced if the cylinders were volume-reduced (e.g., compacted or shredded) at the disposal facilities or a separate waste treatment facility.

Note: To convert cubic yards to cubic meters, multiply by 0.76456.

4.1.1.9 Land Use and Aesthetics

Impacts on land resources, including land use and aesthetics could occur from new construction or changes in land use. DU oxide container storage and maintenance activities and waste loading would occur within the industrialized areas of Paducah and Portsmouth, and there would be no new significant construction and no change in land use. Therefore, potential impacts on land use and aesthetics would be minor at both Paducah and Portsmouth.

4.1.1.10 Cultural Resources

Impacts on cultural resources are not likely. The existing storage yards at Paducah and Portsmouth are located in previously disturbed areas that were graded during the original yard construction, and both are unlikely to contain cultural properties or resources listed on or eligible for listing on the NRHP (DOE 2015b; Miller et al. 2014). No new or expanded DU oxide container storage areas are proposed at either site. In the unlikely event of a container breach, pollutant emissions are not expected to be sufficient to cause impacts on cultural resources (see Section 4.1.1.2 of this *DU Oxide SEIS*).

Continued storage of DU oxide containers would mean maintaining the status quo for known historic properties at Paducah and Portsmouth. At either site there would be no effects on historic properties during long-term storage, monitoring and maintenance, repair of containers, and routine shipping of wastes off-site. In addition, there would be no impacts on religious or sacred sites, burial sites, or resources significant to Native Americans because none has been identified at these locations (DOE 2004a, 2004b). If any cultural resources are discovered during implementation of the alternatives evaluated in this *DU Oxide SEIS*, consultation with the appropriate SHPO and Tribal governments would be undertaken in accordance with law and applicable agreements (DOE 2004a, 2004b).

4.1.1.11 Environmental Justice

A determination of impacts that could disproportionately affect minority and low-income populations is based upon the identification of high and adverse impacts on the resource areas considered in this *DU Oxide SEIS*. As shown in Sections 3.1.11 and 3.2.11, there are a number of census tracts with a higher–than-state-average proportion of minority and low-income populations within 50 miles (80 km) of both Paducah and Portsmouth.

A review of the radiological impacts on the public from normal operations and postulated accidents at Paducah and Portsmouth, as well as impacts from potential chemical exposures and accidents (Section 4.1.1.6), indicates that all of the operational and natural-phenomena-initiated events identified in the hazard evaluation tables in the DSAs that involved DU oxide were found to have low unmitigated (without preventive or mitigative features) radiological and chemical consequences on involved and uninvolved workers, and negligible radiological and chemical consequences on the public.

Minimal impacts on the general public related to air quality, climate, noise, and water resources have been identified, including at the population and individual level. In addition, accidents were found to have negligible radiological and chemical consequences to the public. There would be no disproportionately high and adverse impacts on minority or low-income populations.

4.1.2 Transport of Radioactive Waste to Disposal Facilities

As described in Section 4.1.1.8, LLW and MLLW generated from storage and maintenance of DU oxide containers would be transported to off-site radioactive waste management facilities.

This *DU Oxide SEIS* generally follows the methodology described in the 2004 EISs (DOE 2004a, 2004b), with the following changes. The 2004 EISs used risk factors of 0.0004 LCF per person-rem of exposure for workers and 0.0005 LCF per person-rem of exposure for members of the general public. This *DU Oxide SEIS* uses a risk factor of 0.0006 LCF per person-rem, consistent with current DOE guidance (DOE 2003). In addition, this *DU Oxide SEIS* uses updated population data from the 2010 Census, and for analyses that were modeled, uses updated computer modeling software. For the transport of the DU oxide in bulk bags, impacts from transportation were estimated using the calculated impacts from the 2004 EISs. See Section 4.2.2 and Appendix B for more information on the transportation impacts methodology.

This section summarizes the potential impacts due to shipment of empty and heel cylinders, ancillary LLW and MLLW, and CaF_2 from Paducah in Kentucky and Portsmouth in Ohio to the disposal facilities under incident-free and accident conditions. Potential impacts for the empty and heel cylinders, ancillary LLW and MLLW, and CaF_2 shipments are presented on an annual basis, as identified in **Tables 4-5, 4-6,** and **4-7**. Footnotes in the tables describe how total impacts can be estimated. Because the annual numbers of expected ancillary LLW and MLLW shipments are small, this would make transport by train inefficient. Therefore, only truck transport is analyzed.

Because the quantities of empty and heel cylinder and CaF_2 would be larger than the ancillary LLW and MLLS shipments, both truck and train shipment are analyzed.

Tables 4-5, 4-6 and 4-7 summarize the potential average annual impacts of transporting empty and heel cylinders, ancillary LLW and MLLW, and CaF_2 to a disposal facility (i.e., Energy*Solutions*, NNSS, or WCS). As indicated in these tables, no LCFs are expected, although traffic fatalities could result from transport of CaF_2 to a disposal facility over the duration of the entire shipping campaign.

Table 4-5 Annual Risks to Crew Members and the Public from Transporting 14,000 Empty and Heel Cylinders to a Radioactive Waste Disposal Facility

			Incident-Free[a]				**Accident[a]**	
			Crew		**Population**			
Destination	**Number of Shipments**	**Total One-way Kilometers Traveled**	**Dose (person-rem)**	**LCF[b]**	**Dose (person-rem)**	**LCF[b]**	**Radiological Risk[b]**	**Nonrad Risk[b]**
Truck Transport from Paducah								
Energy*Solutions*	125	321,300	0.004	2×10^{-6}	0.01	6×10^{-6}	3×10^{-9}	0.02
NNSS	125	400,900	0.005	3×10^{-6}	0.01	7×10^{-6}	2×10^{-9}	0.02
WCS	125	212,300	0.003	2×10^{-6}	0.007	4×10^{-6}	2×10^{-9}	0.02
Train Transport from Paducah								
Energy*Solutions*	4	11,100	0.003	2×10^{-6}	0.004	3×10^{-6}	2×10^{-8}	0.002
NNSS[c]	129	55,600	0.004	3×10^{-6}	0.006	4×10^{-6}	2×10^{-8}	0.004
WCS	4	8,000	0.002	1×10^{-6}	0.004	2×10^{-6}	3×10^{-8}	0.003
Truck Transport from Portsmouth								
Energy*Solutions*	125	250,600	0.003	2×10^{-6}	0.008	5×10^{-6}	2×10^{-9}	0.01
NNSS	125	303,700	0.004	2×10^{-6}	0.009	6×10^{-6}	2×10^{-9}	0.01
WCS	125	185,700	0.002	1×10^{-6}	0.006	3×10^{-6}	2×10^{-10}	0.01
Train Transport from Portsmouth								
Energy*Solutions*	4	12,900	0.004	2×10^{-6}	0.006	3×10^{-6}	4×10^{-8}	0.004
NNSS[c]	129	58,100	0.005	3×10^{-6}	0.007	4×10^{-6}	3×10^{-8}	0.006
WCS	4	12,000	0.004	2×10^{-6}	0.006	4×10^{-6}	5×10^{-8}	0.005

Key: LCF = latent cancer fatality; NNSS = Nevada National Security Site; Nonrad = nonradiological; WCS = Waste Control Specialists.

[a] Total risks can be estimated by multiplying by the duration of the conversion period at each site (34 years for Paducah and 22 years for Portsmouth), the duration over which it is expected that the empty and heel cylinders would be shipped to the disposal facility.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because NNSS does not have a rail yard, the waste would be transported from a nearby rail yard (Barstow, California) to NNSS via truck. Annually, there would be 125 truck shipments for the Paducah or Portsmouth wastes, in addition to the 4 train shipments from Paducah or Portsmouth.

Note: To convert kilometers to miles, multiply by 0.62137.

Table 4-6 Average Annual Risks to Crew Members and the Public from Transporting Other Ancillary LLW and MLLW to a Radioactive Waste Disposal Facility

Origin	Number of Shipments	Total One-way Kilometers Traveled	Incident-Free[a]				Accident[a]	
			Crew		Population		Radiological Risk[b]	Nonrad Risk[b]
			Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]		
Truck Transport from Paducah[c]								
Energy*Solutions*	1	2,600	$3x10^{-4}$	2×10^{-7}	2×10^{-4}	1×10^{-7}	7×10^{-14}	1×10^{-4}
NNSS	1	3,200	4×10^{-4}	2×10^{-7}	3×10^{-4}	2×10^{-7}	4×10^{-14}	1×10^{-4}
WCS	1	1,700	2×10^{-4}	1×10^{-7}	1×10^{-4}	9×10^{-8}	4×10^{-14}	1×10^{-4}
Truck Transport from Portsmouth[c]								
Energy*Solutions*	1	3,100	4×10^{-4}	2×10^{-7}	3×10^{-4}	2×10^{-7}	6×10^{-14}	1×10^{-4}
NNSS	1	3,700	4×10^{-4}	3×10^{-7}	3×10^{-4}	2×10^{-7}	5×10^{-14}	2×10^{-4}
WCS	1	2,300	3×10^{-4}	2×10^{-7}	2×10^{-4}	1×10^{-7}	8×10^{-14}	2×10^{-4}

Key: LCF = latent cancer fatality; NNSS = Nevada National Security Site; Nonrad = nanradiological; WCS = Waste Control Specialists.

[a] Total risks can be estimated by multiplying by the duration of the No Action Alternative (100 years).

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because of the small amount of waste requiring shipment to the waste management facility, train transport would be inefficient and was not considered.

Note: To convert kilometers to miles, multiply by 0.62137.

Table 4-7 Annual Population Transportation Risks for Shipment of Calcium Fluoride to a Radioactive Waste Disposal Facility under the Hydrogen Fluoride Neutralization Option

Origin	Paducah		Portsmouth	
Mode of Transport	**Truck**	**Train**	**Truck**	**Train**
Energy*Solutions*				
Number of shipments	954	24	616	15
Total distance (one-way [km])	2,459,706	658,176	1,897,091	499,727
Traffic fatalities (round trip)[a]	0.13	0.01	0.09	0.02
Nevada National Security Site				
Number of shipments	954	24	616	15
Total distance (one-way [km])[b]	3,059,265	1,128,824	2,297955	828,682
Traffic fatalities (round trip)[a]	0.14	0.06	0.1	0.03
Waste Control Specialists				
Number of shipments	954	24	616	15
Total distance (one-way [km])	146,9647	478,206	1,406,773	454,136
Traffic fatalities (round trip)[a]	0.11	0.02	0.06	0.02

[a] Total risks can be estimated by multiplying by the duration of the conversion period at each site (34 years for Paducah and 22 years for Portsmouth), the duration over which it is expected that the CaF_2 would be shipped to the disposal facility.

[b] Because NNSS does not have a direct rail line connection, every train transport requires four shipments of truck transport from an intermodal facility to NNSS. The cited distances are the sum of truck and train transport distances.

Impacts from Incident-Free Transport of Radioactive Waste

The potential annual radiological impacts for transport crews and populations along the routes are shown in Tables 4-5, 4-6, and 4-7. The tables state the impacts from shipping all empty and heel cylinders, ancillary LLW and MLLW, and CaF_2 to a single disposal facility.

The annual transport of empty and heel cylinders would not result in any LCFs to crew members. The maximum calculated annual risk would be less than 5×10^{-6} LCF (refelects the sum of transports from Paducah and Portsmouth to NNSS), or 1 chance in 200,000 of a single LCF among the transportation crew.

The single annual truck shipment of ancillary LLW and MLLW from each site to any disposal facility would lead to a very low crew risk. The maximum calculated annual risk would be less than 5×10^{-7} (reflects the sum of transports from Paducah and Poprtsmouth to NNSS), or 1 chance in 2 million of a single LCF among the transportation crews. The calculated per-shipment risk to the crew is higher than for the empty and heel cylinders because the drums containing the ancillary LLW and MLLW are situated closer to the crew cabin than cylinders during truck transport.

The annual dose to the general population from transporting empty and heel cylinders would not result in an LCF. The maximum calculated annual risk would be 1×10^{-5} LCF (refelects the sum of transports from Paducah and Portsmouth to NNSS), or 1 chance in 100,000 of a single LCF in the exposed population.

The maximum calculated annual risk to the general population for transporting ancillary LLW and MLLW would be 4×10^{-7} (reflects the sum of transports from Paducah and Portsmouth to NNSS), or 1 chance in 2.5 million of a single LCF in the exposed population.

Impacts of Transportation Accidents Involving Radioactive Waste

As indicated in Tables 4-5, 4-6, and 4-7, truck transportation of empty and heel cylinders, ancillary LLW and MLLW, and CaF_2 is not expected to result in any LCFs although traffic fatalities could result from transport of CaF_2 to a disposal facility.

Vehicle Emissions

Under this alternative, ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 would be generated that would need to be shipped off site for disposal. These shipments of ancillary LLW and MLLW would be via truck due to the relatively small annual quantity of waste to be shipped. It is expected that there would be an annual average of 1 truck shipment from Paducah and 1 truck shipment from Portsmouth to transport LLW and MLLW, and 125 truck shipments for the 14,000 intact empty and heel cylinders at each site. Intact empty and heel cylinders could also be shipped via train, and it is assumed that four annual shipments would take place under the train option. Emissions were also calculated for the potential shipment of CaF_2 which would be shipped in 953 and 616 truck shipments from Paducah and Portsmouth, respectively, or via 24 or 15 annual train shipments. Although shipments may go to various facilities, in order to bound the impacts, calculations are based on the longest potential shipping distance which would be to NNSS.

Truck Option

Table 4-8 presents the estimated annual criteria pollutant emissions associated with an annual maximum total of 1,080 semi-tractor trailer truck shipments from Paducah and 742 shipments from Portsmouth to NNSS. Analysis estimated approximately 2,000 miles (3,300 kilometers) per truck shipment from Paducah to NNSS and approximately 2,400 miles (3,800 kilometers) per shipment from Portsmouth to NNSS. Emissions were derived using the emission factors for heavy-duty diesel vehicles in the EPA's MOVES2014a. MOVES is the U.S. Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator. It is used to create emission factors or emission inventories for both onroad motor vehicles and nonroad equipment (EPA 2015). Annual emissions of each criteria pollutant would be less than 28 tons (25 metric tons) for all shipments from Paducah and Portsmouth combined. These emissions would be spread across a large area, so it is not useful to compare to NEI baseline emissions for any particular AQCR. Although the EPA does separately track commercial versus other mobile sources of criteria pollutants, the national on-road emissions associated with heavy-duty diesel vehicles and heavy-duty gasoline vehicles from the 2014 NEI (EPA 2019) are provided for comparison in **Table 4-9**.

Table 4-8 Criteria Pollutant Emissions from No Action Alternative Truck Shipments

Material	**Site**	**Criteria Pollutant Emissions (tons/year)**					
		CO	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**VOC**
LLW and MLLW	Paducah	0.17	0.48	0.02	0.02	0.00	0.05
	Portsmouth	0.14	0.41	0.01	0.01	0.00	0.04
	Total emissions	*0.31*	*0.88*	*0.03*	*0.03*	*0.00*	*0.09*
Empty and heel cylinders	Paducah	0.60	1.70	0.06	0.06	0.00	0.18
	Portsmouth	0.72	2.04	0.07	0.07	0.00	0.21
	Total emissions	*1.31*	*3.74*	*0.14*	*0.13*	*0.01*	*0.39*
CaF_2	Paducah	4.54	12.96	0.47	0.43	0.03	1.35
	Portsmouth	3.52	10.05	0.37	0.34	0.02	1.05
	Total emissions	*8.07*	*23.01*	*0.84*	*0.77*	*0.05*	*2.40*
Grand Total		**9.69**	**27.64**	**1.01**	**0.93**	**0.06**	**2.88**

Key: CaF2 = calcium fluoride; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Table 4-9 National Annual On-Road Heavy-Duty Vehicle Emissions

Emissions (tons/yr)					
CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC
1,435,373	2,196,533	130,823	93,585	3,969	198,397

Key: CO = carbon monoxide; NOx = nitrogen oxides; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.
Source: EPA 2019

Because the criteria pollutant emissions from transportation of wastes to the disposal facilities are so small in comparison to U.S. heavy-duty vehicle emissions, the emissions are not likely to contribute to any significant impact on air quality.

Train/Truck Option

Emissions were calculated to provide an estimate of the annual criteria pollutant emissions associated with waste shipments via the train/truck option to NNSS (considered to be the bounding because of the greatest distance traveled). It was estimated that locomotives would travel approximately 2,000 miles (3,300 kilometers) per train shipment from Paducah to Barstow, California, and approximately 2,400 miles (3,800 kilometers) from Portsmouth to Barstow, California. Because there is no direct rail access to NNSS, shipments via train would travel to Barstow, where they would be transported approximately 200 miles (330 kilometers) from Barstow to the NNSS facility. Emissions for the train portion of the transport were calculated using emission factors for tier 2 line haul locomotives derived from the EPA's *Emission Factors for Locomotives* (EPA 2009). Emissions for the truck portion of the transport were calcualated as described in the "*Truck Option*" section above.

Table 4-10 shows the annual emissions associated with waste shipments via the train/truck option to NNSS. Emissions of all criteria pollutants would be less than 21 tons (19 metric tons) annually for all shipments from Paducah and Portsmouth combined. Emissions would be spread across a large area, so it is not useful to compare to NEI baseline emissions for any particular AQCR. However, because the emissions are so small in comparison to overall locomotive and vehicle transportation emissions, the emissions are not likely to contribute to any significant impact on air quality.

Table 4-10 Criteria Pollutant Emissions from Transportation via Train to Barstow, California, and Truck to NNSS for the No Action Alternative

Material	Mode of Transport	Site	Criteria Pollutant Emissions (tons/year)					
			CO	NO_x	PM_{10}	$PM_{2.5}$	SO_x	VOC
Ancillary LLW and MLLW	Truck	Paducah	0.02	0.05	0.00	0.00	0.00	0.00
		Portsmouth	0.01	0.03	0.00	0.00	0.00	0.00
		Total emissions	*0.03*	*0.08*	*0.00*	*0.00*	*0.00*	*0.01*
	Train	Paducah	*0.09*	*0.34*	*0.01*	*0.01*	*0.01*	*0.02*
		Portsmouth	*0.11*	*0.41*	*0.01*	*0.01*	*0.01*	*0.02*
		Total emissions	*0.19*	*0.75*	*0.03*	*0.03*	*0.01*	*0.04*
14,000 empty and heel cylinders	Truck	Paducah	0.06	0.17	0.01	0.01	0.00	0.02
		Portsmouth	0.06	0.17	0.01	0.01	0.00	0.02
		Total emissions	0.12	0.34	0.01	0.01	0.00	0.04
	Train	Paducah	0.35	1.36	0.05	0.05	0.02	0.08
		Portsmouth	0.42	1.63	0.06	0.06	0.03	0.09
		Total emissions	*0.77*	*3.00*	*0.11*	*0.11*	*0.05*	*0.17*
CaF_2	Truck	Paducah	0.45	1.30	0.05	0.04	0.00	0.14
		Portsmouth	0.29	0.84	0.03	0.03	0.00	0.09
		Total emissions	*0.75*	*2.13*	*0.08*	*0.07*	*0.00*	*0.22*
	Train	Paducah	2.11	8.17	0.30	0.29	0.15	0.45
		Portsmouth	1.58	6.13	0.22	0.22	0.11	0.34
		Total emissions	*3.70*	*14.30*	*0.52*	*0.50*	*0.26*	*0.79*
Grand Total (maximum shipments)			***5.53***	***20.52***	***0.75***	***0.72***	***0.34***	***1.26***

Key: CaF2 = calcium fluoride; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Greenhouse Gases

Table 4-11 shows the annual GHG emissions associated with waste shipments to NNSS. The total GHG emissions for the truck option would be 6,738 tons (6,113 metric tons) per year, which would be minimal in terms of the national annual GHG emissions from truck transportation, which total 467.4 million tons (424.0 million metric tons) annually (EPA 2018d). The total GHG emissions for the train/truck option would be 1,890 tons (1,715 metric tons) per year. This amount would be minimal in terms of the national annual GHG emissions from combined truck and train transportation, which total 512.7 million tons (465.1 million metric tons) annually (EPA 2018d).

Table 4-11 Annual GHG Emissions from Transport of Ancillary LLW and MLLW, Empty and Heel Cylinders, and CaF_2 to the Nevada National Security Site

Site	GHG Emissions (tons per year CO_2e)			
	Train/Truck Option			Truck Option
	Train	Truck	Total	
Paducah[a]	99	862	961	3,693
Portsmouth[a]	85	746	929	3,045
Total	**183**	**1,607**	**1,890**	**6,738**
National Train Emissions[b]	45,300,000			NA
National Truck Emissions[c]	467,400,000			467,400,000
Total National Train/Truck Emissions	512,700,000			NA

Key: GHG = greenhouse gas; NA = not applicable.

[a] Source: PPPO 2018

[b] Source: CNR 2016

[c] Source: ATA 2018

4.1.3 Impacts at the Disposal Facilities

No DU oxide would be shipped from Paducah or Portsmouth for disposal at off-site waste management facilities under the No Action alternative. As described in Section 4.1.1.8, ancillary LLW and MLLW generated from storage and maintenance of DU oxide containers, empty and heel cylinders, and CaF2, would be sent to EnergySolutions, NNSS, or WCS. All waste received at the evaluated facilities would be in compliance with waste acceptance criteria and in accordance with site licenses, permits, and other authorizations.

This section describes the impacts on the disposal capacities at Energy*Solutions*, NNSS, and WCS. This *DU Oxide SEIS* does not analyze other potential environmental impacts of disposal at these sites. As long as the waste to be disposed of is within the authorized capacity and waste acceptance criteria of the disposal facility, it is assumed that the impacts of disposal would be considered and found to be acceptable as part of the licensing and permitting process. Chapter 5, Section 5.4.1, of this *DU Oxide SEIS* briefly describes the licenses and permits held by these facilities.

Table 4-12 compares the total waste generated to the capacities of each of the evaluated disposal facilities, assuming transport of all waste to each facility. The volumes of wastes generated under the No Action Alternative would be within the capacities of the facilities, even assuming all waste from a hypothetical 100 years of storage of DU oxide at both Paducah and Portsmouth was transported to a single facility. The impacts on any one disposal facility could be mitigated by sending the waste to more than one facility.

Table 4-12 Percent of Disposal Capacities at the Evaluated Disposal Facilities under the No Action Alternative

Waste	Waste Volume (cubic yards)[a]	Percent of Disposal Capacity		
		Energy*Solutions*[b]	NNSS[c]	WCS[d]
LLW[e]	370	0.0088	0.021	0.038
MLLW[e]	2.4	0.00066	0.0016	0.00025
Empty and heel cylinders[f]	78,300	1.9	4.4	8.2
CaF_2 in bulk bags	225,000	5.4	13	24

Key: FWF = Federal Waste Facility; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NNSS = Nevada National Security Site; WCS = Waste Control Specialists.

[a] Source: PPPO 2018.

[b] The disposal capacity for LLW and MLLW is assumed to be the remaining capacity in the Class A West Embankment 4.17 million cubic yards (3.19 million cubic meters) and the Mixed Waste disposal cell 358,000 cubic yards (274,000 cubic meters), respectively, as of August 2016 (see Chapter 3, Table 3-27).

[c] The disposal capacity for LLW and MLLW at the Area 5 Radioactive Waste Management Complex is assumed to be 48 million cubic feet (1,778,000 cubic yards or 1.36 million cubic meters) and 4 million cubic feet (148,000 cubic yards or 113,000 cubic meters) (see Chapter 3, Table 3-28).

[d] It is assumed that LLW, MLLW, and DU oxide waste would be disposed of in the FWF at WCS, which has a total capacity of about 963,000 cubic yards (736,000 cubic meters), of which about 8,000 cubic yards (6,100 cubic meters) had been used as of August 2016 (see Chapter 3, Table 3-29).

[e] It is assumed for analysis that all waste from DU oxide storage and maintenance activities from Paducah and Portsmouth would be disposed of at each evaluated disposal facility. Waste volumes reflect totals from both Paducah and Portsmouth assuming on-site storage of DU oxide for 100 years.

[f] The listed volume of the empty and heel cylinders is the envelope volume of the cylinders. Waste volumes may be significantly reduced if the cylinders were volume-reduced (e.g., compacted or shredded) at the disposal facility or separate waste treatment facility.

Note: To convert cubic yards to cubic meters, multiply by 0.76456.

The total volume of intact empty and heel cylinders was determined conservatively as discussed in Section 4.1.1.8 This results in a total LLW disposal volume of about 78,300 cubic yards (59,900 cubic meters), which would represent less than 10 percent of the disposal capacity at any evaluated disposal facility. Waste volumes may be significantly reduced if the cylinders were volume-reduced (e.g., compacted or shredded) at Paducah or Portsmouth before shipping or after receipt at the disposal facility. Disposal operations would need to address the void space within the cylinders, which could include measures such as volume reduction at the disposal facility or at a separate waste treatment facility, filling the void volume within the cylinders with a material such as grout or sand, or by stabilizing the cylinders in place with grout or similar media.

The CaF_2 disposal option would only be instituted if HF could not be recycled into commerce. Although, the CaF_2 could likely be managed and disposed of as nonradioactive nonhazardous solid waste it was conservatively assumed to be low-activity LLW for this analysis. The total volume of CaF_2 in bulk bags results in a total disposal volume of about 225,000 cubic yards (172,000 cubic meters), which would represent less than 25 percent of the disposal capacity at any evaluated disposal facility. Assuming the bags were all shipped by truck from both Paducah and Portsmouth, over 250 working days per year at each site, the disposal site would receive an average of about 6 truckloads of CaF_2 per work day. Otherwise, assuming the same number of bulk bags was shipped by rail from both Paducah and Portsmouth, trains would arrive about one or two per work week.

Because MLLW contains constituents regulated under the RCRA, disposal of MLLW would be conditional at all sites on treatment to meet land disposal restrictions and other regulatory requirements. Because the Energy*Solutions* and WCS disposal sites both provide treatment capacity for many waste streams that contain RCRA-regulated constituents, DOE expects that the

MLLW generated from DU oxide storage and maintenance could be transported directly to these sites for treatment and disposal. NNSS, however, does not currently provide waste treatment capacity for RCRA-regulated constituents in waste generated outside the State of Nevada, although limited treatment capacity for out-of-State MLLW may be available in the future. Therefore, some or all of any MLLW sent to NNSS for disposal could first require transport to a separate waste management facility with the treated residuals then being transported to NNSS. It is assumed that commercial capacity is available to perform treatment for these very small quantities of MLLW.

Receipt of waste is not expected to require modifications to disposal facility operations because of the relatively small number of annual waste deliveries to any evaluated facility.

4.2 DISPOSAL OF DEPLETED URANIUM OXIDE AND OTHER WASTES AT ENERGY*SOLUTIONS*

As described in Section 2.2.2.1, under the Energy*Solutions* Disposal Alternative, DU oxide would be disposed of at Energy*Solutions* near Clive, Utah. This section presents the estimated potential environmental impacts for this alternative including: (1) impacts from storage of DU oxide at Paducah and Portsmouth until shipment to Energy*Solutions* (Section 4.2.1); (2) impacts from transportation of the DU oxide and other radioactive waste to Energy*Solutions* (Section 4.2.2); and (3) impacts on the LLW and MLLW disposal capacities at Energy*Solutions* (Section 4.2.3).

4.2.1 Impacts at Paducah and Portsmouth

DU oxide would be stored at Paducah and Portsmouth until it is shipped to the Energy*Solutions* site for disposal. As described in Chapter 2, Section 2.4.1, in order to provide a conservative estimate of impacts, storage of DU oxide containers was analyzed for 76 years (44 years of storage plus 32 years of shipping) at Paducah and 47 years (32 years of storage plus 15 years of shipping) at Portsmouth under the Action Alternatives. This is a conservative assumption that over-estimates the impacts of storage at Paducah and Portsmouth because: 1) DU oxide would be generated over the duration of the storage period by conversion from DUF_6, and 2) DOE anticipates shipping at least a portion of the DU oxide off-site for disposal soon after it is generated and not storing it for a long period of time.

Under this alternative, the impacts of management of the DU oxide at Paducah and Portsmouth would cease after the material is shipped off site for reuse or disposal.[51] This is in contrast to the No Action Alternative where storage of the DU oxide at Paducah and Portsmouth was assumed to occur for 100 years and could continue indefinitely.

4.2.1.1 Site Infrastructure

Impacts on site infrastructure could occur from new construction. The impacts of storage and maintenance of DU oxide containers, and the loading of ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 at Paducah and Portsmouth for shipment to Energy*Solutions*, would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.1). Therefore, there would be only minor impacts on site utility infrastructure. In addition, there would

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[51] Other activities could continue at Paducah and Portsmouth including DD&D of the cylinder storage yards. These activities are outside the scope of this DU Oxide SEIS.

be adequate capacity to store all the DU oxide containers and therefore, no adverse impacts on the storage infrastructure.

The type of DU oxide disposal container will affect the numbers of shipments from Paducah and Portsmouth to the disposal site. If bulk bags are used, the empty and heel cylinders will need to be managed and disposed of as LLW. **Table 4-13** presents a summary of the potential off-site shipments of waste from the Paducah and Portsmouth Sites. This table shows an annual maximum of 2,520 truck or 66 train shipments from Paducah and 2,180 truck or 47 train shipments from Portsmouth. Assuming 250 shipping days per year, this equates to approximately 10 daily truck shipments or one to two weekly train shipments from Paducah and 9 daily truck shipments or one weekly train shipment from Portsmouth. Therefore, the loading of the DU oxide containers and other wastes, and off-site shipment using either truck or train, would not require new significant construction or changes in infrastructure at Paducah and Portsmouth, and would likely result in minor impacts on the transportation infrastructure at Paducah and Portsmouth.

Table 4-13 Summary of Off-Site Shipments for the Action Alternatives

Location		Container Type and Estimated Number of Shipments[a]							
		DU Oxide in Cylinders[b]		14,000 Intact Empty and Heel Cylinders (volume-reduced)[c]		Bulk Bags with Empty Cylinders Option			
						DU Oxide in Bulk Bags[d]		69,000 Intact Empty and Heel Cylinders (volume-reduced)[e]	
		Truck	Train	Truck	Train	Truck	Train	Truck	Train
Paducah	Total	46,150	769	4,242 (848)	141 (42)	20,500	513	23,100 (4,620)	769 (231)
	Annual	1,440	24	125 (25)	4 (1)	603	15	679 (136)	23 (7)
Portsmouth	Total	22,850	381	2,759 (552)	90 (28)	9,070	227	11,400 (2,290)	381 (114)
	Annual	1.440	24	125 (25)	4 (1)	412	10	519 (104)	17 (5)

Location		Container Type and Estimated Number of Shipments[a]		Maximum Total Shipments[g]	
		CaF_2 in Bulk Bags Option[f]			
		Truck	Train	Truck	Train
Paducah	Total	32,400	811	82,800	2,230
	Annual	953	24	2,520	66
Portsmouth	Total	13,600	339	39,200	1,040
	Annual	616	15	2,180	47

[a] Annual shipments of DU oxide in cylinders were calculated based on a projected 32 years of shipments from Paducah and 15 years of shipments from Portsmouth. Estimates of annual truck and train shipments for the DU oxide in bulk bags, empty and heel cylinders, and CaF_2 in bulk bags, is based on total number of shipments divided by the number of years of conversion facility operation, in this case, 34 years for Paducah and 22 years for Portsmouth.

[b] DU oxide cylinders would be shipped 1 per truck, or 6 per gondola railcar with 10 railcars per train.

[c] The 14,000 empty and heel cylinders would be shipped intact, 2 per truck or 6 per gondola railcar with 10 railcars per train, or volume-reduced and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar with 10 railcars per train.

[d] DU oxide in bulk bags would be shipped 2 per truck or 8 per railcar with 10 railcars per train.

[e] Empty and heel cylinders remaining after DUF_6 conversion to DU oxide and transfer to bulk bags would be shipped intact 2 per truck or 6 per railcar with 10 railcars per train, or volume-reduced and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar with 10 railcars per train (DOE 2004a, 2004b).

[f] CaF_2 in bulk bags would be shipped 1 per truck or 4 per railcar with 10 railcars per train.

[g] The maximum total shipments for truck transportation include DU oxide shipment in cylinders, 14,000 intact empty and heel cylinders, and CaF_2 in bulk bags. The maximum total shipments for train transportation include DU oxide shipment in bulk bags, 14,000 intact empty and heel cylinders, 69,000 intact empty and heel cylinders, and CaF_2 in bulk bags.

Notes: Cylinder and transportation numbers are derived from PPPO (2018) or calculated based on the above table notes.

4.2.1.2 Air Quality, Climate, and Noise

Impacts on air quality, climate, and noise could occur from DU oxide container storage and maintenance activities. The impacts from storage and maintenance of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.2).

Transfer of DU oxide cylinders from storage locations to a loading area for transportation would involve the use of standard equipment at Paducah and Portsmouth including Straddle Buggies and NCH-35 cylinder handlers. Support vehicles (i.e., cars and light trucks) at each site are expected to use 2,080 gallons per year (7,870 liters per year) of gasoline. Cylinder handling using Straddle Buggies and NCH 35 cylinder handlers is expected to use 15,600 gallons per year (59,050 liters per year) of diesel fuel at both Paducah and Portsmouth. These types of equipment are currently in use as part of conversion facility operations and there would be no substantial increase in activity above current levels. Emissions from diesel fuel combustion during container movement and loading activities would therefore be minimal, and would not represent or contribute to any exceedances of SAAQS or NAAQS. Likewise, GHG emissions (measured as CO_2e) would be minimal in the context of the over 1.3 million metric tons CO2e emitted annually from fossil fuel combustion in the industrial sector and would not be expected to contribute substantially to climate change. **Table 4-14** presents the operational emissions at Paducah and compares the emissions to those for McCracken County, Kentucky. **Table 4-15** presents the operational emissions at the Portsmouth Site and compares these emissions to those for Pike County, Ohio.

Table 4-14 Operational Emissions at Paducah under the Action Alternatives

Emission Source	**Criteria Pollutant Emissions (tons per year)**						
	CO	**NO_2**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**CO_2e**
NCH-35 cylinder handler	0.93	1.95	0.080	0.080	0.0024	0.25	240
McCracken County	13,217	15,200	2,464	826	30,162	6,378	497,850
Percentage of County emissions	0.007	0.01	0.003	0.01	8×10^{-6}	4×10^{-4}	0.05

Key: CO = carbon monoxide; CO_2e = carbon dioxide equivalents; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Sources: EPA 2016c; PPPO 2018

In addition, truck and railcar loading activities would occur within the industrialized areas of Paducah and Portsmouth, and there would be little or no increase above current daily operations that would contribute to the noise environment. Off-site shipments via train could increase by 1 or 2 shipments per week per site, and truck shipments could increase by 9 or 10 per day per site (see Section 4.2.1.1). This increase is unlikely to be perceptible on public roadways and existing railways in comparison to existing traffic in the region around the sites and the millions of annual shipments already occurring on public highways (3.68 million trucks travelling 2.74 billion miles annually [ATA 2018]) and railways. Therefore, because the increase is small and would occur in areas, roads, and/or railways already used for these purposes, potential impacts on noise levels near Paducah and Portsmouth would be minor.

Table 4-15 Operational Emissions at Portsmouth under the Action Alternatives

Emission Source	Criteria Pollutant Emissions (tons per year)						
	CO	NO_2	PM_{10}	$PM_{2.5}$	SO_2	VOC	CO_2e
Straddle Buggies and NCH-35 cylinder handler	0.93	1.95	0.080	0.080	0.0024	0.25	240
Pike County	8,297	1,371	2,729	755	35	7,214	268,870
Percentage of County emissions	0.01	0.1	0.003	0.01	0.007	0.003	0.09

Key: CO = carbon monoxide; CO_2e = carbon dioxide equivalents; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Sources: EPA 2016d; PPPO 2018

4.2.1.3 Geology and Soil

Impacts on geology and soils could occur from the disturbance or use of geologic and soil materials, and from contamination by radioactive or hazardous materials via air or water borne pathways. The impacts from storage and maintenance of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.3). The impacts from loading ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 at Paducah and Portsmouth for shipment to Energy*Solutions* would be similar to those described under the No Action Alternative (Section 4.1.1.3).

Truck and railcar loading of DU oxide containers would occur within the industrialized areas of Paducah and Portsmouth, and there would be no significant construction, no use of geologic and soils materials, and no routine releases of DU or other hazardous materials. Therefore, potential impacts on geology and soils would be minor at both Paducah and Portsmouth.

4.2.1.4 Water Resources

Impacts on water resources could occur from changes in water use, surface water discharge, groundwater recharge, or impacts on surface water or groundwater quality resulting from contamination by radioactive or hazardous materials associated with long-term container storage and maintenance or potential cylinder breach. The impacts of storage and maintenance of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.4). The impacts from loading ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 at Paducah and Portsmouth for shipment to Energy*Solutions* would be similar to those described under the No Action Alternative (Section 4.1.1.4).

Truck and railcar loading of DU oxide containers would occur within the industrialized areas of Paducah and Portsmouth and use similar numbers of employees as the No Action Alternative. There would be no routine releases of DU oxide or hazardous materials. Container storage and maintenance and waste-loading activities would occur within the industrialized areas of both Paducah and Portsmouth in areas outside the 100-year floodplain. Therefore, any additional impacts on water resources over those described for the No Action Alternative would be minor.

Primary impacts to floodplains in 2004 were expected to be related to construction of the conversion facilities. The ongoing operational, storage and maintenance, and transportation-related activities are not appreciably different than in 2004, and these activities had negligible impact as shown in the 2004 EISs and Paducah Floodplain/Wetland Assessment (ANL 2004a). At that time, DOE determined that a floodplain assessment was not required for Portsmouth because the site was outside maximum historic flooding levels (see Chapter 3, Section 3.2.4 of this SEIS). Therefore, no additional floodplain assessment is necessary.

4.2.1.5 Biotic Resources

Impacts on biotic resources could occur from removal or degradation of vegetation, wildlife habitats, wetlands, or federally and state-listed species; facility construction and operations; or contamination by radioactive or hazardous materials via air or water borne pathways. The impacts of storage and maintenance of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.5). The impacts from loading ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 at Paducah and Portsmouth for shipment to Energy*Solutions* would be similar to those described under the No Action Alternative (Section 4.1.1.5).

Truck and railcar loading of DU oxide containers would occur within the industrialized areas of Paducah and Portsmouth and there would be no routine releases of DU oxide or hazardous materials. Container storage and maintenance and waste-loading activities would not disturb wetlands, sensitive habitat, or threatened, endangered, or special species. Therefore, any impacts on biotic resources would be minor at both Paducah and Portsmouth. Primary impacts to wetlands in 2004 were expected to be related to construction of the conversion facilities. The ongoing operational, storage and maintenance, and transportation-related activities are not appreciably different than in 2004, and these activities had negligible impact, as shown in the 2004 EISs and the Paducah Floodplain/Wetland Assessment (ANL 2004a) and Portsmouth Wetland Assessment (ANL 2004b). Therefore, no additional wetlands assessment is necessary.

4.2.1.6 Public and Occupational Safety and Health

Impacts on public and worker health at Paducah and Portsmouth would be similar to the impacts described in Section 4.1.1.6 for the No Action Alternative. As described in Section 4.2.1, the major difference would be that under the Energy*Solutions* Disposal Alternative, DU oxide containers would be stored for up to 76 years at Paducah and 47 years at Portsmouth rather than at least 100 years under the No Action Alternative. In addition, under the Energy*Solutions* Disposal Alternative, containers would be loaded on railcars and trucks for shipment to the Energy*Solutions* disposal facility.

Public Safety and Health Under Normal Operations

DU oxide containers emit very low levels of gamma and neutron radiation, resulting in a dose rate of about 2 millirem/hour at 30 centimeters (PPPO 2018). Public health impacts could result from the release of DU oxide due to container breaches. The uranium could be transported through the environment as an airborne release or as a groundwater or surface water release. As indicated in Chapter 2, Section 2.2.1, the numbers of DU oxide cylinder breaches were estimated based on two scenarios. The more conservative ‘uncontrolled corrosion” scenario assumes that the historical rate of breaches would continue throughout the duration of this alternative. In the second “controlled corrosion” scenario, improved storage conditions are expected to result in lowered breach rates. No new cylinder breaches have occurred at Paducah and Portsmouth since improved storage conditions have been implemented (PPPO 2018).

The 2004 EISs (DOE 2004a, 2004b) estimated the public health impacts from storage of DUF_6 at Paducah and Portsmouth. After conversion, any exposure to stored uranium would be from DU oxide. The chemical form of the released uranium does not appreciably impact the radiological characteristics of the material. Therefore, the dose estimates from the 2004 EISs for DUF_6 were used in this *DU Oxide SEIS* to estimate the effects of exposure to DU oxide.

The 2004 Paducah EIS (DOE 2004a) estimated that if all DU annually assumed to be released in cylinder breaches were released to the atmosphere, the dose to the general public would be 0.008 person-rem. When scaled for the increased number of cylinders being stored under this alternative, this results in an annual population dose of 0.01 person-rem.[52] This annual population dose rate would result in a total population dose during 76 years of DU oxide storage of 0.76 person-rem. The population dose associated with DU oxide storage would not result in any expected LCFs. At a calculated value of 4×10^{-4} LCF, there would be a very small likelihood, 1 chance in about 2,700, of an additional cancer fatality in the general population. For comparison, the average natural background radiation level in the United States is 310 millirem per year; which means that during the 76 years of DU oxide storage, the population within 50 miles of Paducah would receive a background dose of 13 million person-rem, based on a population of 534,000 (DOE 2017c**)**. The population dose associated with natural background radiation could result in an estimated 7,600 LCFs.

The 2004 Portsmouth EIS (DOE 2004b) estimated that if all DU annually assumed to be released in cylinder breaches each year were released to the atmosphere, the dose to the general public would be 0.002 person-rem. This annual population dose rate would result in a total population dose during 47 years of DU oxide storage of 0.094 person-rem. The population dose associated with DU oxide storage would not be expected to result in any LCFs. At a calculated value of 6×10^{-5} LCF, there would be a very small likelihood, 1 chance in about 18,000, of an additional cancer fatality in the general population. For comparison, over the same period, the 677,000 people (DOE 2017c**)** living within 50 miles of Portsmouth would receive a background dose of 9.9 million person-rem. The population dose associated with natural background radiation could result in an estimated 5,900 LCFs.

The Paducah Annual Site Environmental Report for 2016 mentions that the effective dose potentially received by a member of the public passing through accessible portions of the Paducah Site would likely receive 4.24 millirem per year received by a member of the public passing through accessible portions of the DOE Reservation would receive 4.24 millirem/year in a scenario where areas of highest exposure are visited 80 hours per year (DOE 2017c). Measurements at one of the locations used in developing this estimate of a direct radiation dose are from monitors

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[52] As with the No Action Alternative, estimates for population doses from the 2004 Paducah EIS (DOE 2004a) are scaled up by 25 percent, to a value of 0.01 person-rem per year, to account for the greater number of cylinders being stored and therefore the greater number of breaches and corresponding increases in the quantities of uranium released per year assumed in this DU Oxide SEIS compared to the 2004 Paducah EIS.

located just outside the controlled (security fenced) area near the cylinder yards. The MEI doses identified in the 2004 Paducah EIS (DOE 2004a) were approximately 0.1 millirem per year from airborne releases of uranium and less than 0.5 millirem per year from ingestion of contaminated water. Scaling for the increase in the annual cylinder breach rate (see footnote 49), combined doses would correspond to an MEI dose of approximately 0.75 millirem per year from potential cylinder breaches. Assuming that the same individual receives all of the MEI doses, combining the direct radiation dose from the Annual Site Environmental Report and the 2004 Paducah EIS results in an MEI dose of less than 5.0 millirem per year. These doses are well below regulatory limits established by EPA and DOE for radiation exposure to a member of the public. EPA has set radiation dose limit to a member of the general public of 10 millirem per year from airborne sources (40 CFR Part 61). DOE has established a limit on the dose to a member of the public of 100 millirem per year from all sources combined (DOE Order 458.1). This less than 5.0 millirem per year dose to the MEI would result in an incremental increase in the risk of an LCF of 3×10^{-6} per year, or 1 chance in about 330,000 of an LCF. Assuming the same individual is the MEI for each year of DU oxide storage under this alternative, the MEI would receive a total dose of less than 380 millirem[53] over 76 years. The likelihood of this individual receiving the MEI dose during that period and contracting an LCF is less than 1 chance in about 4,400.

The Portsmouth Annual Site Environmental Report for 2015 states that a member of the public that drives on Perimeter Road past the cylinder storage yards could receive a direct dose from storage of DU in the cylinder yards (DOE 2017c). In 2015, this hypothetical individual would have received a dose of 0.77 millirem from direct radiation. The MEI doses identified in the 2004 Portsmouth EIS (DOE 2004b) resulted from cylinder breaches and were less than 0.1 millirem per year from airborne releases of uranium and less than 0.4 millirem per year from ingestion of contaminated water. Assuming the same individual receives all of the MEI doses, combining the direct radiation dose from the Annual Site Environmental Report and the 2004 Portsmouth EIS results in an MEI dose of less than 1.3 millirem per year. These doses are well below regulatory limits established by EPA and DOE for radiation exposure to a member of the public. This dose to the MEI results in an incremental increase in the risk of an LCF for the MEI of 8×10^{-7}, or 1 chance in about 1.3 million for an LCF. Assuming the same individual is the MEI for each year of DU oxide storage, the MEI would receive a total dose of 61 millirem over 47 years, corresponding to a risk of 4×10^{-5} LCF. The likelihood of the individual receiving this MEI dose during that period and contracting an LCF is less than 1 chance in about 27,000.

The 2004 EISs (DOE 2004a, 2004b) also provide estimates of the nonradiological impacts of uranium releases on the public. Both of the 2004 EISs estimated that the HI associated with airborne releases of uranium would be less than 0.1 and that for releases into the waters around Paducah and Portsmouth the HI would be less than 0.05. Both HIs are less than 1, therefore, no adverse impacts are expected from chemical exposure.

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[53] In evaluating the total impacts for the duration of this alternative, no credit is taken for the reduction in DU oxide stored at Paducah or Portsmouth resulting from shipment of material to an off-site disposal facility. The timeframe considered includes the full storage period plus the shipment period, which is assumed to begin at the end of the maximum storage period.

Occupational Safety and Health Under Normal Operations

Workers would be exposed to low levels of gamma and neutron radiation while working in the cylinder storage yards and performing activities that include routine inspections, radiological monitoring and maintenance, and cylinder repair and relocations. At Paducah, 16 workers would be required for these activities. At Portsmouth, 12 workers would be required (PPPO 2018).

The average annual doses to Paducah and Portsmouth cylinder yard workers are provided in DOE's 2014 and 2016 Occupational Radiation Exposure Reports (DOE 2015h, 2017b). In 2014, the average dose (considering only those workers that received a measurable dose) was 74 millirem at Paducah, and in 2016 the average dose was 63 millirem at Portsmouth. These reported doses are well below the worker exposure limit of 5,000 millirem per year as required by 10 CFR 835, "*Occupational Radiation Protection*," and correspond to an annual risk of about 4×10^{-5} LCF. These workers performed duties similar to those expected of the cylinder yard workers during the implementation of this alternative. Therefore, it is estimated that at Paducah the collective worker dose for the 16 cylinder yard workers would be about 1.2 person-rem per year with a total dose of 90 person-rem for 76 years of DU oxide storage. No LCFs (calculated value of 0.05) would be expected from this exposure. Similarly, the collective worker dose for the 12 Portsmouth cylinder yard workers would be about 0.76 person-rem per year with a total dose of 36 person-rem for 47 years of DU oxide storage. No LCFs (calculated value of 0.02) would be expected from this exposure.

Worker exposure would also result from the handling of the DU oxide cylinders and empty and heel cylinders during loading operations at the site in preparation for shipment to the waste disposal site. For the DU oxide cylinders, it is assumed that the cylinders could be shipped either by train (six cylinders per railcar) or by truck (one cylinder per truck). It would take four workers and a supervisor about four hours to load six cylinders onto a railcar (PPPO 2018). The same crew would take about a half-hour to load a single cylinder onto a truck. As noted in the transportation analysis the dose at 30 cm from the cylinder surface is about 2 millirem/hour which equates to less than 1 millirem/hour at 1 meter from the cylinder surface. Although it takes four hours to load six cylinders onto a railcar, the time spent in close proximity to the cylinder is limited. It is estimated that the worker dose associated with loading these six cylinders would be 2 millirem per person for a total of 0.01 person/rem for the 5 workers. Given the shorter time to load a single cylinder onto a truck, compared to a single cylinder onto a railcar, this dose should be bounding for this operation.

At Paducah, 46,150 DU oxide cylinders are to be shipped to a waste disposal facility. Given the dose rate per railcar provided above this results in a total worker dose of 77 person-rem. No LCFs (calculated value of 0.05) would be expected from this exposure. Over the 32 years of shipment operations, the average individual worker dose would be 480 millirem/yr which corresponds to an annual risk of about 3×10^{-4} LCF. At Portsmouth, 22,850 DU oxide cylinders are to be shipped to a waste disposal facility. Given the dose rate per railcar provided above this results in a total worker dose of 38 person-rem. No LCFs (calculated value of 0.02) would be expected from this exposure. Over the 15 years of shipment operations, the average individual worker dose would be 510 millirem/yr which corresponds to an annual risk of about 3×10^{-4} LCF.

There are also a number of empty and heel cylinders at both sites, 8,483 at Paducah and 5,517 at Portsmouth, that would need to be disposed. However, the surface dose for these cylinders is 0.01 millirem at 1 meter (see Appendix B of this *DU Oxide SEIS*), two orders of magnitude less than that for a loaded DU oxide cylinder. Assuming an equivalent reduction in the dose (0.1 millirem to a crew loading 6 bulk bags) loading these cylinders onto either railcars or trucks results in a total dose of less than 1 person-rem. Therefore, the total worker dose for loading operations would be dominated by the dose for loading DU oxide cylinders. **Table 4-16** provides a summary of the worker doses from the storage and loading operations.

Table 4-16 Disposal of Depleted Uranium Oxide Alternative - Worker Health Radiological Impacts

	Involved Worker					
	Average Worker			**Worker Population**		
	Annual	**Duration of Activity**		**Annual**	**Duration of Activity**	
Site	**Dose (mrem/yr)**	**Dose (rem)**	**Health Risk (LCF)**	**Dose (person-rem/yr)**	**Dose (person-rem)**	**Health Risk (LCF)**
Paducah						
Cylinder storage	74	3.7[a]	2×10^{-3}	1.2	90	0.05
Cylinder loading[b]	480	15	9×10^{-3}	2.4	77	0.05
Total[c]	**550**	**19**	**1×10^{-2}**	**3.6**	**170**	**0.10**
Portsmouth						
Cylinder storage	63	3.2[a]	2×10^{-3}	0.76	36	0.02
Cylinder loading[b]	510	7.6	5×10^{-3}	2.5	38	0.02
Total[c]	**570**	**11**	**7×10^{-3}**	**3.3**	**74**	**0.04**

Key: LCF = latent cancer fatality; mrem = millirem; yr = year.

[a] Due to the length of cylinder storage, individual worker exposure was limited to a 50 year exposure time.

[b] Average worker dose is based on the assumption that the same team performs all loading operations.

[c] Only for the years during shipping and assuming no reduction in storage impacts due to reduced quantities in storage from shipping.

The 2004 EISs (DOE 2004a, 2004b) calculated a maximum noninvolved worker dose of 0.15 millirem per year from storage of DUF_6. The dose, primarily from direct radiation, was estimated based on the uranium in the cylinders in the conversion facility and cylinder storage yards and the cylinders being moved to and from the conversion facility. Because the amount of uranium that will be stored as an oxide would be similar to that previously being stored as DUF_6, the dose to the noninvolved worker would be similar for the storage and handling of DU oxide.

The 2004 EISs (DOE 2004a, 2004b) also calculated a total worker dose for noninvolved workers. The collective noninvolved worker dose at the two Sites was estimated to be 0.003 person-rem per year at Paducah and 0.001 person-rem per year at Portsmouth for workforces that vary from those predicted in this *DU Oxide SEIS* during storage of DU oxide.[54] During the years of DU oxide storage, the total noninvolved worker dose would be 0.22 person-rem at Paducah and 0.047 person-rem at Portsmouth. No LCFs (calculated values are less than 1×10^{-4} LCF at Paducah and 3×10^{-5}

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[54] The size of the workforces used in the 2004 EISs were 1,799 at Paducah and 1,727 at Portsmouth. In 2016 the size of the workforce at each site was approximately 1,200 at Paducah and 2,527 at Portsmouth (DOE 2017b). Noninvolved worker doses were not scaled due to these differences.

LCF at Portsmouth) would be expected at either site for DU oxide storage and handling before shipment to Energy*Solutions*.

For worker protection from the toxic effects of uranium, DOE uses the OSHA permissible exposure levels for workplace exposure to uranium of 0.25 milligram per cubic meter for insoluble and 0.05 milligram per cubic meter for soluble uranium (29 CFR 1910.1000 Table Z-1). Under the requirements of DOE's worker protection program, site worker exposures to airborne uranium are maintained below these levels. Adherence to these limits would result in no adverse health effects to workers at either site from the toxic effects of uranium exposure.

Nonradiological accidents could also pose risks to site workers. All on-site work would be performed in accordance with best management practices, and in accordance with applicable OSHA requirements and DOE Orders and regulations. In particular, worker safety practices would be governed by worker safety requirements in 10 CFR 851, "*Worker Safety and Health Program*." DOE Order 450.2, "*Integrated Safety Management*," integrates safety into management and work practices at all levels ensuring protection of workers, the public, and the environment.

The estimated number of accidental worker injuries and fatalities were determined on the basis of the number of workers in the cylinder yard (16 at Paducah and 12 at Portsmouth) and national worker injury and fatality rates. There would be no expected fatalities at either site based on an average worker fatality rate of 3.4 fatalities per 100,000 worker years (BLS 2014). In 2016, the national average across all industries for accidents resulting in lost worker days was 3.0 accidents per 100 worker-years (BLS 2016b). This accident rate results in an annual estimated 0.48 cylinder yard worker injury at Paducah and 0.36 cylinder yard worker injury at Portsmouth. During the evaluated 76 years of DU oxide storage at Paducah and 47 years of DU oxide storage at Portsmouth, this accident rate could result in 36 and 17 worker injuries, respectively.

Public and Occupational Safety and Health Under the Bulk Bags Option

An option is being considered for the Action Alternative under which the DU oxide would be placed in bulk bags directly from the conversion process. These bulk bags would then be loaded onto trucks or railcars and shipped to a waste disposal facility and would not be placed in the cylinder yards for storage. Based on the amount of DU oxide that would be produced and the assumed capacity of the bulk bags; 41,016 bulk bags would be filled and shipped to the disposal facility from Paducah and 18,142 bulk bags would be filled and shipped from Portsmouth. In this option, the empty and heel cylinders (46,150 at Paducah and 22,850 at Portsmouth) would be volume-reduced and shipped off site as waste.

Public Health and Safety for the Bulk Bag Option

Under this option there would be little or no individual or population dose from the temporary storage and loading for shipment of DU oxide in bulk bags. Comparatively, there would be less DU oxide on site at any one time since the bags are filled, loaded, and shipped as the DU oxide is generated. This means there would be less material available as a source of direct radiation for any member of the public near the site boundary. The dose at 1 meter from the surface of the bulk bag is expected to be similar to that for a cylinder, less than 1 millirem/hour (PPPO 2018).

The primary source of the normal operations population dose from cylinder storage is the release of material during cylinder breaches. Because the bulk bags are on-site for a short period there would little to no likelihood of a breach of a bulk bag that would be considered a normal operational event. Any rupture of the bulk bags would be the result of an accident and not from normal wear during storage.

Occupational Safety and Health for the Bulk Bag Option

As with the public health and safety, there would be no worker exposure due to the temporary storage of bulk bags. Worker exposure would result from the handling of the DU oxide in bulk bags and empty and heel cylinders during loading operations at the site in preparation for shipment to the waste disposal site.

For the DU oxide bulk bags, it is assumed that the bulk bags could be shipped either by train (eight bulk bags per railcar) or by truck (two bulk bags per truck). It is assumed that the information on the loading of cylinders is a reasonable approximation for the loading of bulk bags. It would take four workers and a supervisor about four hours to load six bulk bags onto a railcar (PPPO 2018). The same crew would take about a half-hour to load a single bulk bag onto a truck. The dose at 1 meter from the bulk bag is less than 1 millirem/hour (PPPO 2018), similar to the dose associated with a full cylinder. Although it takes four hours to load six bulk bags onto a railcar, the time spent in close proximity to the bulk bag is limited. It is estimated that the worker dose associated with loading these six bulk bags would be 2 millirem per person, for a total of 0.01 person/rem for the 5 workers. Given the shorter time to load a single bulk bag onto a truck, compared to a single bulk bag onto a railcar, this dose should be bounding for this operation.

At Paducah, 41,016 DU oxide bulk bags would be shipped to a waste disposal facility. Given the dose rate per railcar provided above this results in a total worker dose of 68 person-rem. No LCFs (calculated value of 0.04) would be expected from this exposure. Over the assumed 34 years of shipment operations, the average annual worker dose would be 2.1 person-rem per year which corresponds to an annual risk of about 1.2×10^{-3} LCF. At Portsmouth, 18,142 DU oxide bulk bags are to be shipped to a waste disposal facility. Given the dose rate per railcar provided above this results in a total worker dose of 30 person-rem. No LCFs (calculated value of 0.02) would be expected from this exposure. Over the assumed 22 years of shipment operations, the average individual worker dose would be 1.4 person-rem per year which corresponds to an annual risk of about 8.2×10^{-4} LCF.

The use of bulk bags results in the generation of a large number of empty and heel cylinders at both sites (46,150 at Paducah and 22,850 at Portsmouth) that would need to be disposed. These cylinders would be compacted and cut in half to reduce their length at the on-site volume-reduction reduction facility. The reduced size cylinder would then be loaded by overhead crane into a shipping container. Secondary containment would be provided for the intermodal container loadout. Operation of the volume-reduction facility was analyzed in the 2004 EISs and is not within the scope of this *DU Oxide SEIS*. None of these activities requires a worker to be in close proximity to the cylinders. In assessing the worker doses associated with this activity, the 2004 EISs, while identifying this activity as part of the conversion operations with the use of bulk bags, did not modify the worker doses associated with conversion operations. Based on that treatment of this activity and the fact that no worker needs to be in close proximity to the empty and heel cylinders during the activity, these worker impacts are assumed not to significantly contribute to worker dose.

Public and Occupational Safety and Health Related to Accident Scenarios

The impacts of accidents, should they occur, during storage and maintenance of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.3). However, because the storage time is shorter, the probability of an accident is lower.

Truck and railcar loading activities could result in an increased likelihood of container handling accidents as compared to the No Action Alternative. Although greater than the No Action Alternative, the accident likelihood would be similar to existing activities where DUF_6 containers are regularly moved into and DU oxide containers moved out of the conversion facility. See Section 4.1.1.6 of this *DU Oxide SEIS* for a discussion of accidents under existing conditions.

Public and Occupational Safety and Health—Intentional Destructive Acts

Because of the low hazard posed by DU oxide, the material would not be an attractive target for a terrorist attack or other intentional destructive acts. The potential impacts of intentional destructive acts during storage of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.6).

The impacts caused by potential intentional destructive acts during loading of DU oxide containers for transportation to Energy*Solutions* were not specifically calculated in the 2004 EISs (DOE 2004a, 2004b). However, because of the relatively low hazard posed by DU oxide, should an intentional destructive act occur, the consequences of the act are expected to be comparable to the consequences of the accidents described in the 2004 EISs and summarized in this *DU Oxide SEIS*.

4.2.1.7 Socioeconomics

The socioeconomic analysis covers the effects on population, employment, income, regional growth, housing and community resources in the ROI of Paducah and Portsmouth. The impacts of storage and maintenance of DU oxide containers, and the loading of waste for off-site disposal, at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.7).

DU oxide storage containers would be moved and loaded onto trucks or railcars for shipment to the disposal site. As shown in **Table 4-17**, employment for DU oxide container monitoring and maintenance is estimated at 16 full-time employees for Paducah and 12 full-time employees for Portsmouth. These employees would also perform the truck- and rail-loading duties. Disposal of DU oxide in bulk bags would likely be similar to disposal of DU oxide in cylinders since bulk bags would require fewer bags than DU oxide in cylinders (less labor) but would generate a greater number of empty and heel cylinders (more labor). In addition, management of large quantities of CaF_2 would only be required if the DOE was unable to sell HF; in which case, staff assigned to manage HF could manage CaF_2. Therefore, because of the small numbers of employees involved, no appreciable in-migration or out-migration is expected, and there would be no impacts on population and regional growth, housing, or community services in the Paducah and Portsmouth ROIs.

Table 4-17 Comparison of Site Employment to Employment for DU Oxide Container Management under the Action Alternatives

Site	Employment for DU Oxide Container Monitoring, Maintenance, and Shipping	Site Employment (Percent of Employment)	
		Estimated for Conversion Facility	Current Total Site
Paducah	16	250 (6)	1,200 (1)
Portsmouth	12	210 (6)	2,612 (0.5)

Key: DU = depleted uranium.
Source: PPPO 2018

4.2.1.8 Waste Management

The impacts from storage and maintenance of DU oxide cylinders at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.8). No impacts on waste management capabilities at Paducah or Portsmouth would be expected from generation of ancillary LLW and MLLW from storage and maintenance of DU oxide containers, or from generation of empty and heel cylinders or CaF_2.

Activities at Paducah and Portsmouth to load DU oxide cylinders onto trucks or railcars for transport to Energy*Solutions* would generate negligible quantities, if any, of LLW or MLLW. DOE expects the cylinders to be free from surface contamination. As part of the oxide conversion process, any contamination that may be present on the surfaces of the cylinders after loading with DU oxide would be removed before transfer of the cylinders to the storage yards. The small quantities of nonhazardous waste and sanitary wastewater would be similar to the quantities currently generated from cylinder surveillance and maintenance activities and would be managed as described in Section 4.1.1.8, with no additional impacts on waste management capabilities at Paducah or Portsmouth.

4.2.1.9 Land Use and Aesthetics

Adverse impacts on land use and aesthetics could occur from new construction or changes in land use. The impacts from storage and maintenance of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.9). There would be no new significant construction and no changes in land use at Paducah and Portsmouth. The impacts from loading ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 at Paducah and Portsmouth for shipment to Energy*Solutions* would be similar to those described under the No Action Alternative (Section 4.1.1.9).

As the DU oxide containers are shipped off site, the numbers of containers stored at Paducah and Portsmouth would be reduced. Over time, the storage yards would be emptied and the visual impact of the large numbers of storage containers would be reduced and finally eliminated.

Because the storage pads would remain until a final disposition decision is made, the industrial character of the Sites would not change appreciably. Therefore, minimal impacts are expected on land use and aesthetics at Paducah or Portsmouth.

4.2.1.10 Cultural Resources

The impacts of storage and maintenance of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.10). The impacts from loading ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 at Paducah and Portsmouth for shipment to Energy*Solutions* would be similar to those described under the No Action Alternative (Section 4.1.1.10).

Impacts on cultural resources could occur if ground disturbance resulted in the discovery of previously unrecorded cultural resources that, once evaluated, were determined to be eligible for listing on the NRHP. This alternative does not include any ground disturbance at Paducah and Portsmouth. Therefore, handling wastes, including DU oxide containers, and shipping them off-site from Paducah and Portsmouth would be expected to have no effect on cultural resources at either site (DOE 2004a, 2004b).

4.2.1.11 Environmental Justice

A determination of impacts that could disproportionately affect minority and low-income populations is based upon the identification of high and adverse impacts on the resource areas considered in this *DU Oxide SEIS*. The impacts of storage and maintenance of DU oxide containers at Paducah and Portsmouth until shipment to Energy*Solutions* would be similar to those described for long-term storage under the No Action Alternative (Section 4.1.1.11). The impacts from loading ancillary LLW and MLLW, empty and heel cylinders, and CaF_2 at Paducah and Portsmouth for shipment to Energy*Solutions* would be similar to those described under the No Action Alternative (Section 4.1.1.11).

In addition, DU oxide containers would be loaded onto trucks or railcars for shipment to the disposal site. As described in Section 4.2.1.6, there would be minimal impacts on the general public from normal operations. Therefore, there would be no disproportionate high and adverse impacts on minority and low-income populations from normal operations.

Potential adverse human health impacts associated with a truck or railcar loading accident could impact the health and safety of the general population surrounding the site. The results of the accident analysis (Section 4.2.1.6) identified that, although there would be an increased likelihood of container handling accidents, consequences would be expected to be minor and similar to those from current container handling operations. Therefore, disproportionate high and adverse impacts on minority or low-income populations near the Paducah and Portsmouth Sites are not expected.

Minimal impacts on the general public related to air quality, climate, noise, and water resources have been identified, including at the population and individual level. In addition, accidents were found to have negligible radiological and chemical consequences to the public. There would be no disproportionately high and adverse impacts on minority or low-income populations.

4.2.2 Transport of Depleted Uranium Oxide and Other Wastes to Energy*Solutions*

This section summarizes the potential impacts associated with the shipment of DU oxide and other wastes from Paducah in Kentucky and Portsmouth in Ohio, to Energy*Solutions* in Utah under incident-free and accident conditions. Details of the analysis methodology and analytical results are presented in Appendix B. Two options are considered: train and truck. Under the truck option, one DU oxide cylinder would be transported per truck. Under the train option, each train would consist of 10 railcars, each gondola railcar containing six DU oxide cylinders.[55] It is expected that Paducah and Portsmouth would each annually make 24 train shipments or 1,440 truck shipments to Energy*Solutions*.

As discussed in Chapter 2, Section 2.2.2, as another shipping option, DOE could ship 12 DU oxide cylinders per railcar using 10 ABC railcars (120 DU oxide cylinders in total). This would result in half the number of annual train shipments (12 shipments) compared to shipment via gondola railcar (24 shipments).

Empty and heel cylinders, ancillary LLW and MLLW, and CaF_2, would also be shipped to Energy*Solutions*. Under the train option, intact empty or heel cylinders would be shipped 6 per railcar with 10 railcars per train, while under the truck option, 2 intact empty or heel cylinders would be shipped per truck. There would be a total of 141 train shipments of intact empty and heel cylinders from Paducah and 90 train shipments from Portsmouth, or 4,242 truck transports from Paducah and 2,759 truck shipments from Portsmouth. Each heel cylinder is assumed to contain between 10 to 23 kilograms (22 to 50 pounds) of residual DU. The ancillary LLW and MLLW is estimated to annually require one truck shipment each from Paducah and Portsmouth; although because of logistics and regulations on the length of time waste can be stored, this waste might be shipped in two to three smaller shipments. Furthermore, it is assumed that for CaF_2, four bulk bags would be shipped per railcar with 10 railcars per train, and one bulk bag would be shipped per truck. It is estimated that there would be 32,400 CaF_2 truck shipments or 811 train shipments from Paducah and 13,600 truck shipments or 339 train shipments from Portsmouth to Energy*Solutions*.

For incident-free transportation, the potential human health impacts from the radiation field surrounding the packages were estimated for transportation workers and populations along the route (off-traffic, or off-link[56]), people sharing the route (in-traffic or on-link[57]), and people at rest areas and stops along the route. The System for Analyzing the Radiological Impact of the Transportation of Radioactive Materials (RADTRAN) 6 computer program (SNL 2013) was used to estimate impacts on transportation workers and populations, as well as the impact to an MEI,

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[55] As described in Chapter 2, Section 2.1.2, small quantities of DU oxide may also be stored in 55-gallon drums. The DU oxide stored in these drums would result in fewer DU oxide cylinders or bulk bags being generated. Therefore, transportion of the drums is not specifically analyzed, but the impacts of transporting these drums would be encompassed by the transportion of DU oxide in cylinders or bulk bags.

[56] All persons residing or working alongside of a transportation route (DOE 2002b; see Appendix B).

[57] Persons in all vehicles sharing the transportation route. This group includes persons traveling in the same or the opposite direction as the shipment, as well as persons in vehicles passing the shipment (DOE 2002b; see Appendix B).

who may be a worker or a member of the public (for example, a resident along the route, a person struck in traffic, a gasoline station attendee, or an inspector).

Potential human health impacts from transportation accidents were evaluated. The impact of a specific radiological accident is expressed in terms of probabilistic risk, which is defined as the accident probability (accident frequency) multiplied by the accident consequences. The overall risk was obtained by summing individual risks from all accidents evaluated in this *DU Oxide SEIS*. The analysis of accident risks accounts for a spectrum of accidents ranging from high-probability accidents of low severity (a fender-bender) to hypothetical high-severity accidents that have a corresponding low probability of occurrence.

In addition to calculating the radiological risks that would result from all evaluated accidents that could occur during transportation of radioactive waste, DOE evaluated the radiological consequences of maximum reasonably foreseeable accidents with probabilities greater than 1×10^{-7} (1 chance in 10 million) per year. These latter consequences were determined for the atmospheric conditions that would likely prevail during accidents. This analysis used the Risks and Consequences of Radioactive Material Transport (RISKIND) computer program to estimate doses to individuals and populations (Yuan et al. 1995).

Incident-free radiological health impacts are expressed as additional LCFs. Radiological accident health impacts are also expressed as additional LCFs, and nonradiological accident risks are expressed in terms of additional immediate traffic fatalities. LCFs associated with radiological exposure are estimated by multiplying the occupational (worker) and public dose by a risk factor of 0.0006 (6×10^{-4}) LCF per rem or person-rem of exposure (DOE 2003). Impacts from transporting wastes were calculated assuming that the wastes are shipped by truck or by train. All shipments would meet applicable DOT and NRC packaging and other transportation regulations (see Appendix B, Sections B.3.1 and B.3.2, of this *DU Oxide SEIS*).

In determining transportation risks, per-shipment risk factors were calculated for incident-free and accident conditions using the RADTRAN 6 computer program (SNL 2013) in conjunction with the Transportation Routing Analysis Geographic Information System (TRAGIS) computer program (Johnson and Michelhaugh 2003) to choose transportation routes in accordance with DOT regulations. The TRAGIS program provides population density estimates for rural, suburban, and urban areas along the routes based on the 2010 U.S. Census. The population density estimates were escalated to 2020 population density estimates using state-level 2000 and 2010 Census data and assuming population growth between 2000 and 2010 would continue through 2020. The ROI of this analysis is the affected population, including individuals living within 0.5 miles (0.8 kilometers) of each side of the road or rail line for incident-free operations and, for accident conditions, individuals living within 50 miles (80 kilometers) of the accident. The MEI is assumed to be a receptor located 100 meters (330 feet) directly downwind from the accident. Details of the analytical approach and the modeling parameter selections are provided in Appendix B.

Route-specific accident and fatality rates for commercial truck transports and train shipments were used to determine the risk of traffic accident fatalities (Saricks and Tompkins 1999) after being adjusted for possible under-reporting (UMTRI 2003). The methodology for obtaining and using accident and fatality rates is provided in Appendix B, Section B.6.2.

It is estimated that transportation of DU oxide from Paducah via truck or train would require about 32 years, based on transport of up to 1,440 cylinders per year. About 46,150 cylinders would be transported from Paducah containing 446,520 metric tons of DU oxide (PPPO 2018). The transportation of DU oxide from Portsmouth via truck or train requires about 15 years, also based on transport of up to 1,440 cylinders per year. About 22,850 cylinders would be transported from Portsmouth containing 199,340 metric tons of DU oxide (PPPO 2018).

Table 4-18 summarizes the potential transportation impacts for disposal of DU oxide in cylinders at Energy*Solutions*. As indicated, all risk values are less than one, except for the nonradiological accident risk associated with truck or train shipments. This means that no LCFs are expected during transport by truck or train, but a small number of traffic fatalities could result from nonradiological accidents. This is the result of the large number of transports over 32 years.

As discussed in Chapter 2, Section 2.2.2, as another shipping option, DOE could ship 12 DU oxide cylinders per railcar using an ABC railcar. This would result in half the number of annual train shipments while transporting the same number of cylinders. The same number of cylinders would be handled each year and in total. Therefore, for impacts related to the annual or total number of shipments and impacts related to the number of cylinders handled, shipping in gondola railcars would be similar to or bound the impacts of shipping in ABC railcars, and this topic is not discussed further. This topic is only discussed in more detail in relation to transportation impacts. For nonradiological transportation impacts (e.g., air emissions from the train engine, traffic fatalities) transporting DU oxide cylinders in ABC railcars would have approximately half the impacts of shipping in gondola railcars. For radiological transportation impacts, annual and total impacts would remain similar, but per shipment impacts could increase due to the higher quantity of DU oxide per shipment.

Table 4-18 Total Risks to Crew Members and the Public from Transporting Depleted Uranium Oxide in Cylinders to Energy*Solutions*

			Incident-Free				Accident	
			Crew		Population			
Origin	Number of Shipments[a]	One-way Kilometers Traveled	Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck								
Paducah	46,200	119,200,000	141	0.08	375	0.2	3×10^{-4}	6
Portsmouth	21,900	70,500,000	84	0.05	216	0.1	1×10^{-4}	3
Train								
Paducah	770	2,100,000	61	0.04	82	0.05	2×10^{-3}	0.7
Portsmouth	380	1,200,000	38	0.02	52	0.03	1×10^{-3}	0.3

Key: LCF = latent cancer fatality; Nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

Note: To convert kilometers to miles multiply by 0.62137.

Tables 4-19 and 4-20 summarize the potential transportation impacts for shipment of empty and heel cylinders and other LLW and MLLW to Energy*Solutions*. Table 4-19 shows the transportation impacts assuming the empty and heel cylinders are transported intact. As indicated in Tables 4-19, and 4-20, all risk values are less than one. This means that no LCFs are expected to occur during transport by truck or train.

Table 4-19 Total Risks to Crew Members and the Public from Transporting Empty and Heel Cylinders to Energy*Solutions*

			Incident-Free				Accident	
			Crew		Population			
Origin	Number of Shipments[a]	One-way Kilometers Traveled	Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk [b]
Truck								
Paducah	4,242	10,900,000	0.1	8×10^{-5}	0.3	2×10^{-4}	1×10^{-7}	0.6
Portsmouth	2,759	8,500,000	0.1	6×10^{-5}	0.3	2×10^{-4}	6×10^{-8}	0.4
Train								
Paducah	140	390,000	0.1	7×10^{-5}	0.1	9×10^{-5}	8×10^{-7}	0.1
Portsmouth	90	290,000	0.09	5×10^{-5}	0.1	7×10^{-5}	7×10^{-7}	0.07

Key: LCF = latent cancer fatality; Nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero dio

Table 4-20 Annual Risks to Crew Members and the Public from Transporting Other Low-Level Radioactive Waste and Mixed Level Radioactive Waste to Energy*Solutions*

			Incident-Free[a]				Accident[a]	
			Crew		Population			
Origin	Number of Shipments	One-way Kilometers Traveled	Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck[c]								
Paducah	1	2,600	3×10^{-4}	2×10^{-7}	2×10^{-4}	1×10^{-7}	7×10^{-14}	1×10^{-4}
Portsmouth	1	3,100	4×10^{-4}	2×10^{-7}	3×10^{-4}	2×10^{-7}	6×10^{-14}	1×10^{-4}

Key: LCF = latent cancer fatality; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; Nonrad = nonradiological.

[a] Total risks can be estimated by multiplying by the maximum duration of the storage period for this alternative (76 years [44 + 32) for Paducah and 47 years (32 +15) for Portsmouth)

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because of the small amount of waste requiring shipment to the waste management facility, train transport would be inefficient and was not considered.

DOE is also considering the option of transporting DU oxide using bulk bags. As described in Appendix B, Section B.8, the impacts of transport of DU oxide in bulk bags were estimated using the analyses presented in the 2004 EISs (DOE 2004a, 2004b). In addition, it is estimated that there would be 20,500 and 9,070 truck shipments and 513 and 227 train shipments from Paducah and

Portsmouth, respectively, using consistent assumptions as those used in the 2004 EISs. Therefore, because the amount of DU oxide evaluated in this *DU Oxide SEIS* is larger than that evaluated in the 2004 EISs, the bulk bag shipment numbers presented in this SEIS are proportionally larger than those cited in the 2004 EISs. If the bulk bags are used, the empty and heel cylinders also need to be transported to the disposal sites. It is assumed that the cylinders would be volume-reduced and packaged 10 to a 20-foot (6-meter) intermodal container and transported one container per truck and two containers per railcar with 10 railcars per train. The 2004 EISs also considered that about 10 percent of the cylinders could not be accepted at the Energy*Solutions*; therefore, these cylinders would be transported intact to NNSS. The risks of transporting the volume-reduced cylinders and those for the intact cylinders are calculated using the same assumptions used in Table 4-19 in this *DU Oxide SEIS*.

Tables 4-21 and **4-22** summarize the potential transportation impacts for shipping DU oxide in bulk bags, and the empty and heel cylinders to the Energy*Solutions* site. As indicated in Tables 4-21 and 4-22, all radiological risk values are less than 1. This means that no LCFs are expected to occur during transport by truck or train.

Table 4-21 Total Risks to Crew Members and the Public from Transporting Depleted Uranium Oxide in Bulk Bags to Energy*Solutions*

Origin	Number of Shipments[a]	One-way Kilometers Traveled	Incident-Free				Accident	
			Crew		Population			
			Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck								
Paducah	20,510	52,900,000	69	0.04	233	0.14	2×10^{-4}	3
Portsmouth	9,070	27,900,000	36	0.02	120	0.07	9×10^{-5}	1
Train								
Paducah	510	1,400,000	53	0.03	64	0.04	2×10^{-3}	0.3
Portsmouth	230	700,000	30	0.02	37	0.02	2×10^{-3}	0.2

Key: LCF = latent cancer fatality; nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

Note: To convert kilometers to miles multiply by 0.62137.

Furthermore, the impacts from the transport of CaF_2 from neutralization of HF to a LLW disposal facility are also estimated. It is estimated that there would be 32,400 truck shipments or 811 train shipments from Paducah and 13,550 truck shipments or 339 train shipments from Portsmouth to Energy*Solutions*. Although conservatively considered LLW for purposes of disposal, the CaF_2 has such low levels of radiation, it would provide a neglibile dose to the crew and the public during transport. The estimated traffic fatalities from these shipments are summarized in **Table 4-23**.

Table 4-22 Total Risks to Crew Members and the Public from Transporting Empty and Heel Cylinders to Energy*Solutions*

			Incident-Free				Accident	
			Crew		Population			
Origin	Number of Shipments[a]	One-way Kilometers Traveled	Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck (volume-reduced to Energy*Solutions*)								
Paducah	4,920	12,700,000	9	0.006	3	0.002	6×10^{-7}	0.7
Portsmouth	2,550	7,900,000	6	0.003	2	0.001	3×10^{-7}	0.4
Truck (10% intact to NNSS)								
Paducah	2,730	8,758,800	0.1	6×10^{-5}	0.3	0.0002	4×10^{-8}	0.4
Portsmouth	1,420	5,298,000	0.06	4×10^{-5}	0.2	0.0001	3×10^{-8}	0.2
Train (volume-reduced to Energy*Solutions*)								
Paducah	250	690,000	0.9	0.0005	1	0.0007	3×10^{-7}	0.2
Portsmouth	130	420,000	0.6	0.0003	0.8	0.0005	5×10^{-7}	0.1
Train (10% intact to NNSS)[c,d]								
Paducah	2,820	1,223,000	0.1	6×10^{-5}	0.1	8×10^{-5}	4×10^{-7}	0.08
Portsmouth	1,470	679,000	0.1	0.0008	0.1	0.0007	8×10^{-7}	0.1

Key: LCF = latent cancer fatality; NNSS = Nevada National Security Site; Nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because NNSS does not have a rail yard, the waste would be transported from a nearby rail yard (Barstow, California) to NNSS via truck.

[d] The intact cylinders represent transport of 10 percent of the total empty and heel cylinders, which are 83,000 (69,000 plus 14,000) to NNSS. The calculated doses and risks are based on the information provided in Table 4-29 of this *DU Oxide SEIS*, assuming that the intact cylinders are transported 2 per truck and 60 per train. These cylinders would be transported to NNSS when the disposal facility is other than NNSS. The train shipments to NNSS includes 2,730 truck shipments for Paducah and 1,420 truck shipments for Portsmouth in addition to 90 and 50 train shipments from Paducah and Portsmouth, respectively..

Note: To convert kilometers to miles multiply by 0.62137.

Table 4-23 Total Population Transportation Risks for Shipment of CaF_2 to Energy*Solutions* under the Hydrogen Fluoride Neutralization Option

Origin	Paducah		Portsmouth	
Mode of Transport	**Truck**	**Train**	**Truck**	**Train**
Number of shipments[a]	32,400	810	13,600	340
Total distance (one-way [km])	83,630,000	22,378,000	41,736,000	10,994,000
Traffic fatalities (round trip)	4.5	0.50	1.92	0.52

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

Impacts from Incident-Free Transport of Radioactive Waste

The potential radiological impacts for transport crews and populations along the routes are shown in Tables 4-18 through 4-23. The table includes the results of shipping all DU oxide and other radioactive waste to Energy*Solutions*. As shown in Tables 4-18 through 4-23, transportation of the DU oxide dominates the risks of transportation. Therefore, the impacts of shipping empty and heel cylinders and other LLW and MLLW to Energy*Solutions* are not discussed further.

Transport of DU oxide in cylinders results in the maximum impact on the transportation crew compared to transport of DU oxide in bulk bags, because there are more transports using cylinders.

Under the Energy*Solutions* Disposal Alternative, transport of DU oxide would likely not result in any LCFs to crew members, as detailed in Table 4-21. For truck transport, the LCF risk over the duration of the project (assuming all DU oxide waste from both Paducah and Portsmouth was disposed of at Energy*Solutions*) would be 0.13, or 1 chance in about 8 of developing a single LCF among the transportation crews. For train transport, the calculated LCF risk over the duration of the project would be 0.06, or 1 chance in about 16 of a single LCF among the transportation crews.

Transport of DU oxide in cylinders results in the maximum impact on the general population compared to transport of DU oxide in bulk bags. This difference is driven by the higher population estimates along the routes, both on and off the roads. However, as detailed in Table 4-18, the dose to the general population would likely not result in an LCF. For truck transport of DU oxide, the calculated LCF risk over the duration of the project would be 0.35, or 1 chance in about 3 of a single LCF in the exposed population. For train transport, the calculated LCF risk over the duration of the project would be 0.08, or 1 chance in about 13 of a single LCF in the exposed population.

The total radioactive dose received by an MEI (a resident along the route near Energy*Solutions*), hypothetically assumed to be exposed to every DU oxide truck shipment from both Paducah and Portsmouth would be about 2.14 millirem, resulting in an increased risk of developing a fatal cancer of 1×10^{-6}, or 1 chance in 780,000. Assuming that shipments would occur over 34 years, the average annual dose to this individual would be 0.063 millirem, which is 0.063 percent of DOE’s limit in DOE Order 458.1 of 100 millirem a year, for exposure to a member of the public.

Impacts of Transportation Accidents Involving Radioactive Waste

Two sets of analyses were performed to evaluate potential radiological transportation accident impacts: (1) all reasonably foreseeable accidents (total transportation accidents) and (2) maximum reasonably foreseeable accidents (accidents with radioactive release probabilities greater than 1×10^{-7} [1 chance in 10 million] per year).

As indicated in Tables 4-18 through 4-20, considering all reasonably foreseeable accidents, transport of radioactive waste would likely result in no LCFs, but there could be nonradiological fatalities due to traffic accidents under the truck and train transportation options.

For maximum reasonably foreseeable accidents, transportation accident probabilities were calculated for all route segments (that is, rural, suburban, and urban), and maximum consequences were determined for those shipment routes with a likelihood-of-release frequency exceeding 1 chance in 10 million per year. For DU oxide shipped under this alternative, the reasonably foreseeable transportation accident with the highest consequence would involve train transport with the assumption of the breach of all six cylinders in a railcar in an urban area (see Appendix B, Table B-7). The maximum reasonably foreseeable probability of a train accident involving transport of DU oxide to Energy*Solutions* would be up to 1.5×10^{-7} per year in an urban area, or approximately 1 chance in 7 million each year. The consequences of the train transport accident, if it occurred, in terms of population and MEI dose would be about 47 person-rem and 0.039 rem, respectively. These doses would likely result in no (calculated value: 0.03 LCF) additional LCFs among the exposed population and a risk of 2×10^{-5} that the MEI would develop an LCF. When the annual frequency of the accident occurring is taken into account, the increased risk of a single LCF in the exposed population would be negligible (calculated value: 4×10^{-9} LCF).

Vehicle Emissions

Transport of DU oxide and other radioactive wastes to Energy*Solutions* would result in emissions from trains or trucks. It is expected that Paducah and Portsmouth would each make 24 train shipments of DU oxide annually. For shipment by truck, it is expected that Paducah and Portsmouth would each ship approximately 1,440 truckloads per year. The intact empty and heel cylinders could be shipped via train in 4 annual shipments or via truck in 125 annual shipments. Transport of CaF_2 via train is assumed to be an additional 24 and 15 shipments annually from Paducah and Portsmouth, respectively. Shipment of CaF_2 via truck would result in an additional 953 and 616 shipments from Paducah and Portsmouth, annually.

The quantity of DU oxide in each truck or train shipment would vary depending on whether cylinders or bulk bags are used. If bulk bags were to be used, the total number of truck shipments of DU oxide would decrease, but the number of empty and heel cylinders to be shipped for disposal would increase. If the empty and heel cylinder were shipped intact, the total number of train shipments under the bulk bag shipment scenario would be more than the number of shipments for DU oxide in cylinders. The analysis below represents the most conservative scenario (i.e., the largest quantity of emissions), and all other potential shipping scenarios would generate lower levels of emissions of both criteria pollutants and GHGs.

Train Option

Emissions were calculated to provide an estimate of the annual criteria pollutant emissions associated with shipments via railcar from Paduchah and Portsmouth to Energy*Solutions.* It was estimated that locomotives would travel approximately 1,600 miles (2,600 kilometers) per train shipment from Paducah to Energy*Solutions* and approximately 1,900 miles (3,100 kilometers) from Portsmouth to Energy*Solutions.* Emissions were calculated using emission factors for tier 2 line haul locomotives derived from the EPA's *Emission Factors for Locomotives* (EPA 2009).

Emissions of all criteria pollutants would be less than 34 tons (31 metric tons) annually for all shipments from Paducah and Portsmouth combined (see **Table 4-24).** Emissions would be spread across a large area, so it is not useful to compare to NEI baseline emissions for any particular AQCR. However, because the emissions are so small in comparison to overall U.S. locomotive and vehicle transportation emissions, the emissions are not likely to contribute to any significant impact on air quality.

Truck Option

Annual criteria pollutant emissions were calculated based on estimated shipments from each facility to Energy*Solutions* (see **Table 4-25)**. Analysis estimated approximately 1,600 miles (2,600 kilometers) per truck shipment from Paducah to Energy*Solutions* and approximately 1,900 miles (3,100 kilometers) per shipment from Portsmouth to Energy*Solutions* via truck. Emissions were derived using the emission factors for heavy-duty diesel vehicles in the EPA's MOVES2014a. MOVES is the U.S. Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator. It is used to create emission factors or emission inventories for both onroad motor vehicles and nonroad equipment (EPA 2015).

Table 4-24 Annual Criteria Pollutant Emissions from Transportation via Train to Energy*Solutions*

Material	Site	Criteria Pollutant Emissions (tons/year)					
		CO	**NO$_x$**	**PM$_{10}$**	**PM$_{2.5}$**	**SO$_x$**	**VOC**
Ancillary LLW and MLLW	Paducah	0.09	0.34	0.01	0.01	0.01	0.02
	Portsmouth	0.11	0.41	0.01	0.01	0.01	0.02
	Total emissions	*0.19*	*0.75*	*0.03*	*0.03*	*0.01*	*0.04*
DU oxide in cylinders	Paducah	1.69	6.54	0.24	0.23	0.12	0.36
	Portsmouth	2.01	7.76	0.28	0.27	0.14	0.43
	Total emissions	*3.70*	*14.30*	*0.52*	*0.50*	*0.26*	*0.79*
14,000 empty and heel cylinders	Paducah	0.28	1.09	0.04	0.04	0.02	0.06
	Portsmouth	0.33	1.29	0.05	0.05	0.02	0.07
	Total emissions	*0.62*	*2.38*	*0.09*	*0.08*	*0.04*	*0.13*
DU oxide in bulk bags	Paducah	1.06	4.09	0.15	0.14	0.07	0.23
	Portsmouth	0.84	3.23	0.12	0.11	0.06	0.18
	Total emissions	*1.89*	*7.32*	*0.27*	*0.26*	*0.13*	*0.40*
69,000 empty and heel cylinders	Paducah	1.62	6.26	0.23	0.22	0.11	0.35
	Portsmouth	1.42	5.50	0.20	0.19	0.10	0.30
	Total emissions	*3.04*	*11.76*	*0.43*	*0.41*	*0.21*	*0.65*
CaF$_2$	Paducah	1.69	6.54	0.24	0.23	0.12	0.36
	Portsmouth	1.25	4.85	0.18	0.17	0.09	0.27
	Total emissions	*2.95*	*11.39*	*0.41*	*0.40*	*0.21*	*0.63*
Grand Total (DU Oxide in Cylinders)		**7.45**	**28.82**	**1.05**	**1.02**	**0.53**	**1.59**
Grand Total (DU Oxide in Bulk Bags)		**8.69**	**33.61**	**1.22**	**1.19**	**0.61**	**1.86**

Key: CaF2 = calcium fluoride; CO = carbon monoxide; NO$_2$ = nitrogen dioxide; PM$_{10}$ and PM$_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO$_2$ = sulfur dioxide; VOC = volatile organic compounds.

Table 4-25 Annual Criteria Pollutant Emissions from DU Oxide Transportation via Truck to Energy*Solutions*

Material	Site	Criteria Pollutant Emissions (tons/year)					
		CO	**NO$_x$**	**PM$_{10}$**	**PM$_{2.5}$**	**SO$_x$**	**VOC**
Ancillary LLW and MLLW	Paducah	0.17	0.48	0.02	0.02	0.00	0.05
	Portsmouth	0.14	0.41	0.01	0.01	0.00	0.04
	Total emissions	*0.31*	*0.88*	*0.03*	*0.03*	*0.00*	*0.09*
DU oxide (cylinders)	Paducah	5.49	15.67	0.57	0.53	0.04	1.63
	Portsmouth	6.52	18.61	0.68	0.62	0.04	1.94
	Total emissions	*12.02*	*34.27*	*1.25*	*1.15*	*0.08*	*3.57*
14,000 empty and heel cylinders	Paducah	0.48	1.36	0.05	0.05	0.00	0.14
	Portsmouth	0.57	1.62	0.06	0.05	0.00	0.17
	Total emissions	*1.04*	*2.98*	*0.11*	*0.10*	*0.01*	*0.31*
DU oxide (bulk bags)	Paducah	2.30	6.56	0.24	0.22	0.01	0.68
	Portsmouth	1.87	5.32	0.19	0.18	0.01	0.55
	Total emissions	*4.17*	*11.88*	*0.43*	*0.40*	*0.03*	*1.24*
69,000 empty and heel cylinders	Paducah	2.59	7.39	0.27	0.25	0.02	0.77
	Portsmouth	2.35	6.71	0.24	0.23	0.02	0.70
	Total emissions	*4.94*	*14.09*	*0.51*	*0.47*	*0.03*	*1.47*

Material	Site	Criteria Pollutant Emissions (tons/year)					
		CO	NO_x	PM_{10}	$PM_{2.5}$	SO_x	VOC
CaF_2	Paducah	3.64	10.37	0.38	0.35	0.02	1.08
	Portsmouth	2.79	7.96	0.29	0.27	0.02	0.83
	Total emissions	*6.43*	*18.33*	*0.67*	*0.61*	*0.04*	*1.91*
Grand Total (DU Oxide in Cylinders)		**19.80**	**56.46**	**2.06**	**1.89**	**0.13**	**5.88**
Grand Total (DU Oxide in Bulk Bags)		**16.89**	**48.16**	**1.76**	**1.62**	**0.11**	**5.02**

Key: CaF2 = calcium fluoride; CO = carbon monoxide; NO_x = nitrogen oxides; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Under the truck option, emissions of all criteria pollutants would be less than 57 tons (52 metric tons) annually for all shipments from Paducah and Portsmouth combined. These emissions would be spread across a large area, so it is not useful to compare to NEI baseline emissions for any particular AQCR. Although the EPA does separately track commercial versus other mobile sources of criteria pollutants, the national on-road emissions associated with heavy-duty diesel vehicles and heavy-duty gasoline vehicles from the 2014 NEI (EPA 2019) are provided for comparison in Table 4-9 of this *DU Oxide SEIS*. Because the criteria pollutant emissions from transportation of wastes to Energy*Solutions* are so small in comparison to overall U.S. heavy-duty vehicle emissions, the emissions are not likely to contribute to any significant impact on air quality.

Greenhouse Gases

Estimating approximately 1,600 miles (2,600 kilometers) per train shipment from Paducah to Energy*Solutions*, approximately 186 tons (169 metric tons) of GHG emissions (measured as CO_2e) would be produced annually (CNR 2016) (see **Table 4-26**). Estimating approximately 1,900 miles (3,100 kilometers) per train shipment from Portsmouth to Energy*Solutions*, approximately 157 tons (142 metric tons) of GHG emissions would be produced annually (CNR 2016). Total annual GHG emissions from shipping DU oxide and other wastes to the disposal facilities by train would be 344 tons (312 metric tons) which would be minimal in terms of the national GHG emissions from railway transportation which total 45.3 million tons (41.1 million metric tons) annually (EPA 2018d).

Table 4-26 Annual GHG Emissions from the Transport of DU Oxide to Energy*Solutions*

Site	GHG Emissions (CO_2e tons per year)	
	Train Option[a]	**Truck Option**[a]
Paducah[b]	186	6,894
Portsmouth[b]	157	7,082
Total	**344**	**13,977**
National Train Emissions[c]	45,300,000	NA
National Truck Emissions[c]	NA	467,400,000

Key: CO_2e = carbon dioxide equivalents; GHG = greenhouse gas; NA = not applicable.

[a] The train and truck options both include emissions from truck shipment for disposal of LLW, MLLW, and empty and heel cylinders as discussed in Section 4.1.2 for the No Action Alternative.

[b] Source: CNR 2016

[c] Source: EPA 2018d

Estimating approximately 1,600 miles (2,600 kilometers) per truck shipment from Paducah to Energy*Solutions*, approximately 6,894 tons (6,254 metric tons) of GHG emissions would be produced annually (CNR 2016). Estimating approximately 1,900 miles (3,100 kilometers) per truck shipment from Portsmouth to Energy*Solutions*, approximately 7,082 tons (6,425 metric tons) of GHG emissions would be produced annually (CNR 2016). Total annual GHG emissions from shipping DU oxide and other wastes to the disposal facilities by truck would be 13,977 tons (12,680 metric tons) which would be minimal in terms of the national GHG emissions from truck transportation, which total 467.4 million tons (424.0 million metric tons) annually (EPA 2018d).

U.S. Nuclear Regulatory Commission 10 CFR Part 61 Rulemaking

Chapter 5, Section 5.4.4, of this *DU Oxide SEIS* describes the status of U.S. Nuclear Regulatory Commission (NRC) 10 CFR Part 61 Rulemaking that may affect the commercial disposal of large quantities of DU oxide. Disposal of bulk DU oxide will only be allowed if it meets all applicable requirements of DOE, NRC, and the affected Agreement States.

4.2.3 Impacts on Disposal Capacity at Energy*Solutions*

This section describes the impacts on the disposal capacity at Energy*Solutions*. Other potential environmental impacts of disposal at this site are not analyzed in this *DU Oxide SEIS*. As long as the waste to be disposed of is within the authorized capacity and waste acceptance criteria of the disposal facility, it is assumed the impacts of disposal would be considered and found to be acceptable as part of the licensing and permitting process. Chapter 5, Section 5.4.3, briefly describes the licenses and permits held by Energy*Solutions*. Energy*Solutions*' operating licenses and permits are available for review at https://customerportal.energysolutions.com/.

The disposal of DU oxide, ancillary LLW and MLLW from storage and maintenance of DU oxide cylinders, empty and heel cylinders, and CaF_2 would not exceed Energy*Solutions*' disposal capacities, even if Energy*Solutions* received all DU oxide and other radioactive waste from both Paducah and Portsmouth.

Table 4-27 shows the waste volumes and percent of disposal capacity under the Disposal of Waste at Energy*Solutions* Alternative. DOE projects a total of 46,150 DU oxide cylinders from Paducah and 22,850 cylinders from Portsmouth, or a total of 69,000 cylinders. Assuming each cylinder has an envelope volume of about 5.59 cubic yards (4.28 cubic meters) (see Section 4.1.1.8), the volume of the DU oxide cylinders would total about 386,000 cubic yards (295,000 cubic meters). In addition, 205, 55-gallon (208 liter) drums containing DU oxide were generated at Portsmouth during 5 years of start-up operations and outages. Conservatively assuming 5 drums with oxide are generated each year at each site during the projected periods of oxide conversion, about 380 additional drums of DU oxide would be generated at both sites combined for a total of 585 drums. Assuming the volume of each drum is 0.27 cubic yards (0.21 cubic meters), the volume of the DU oxide drums would total about 158 cubic yards (123 cubic meters). This is within the rounding error for the DU oxide in cylinders and therefore the impact on site capacity is not discussed further.

Table 4-27 Waste Volumes and Percent of Disposal Capacity under the Disposal of Waste at Energy*Solutions* Alternative

Waste			Waste Volume (cubic yards)[a]	Disposal Capacity (cubic yards)[b]	Percent of Disposal Capacity
LLW – DU oxide	In cylinders[c]		386,000	NA	100
	Bulk bag option	In bulk bags	386,000	NA	100
		Volume-reduced empty and heel cylinders	38,600	4,170,000	0.9
LLW – empty and heel cylinders[d]			78,300	4,170,000	1.9
Ancillary LLW[e]			230	4,170,000	0.0056
Ancillary MLLW[e]			1.5	358,000	0.00042
LLW – CaF_2 option			225,000	4,170,000	5.4

Key: DU = depleted uranium; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NA = not applicable.

[a] It is assumed for analysis that all waste generated at both Paducah and Portsmouth from the Proposed Action would be disposed of at Energy*Solutions* under this alternative. Waste volumes from DU oxide storage and maintenance were determined assuming these activities would last for 76 years (44 years of storage and 32 years of shipping) at Paducah and 47 years (32 years of storage and 15 years of shipping) at Portsmouth. Source: PPPO 2018.

[b] DU oxide would be disposed of in a separate disposal unit sized to receive all DU oxide waste. The disposal capacity for LLW and MLLW other than DU oxide is assumed, respectively, to be the remaining capacity in the Class A West Embankment (4.17 million cubic yards [3.25 million cubic meters]) and the Mixed Waste disposal cell (358,000 cubic yards [274,000 cubic meters]) as of August 2016 (see Chapter 3, Table 3-27).

[c] Determined assuming 69,000 DU oxide cylinders each measuring 4 feet (1.2 meters) in diameter and 12 feet (3.7 meters) long; plus approximately 161 cubic yards (123 cubic meters) of DU oxide in drums.

[d] The listed volume of the empty and heel cylinders is the envelope volume of the cylinders. Waste volumes may be significantly reduced if the cylinders were volume-reduced (e.g., compacted or shredded) at the disposal facilities or a separate waste treatment facility.

[e] It is assumed for analysis that all waste from storage and maintenance of DU oxide cylinders from both Paducah and Portsmouth would be disposed of in each evaluated disposal site. Waste volumes from oxide storage and maintenance were determined assuming these activities would last for 76 years (44 years of storage and 32 years of shipping) at Paducah and 47 years (32 years of storage and 15 years of shipping) at Portsmouth.

Note: To convert cubic yards to cubic meters, multiply by 0.76456.

There would be no impacts on disposal capacity at Energy*Solutions* from disposal of DU oxide because, as described in Chapter 3, Section 3.3, of this *DU Oxide SEIS*, the disposal unit that would receive the DU oxide would be separate from the other disposal units at the site and, would be designed to receive all DU oxide that may be sent from both Paducah and Portsmouth. In addition, if DU oxide were disposed of in bulk bags, it would result in a similar disposal volume as DU oxide in cylinders, and therefore similar impacts on the capacity of the disposal facility. The volume-reduced empty and heel cylinders generated as a result of disposal of DU oxide in bulk bags would generate an additional waste stream estimated at 38,600 cubic yards or 0.9 percent of disposal capacity at Energy*Solutions*.

As shown in Table 4-16 above, the small quantities of ancillary LLW and MLLW from storage and maintenance of DU oxide cylinders would represent only small fractions of the disposal capacities for LLW and MLLW at Energy*Solutions*. Disposal of empty and heel cylinders would represent about 1.9 percent of Energy*Solutions*' LLW disposal capacity. Disposal of CaF_2, if this option is exercised, would represent about 5.4 percent of Energy*Solutions*' LLW disposal capacity.

DOE would coordinate shipment scheduling with Energy*Solutions* to ensure that appropriate personnel and equipment would be available to safely manage waste receipts. Energy*Solutions* routinely receives waste by both truck and train transport. Assuming Energy*Solutions* received

DU oxide cylinders from both Paducah and Portsmouth, the disposal facility could conservatively receive up to 2,880 cylinders in a year. Assuming the cylinders were all shipped by truck from both Paducah and Portsmouth, over 250 working days per year at each site, the disposal site would receive an average of about 12 truckloads of DU oxide cylinders per day. Otherwise, assuming the same number of cylinders was all shipped by train from both Paducah and Portsmouth, trains with DU oxide cylinder would arrive about 4 times per month. Assuming 6 cylinders per railcar and 10 gondola railcars per train, each train shipment would contain 60 cylinders to be offloaded and transferred to the designated disposal unit.

DOE expects that Energy*Solutions* would have little difficulty in accommodating either shipment mode. DOE expects that an average of 12 trucks per day or 4 trains per month would be within the range of truck and train shipments that routinely arrive at Energy*Solutions*, and the uniform nature of the DU oxide shipments in terms of container type and size, and waste content, enhances the efficiency of disposal operations.[58] The small quantity of DU oxide shipped in drums could be delivered in a few annual truck loads or with the train shipments of DU oxide cylinders which would be easily managed at Energy*Solutions*.

Similarly, DOE expects that deliveries of empty and heel cylinders would be readily managed at Energy*Solutions*. Paducah would annually make an average of 125 truck deliveries of intact empty and heel cylinders to Energy*Solutions*, while Portsmouth would annually make an average of 125 truck deliveries. Assuming 250 working days per year at the disposal facilities, there would be an average of one delivery of intact empty and heel cylinders every work day from Paducah and Portsmouth. As discussed in Section 4.1.3, the projected volume of empty and heel cylinders could be reduced by volume reduction activities (e.g., compaction or shredding) at the disposal facility or a separate treatment facility. In addition, the void space within the cylinders would need to be addressed; this could be accomplished through volume reduction or other measures. Otherwise, assuming the same number of empty and heel cylinders was shipped by train from both Paducah and Portsmouth, trains with the cylinders would arrive about 8 times per year. Assuming 6 empty and heel cylinders per railcar and 10 railcars per train, each train shipment would contain 60 cylinders to be offloaded and transferred to the designated disposal unit.

Other volumes of radioactive wastes generated from storage and maintenance of DU oxide cylinders are very small and could be easily managed at Energy*Solutions*. The annual generation of LLW from these activities is about 2.1 cubic yards (1.7 cubic meters) at Paducah and 1.6 cubic yards (1.2 cubic meters) at Portsmouth. Assuming this waste would be shipped within 55-gallon drums with an average volume of 0.2 cubic meters per drum, LLW from Paducah could be shipped in nine 55-gallon drums while LLW from Portsmouth could be shipped in six 55-gallon drums. Only a single truckload would be required to ship the waste from Paducah to Energy*Solutions*, and

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[58] Shipments to LLW and MLLW disposal facilities are inspected upon arrival for compliance with acceptance criteria such as direct radiation levels, the presence of detectable removable contamination, waste content, and manifesting. Departing vehicles are also inspected to ensure compliance with transportation requirements including the presence of detectable removable contamination. A uniform waste stream such as DU oxide would require less time to perform these inspections than another waste stream containing – for example, a more variable range of isotopes. It may also require less time to inspect a rail shipment than it would if the same quantity of waste in the rail shipment was instead shipped in multiple truck loads. The uniform size and configuration of the DU oxide containers (i.e., cylinders) also promotes a more efficient and timely waste emplacement process compared to that required for shipments containing the same quantity of waste but in containers of a variety of sizes and configurations (e.g., drums, boxes, lift liners).

another single truckload would be required to ship the waste from Portsmouth. Annual volumes of MLLW could be shipped in a single 55-gallon drum from Paducah and a single 55-gallon drum from Portsmouth.

If HF could not be sold and needed to be converted to CaF_2 and disposed, the CaF_2 would be packaged in bulk bags and sent to a disposal facility. Although the CaF_2 would likely have little or no radioactivity, in order to be conservative, it is considered LLW for this waste management analysis. Assuming Energy*Solutions* received CaF_2 in bulk bags from both Paducah and Portsmouth, the disposal facility could conservatively receive up to 46,000 CaF_2 bulk bags. Assuming the bags were all shipped by truck from both Paducah and Portsmouth, over 250 working days per year at each site, the disposal site would receive an average of about six truckloads of CaF_2 per work day. Otherwise, assuming the same number of bulk bags was shipped by train from both Paducah and Portsmouth, trains would arrive about one or two per work week.

4.3 DISPOSAL OF DEPLETED URANIUM OXIDE AND OTHER WASTES AT THE NEVADA NATIONAL SECURITY SITE

As described in Section 2.2.2.2, under the NNSS Disposal Alternative, DU oxide would be disposed of at NNSS in Nye County, Nevada. This section presents the estimated potential environmental impacts for this alternative including: (1) impacts from storage of DU oxide at Paducah and Portsmouth until shipment to NNSS (Section 4.3.1); (2) impacts from the transportation of DU oxide and other radioactive waste to NNSS (Section 4.3.2); and (3) impacts on the LLW and MLLW disposal capacities at NNSS (Section 4.3.3).

Many of the environmental impacts would be similar regardless of which disposal site (Energy*Solutions*, NNSS or WCS) receives the wastes from Paducah and Portsmouth. Therefore, some portions of the discussion of disposal of wastes at NNSS (Section 4.3) refers back to sections of the Energy*Solutions* discussion (Section 4.2) rather than repeating the same information.

4.3.1 Impacts at Paducah and Portsmouth

DU oxide would be stored at Paducah and Portsmouth until it is shipped to NNSS for disposal. The impacts of storage at Paducah and Portsmouth would be the same as those described in Section 4.2.1 for the Energy*Solutions* Disposal Alternative.

4.3.2 Transport of Depleted Uranium Oxide and Other Wastes to the Nevada National Security Site

This section summarizes the potential impacts from shipment of DU oxide and other radioactive waste from Paducah in Kentucky and Portsmouth in Ohio, to NNSS in Nevada, under incident-free and accident conditions. Section 4.2.2 summarizes some of the general transportation assumptions. Details of the analysis methodology and analytical results are presented in Appendix B.

Because NNSS lacks a direct rail connection for waste delivery, truck transports were evaluated for shipments from an intermodal facility to NNSS. For purposes of analysis and consistent with the NNSS SWEIS (DOE 2013a), the intermodal facility is assumed to be the rail yard in Barstow, California.

Table 4-28 summarizes the potential transportation impacts for disposal of DU oxide at NNSS. As indicated in Table 4-16, all risk values are less than one, except for nonradiological accident risk associated with truck or train shipments. This means that no LCFs are expected to occur during transport by truck or train, but a small number of traffic fatalities could result from nonradiological accidents. This is the result of the large number of DU oxide and CaF_2 transports.

As discussed in Section 4.2.2, DU oxide cylinders could be shipped in ABC railcars instead of gondola railcars. The annual and total impacts of shipping in ABC railcars would be similar to or less than those of shipping in gondola railcars.

Tables 4-29 and **4-30** summarize the potential transportation impacts for shipment of empty and heel cylinders and other LLW and MLLW to NNSS. Table 4-29 shows the transportation impacts assuming the empty and heel cylinders are transported intact. As indicated in Tables 4-29 and 4-30, all risk values are less than one. This means that no LCFs are expected to occur during transport by truck or train under this alternative.

Table 4-28 Total Risks to Crew Members and the Public from Transporting Depleted Uranium Oxide in Cylinders to the Nevada National Security Site

			Incident-Free				**Accident**	
			Crew		**Population**			
Origin	**Number of Shipments**[a]	**One-way Kilometers Traveled**	**Dose (person-rem)**	**LCF**[b]	**Dose (person-rem)**	**LCF**[b]	**Radiological Risk**[b]	**Nonrad Risk**[b]
Truck								
Paducah	46,200	148,100,000	175	0.1	458	0.3	1×10^{-4}	6
Portsmouth	22,900	85,400,000	101	0.06	264	0.2	9×10^{-5}	4
Train/Truck[c]								
Paducah, train	770	2,600,000	73	0.04	89	0.05	1×10^{-3}	0.8
Paducah Barstow, truck	46,200	15,600,000	18	0.01	48	0.03	2×10^{-6}	0.3
Total	**46,970**	**18,200,000**	**91**	**0.05**	**137**	**0.08**	$\mathbf{1\times10^{-3}}$	**1**
Portsmouth, rail	380	1,500,000	45	0.03	56	0.03	1×10^{-5}	0.5
Portsmouth Barstow, truck	22,900	7,700,000	9	0.005	24	0.01	8×10^{-7}	0.1
Total	**23,280**	**9,200,000**	**54**	**0.03**	**79**	**0.05**	$\mathbf{1\times10^{-3}}$	**0.7**

Key: LCF = latent cancer fatality; nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because NNSS does not have a rail connection, train shipments would be shipped to an intermodal facility (which was assumed for analysis to be at Barstow, California) and then the cargo will be transported by truck to NNSS. Impacts from these additional shipments were included in the tabulated results for NSSS under Train/Truck section in this table. For transport of cylinders originating from Paducah, 46,000 truck transports are required between Barstow, California and NNSS, whereas for cylinders originating from Portsmouth 21,000 truck transports are required.

Note: To convert kilometers to miles multiply by 0.62137.

Table 4-29 Total Risks to Crew Members and the Public from Transporting Empty and Heel Cylinders to the Nevada National Security Site

			Incident-Free				Accident	
			Crew		Population			
Origin	Number of Shipments[a]	One-way Kilometers Traveled	Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck								
Paducah	4,242	13,600,000	0.2	1×10^{-4}	0.4	3×10^{-4}	6×10^{-8}	0.6
Portsmouth	2,260	10,300,000	0.1	7×10^{-5}	0.3	2×10^{-4}	5×10^{-8}	0.5
Train/Truck[c]								
Paducah, train	140	470,000	0.1	8×10^{-5}	0.2	1×10^{-4}	6×10^{-7}	0.1
Paducah Barstow, truck	4,242	1,430,000	0.02	1×10^{-5}	0.04	3×10^{-5}	7×10^{-10}	0.02
Total	**4,380**	**1,900,000**	**0.1**	**9×10^{-5}**	**0.2**	**1×10^{-4}**	**6×10^{-7}**	**0.1**
Portsmouth, train	90	360,000	0.1	6×10^{-5}	0.1	8×10^{-5}	8×10^{-7}	0.1
Portsmouth Barstow, truck	2,759	930,000	0.01	7×10^{-6}	0.03	2×10^{-5}	4×10^{-10}	0.02
Total	**2,850**	**1,290,000**	**0.1**	**7×10^{-5}**	**0.2**	**1×10^{-4}**	**8×10^{-7}**	**0.1**

Key: LCF = latent cancer fatality, nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because NNSS does not have a rail connection, train shipments would be shipped to an intermodal facility (which was assumed for analysis to be at Barstow, California) and then the cargo will be transported by truck to NNSS. Impacts from these additional shipments were included in the tabulated results for the NSSS under Train/Truck in this table. For transport of cylinders originating from Paducah, 4,242 truck transports between Barstow, California and NNSS are required, whereas for cylinders originating from Portsmouth 2,759 truck transports are required.

Note: To convert kilometers to miles multiply by 0.62137.

Table 4-30 Annual Risks to Crew Members and the Public from Transporting Other Low-Level Radioactive Waste and Mixed Level Radioactive Waste to the Nevada National Security Site

			Incident-Free[a]				Accident[a]	
			Crew		Population			
Origin	Number of Shipments	One-way Kilometers Traveled	Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck[c]								
Paducah	1	3,200	4×10^{-4}	2×10^{-7}	3×10^{-4}	2×10^{-7}	4×10^{-14}	1×10^{-4}
Portsmouth	1	3,700	5×10^{-4}	3×10^{-7}	3×10^{-4}	2×10^{-7}	5×10^{-14}	2×10^{-4}

Key: LCF = latent cancer fatality; nonrad = nonradiological.

[a] Total risks can be estimated by multiplying by the maximum duration of the storage period for this alternative (76 years [44 + 32] for Paducah and 47 years [32 +15] for Portsmouth).

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because of the small amount of waste requiring shipment to the waste management facility, train transport would be inefficient and was not considered.

Note: To convert kilometers to miles multiply by 0.62137.

DOE is also considering the option of transporting DU oxide using bulk bags consistent with the analysis presented in the 2004 EISs (DOE 2004a, 2004b). It is estimated that there would be 20,500 and 9,070 truck shipments and 513 and 227 train shipments from Paducah and Portsmouth, respectively, using consistent assumptions as those used in the 2004 EISs. Therefore, because the amount of DU oxide evaluated in this *DU Oxide SEIS* is larger than that evaluated in the 2004 EISs, the bulk bag shipment numbers presented in this SEIS are proportionally larger than those cited in the 2004 EISs. If the bulk bags are used, then, the empty and heel cylinders also need to be transported to the disposal sites. It is assumed that the cylinders would be volume-reduced and packaged 10 to a 20-foot (6-meter) intermodal container and transported one per truck and two per railcar with 10 railcars per train. The conversion EISs also considered that about 10 percent of the cylinders could not be accepted at the Energy*Solutions*, therefore, these cylinders would be transported intact to NNSS. The risks of transporting the volume-reduced cylinders and those for the intact cylinders are calculated using the same assumptions used in Table 4-30.

Tables 4-31 and **4-32** summarize the potential transportation impacts for shipment DU-oxides in bulk bags, and the empty and heel cylinders to NNSS. As indicated in Tables 4-31 and 4-32, all risk values are less than one. This means that no LCFs are expected to occur during transport by truck or train.

Furthermore, the impacts from the transport of CaF_2 from neutralization of HF to a LLW disposal facility are also estimated. It is estimated that there would be 32,400 truck shipments or 811 train shipments from Paducah and 13,600 truck shipments or 339 train shipments from Portsmouth to NNSS. Although conservatively considered LLW for purposes of disposal, CaF_2 has such low levels of radiation it would provide a negligible dose to the crew and the public turing transport. The estimated traffic fatalities from these shipments are summarized in **Table 4-33**.

Table 4-31 Total Risks to Crew Members and the Public from Transporting Depleted Uranium Oxide in Bulk Bags to the Nevada National Security Site

Origin	Number of Shipments[a]	One-way Kilometers Traveled	Incident-Free				Accident	
			Crew		Population			
			Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck								
Paducah	20,500	65,800,000	85	0.05	285	0.17	1×10^{-4}	3
Portsmouth	9,070	33,800,000	44	0.03	147	0.09	8×10^{-5}	2
Train/Truck[c]								
Paducah	21,020	8,600,000	72	0.04	99	0.06	2×10^{-3}	0.7
Portsmouth	9,300	4,000,000	39	0.02	53	0.03	2×10^{-3}	0.4

Key: LCF = latent cancer fatality.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because NNSS does not have a rail yard, the waste would be transported from a nearby rail yard (Barstow, California) to NNSS via truck. There are 20,510 truck shipments for the Paducah wastes and 9,070 truck shipments for the Portsmouth wastes, in addition to the regular train shipments of 510 and 230 for the Paducah and Portsmouth, respectively.

Note: To convert kilometers to miles multiply by 0.62137.

Table 4-32 Total Risks to Crew Members and the Public from Transporting Empty and Heel Cylinders to the Nevada National Security Site

Origin	Number of Shipments[a]	One-way Kilometers Traveled	Incident-Free				Accident	
			Crew		Population			
			Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck (volume-reduced)								
Paducah[c]	4,920	15,800,000	10	0.007	4	0.003	3×10^{-7}	0.7
Portsmouth[d]	2,550	9,500,000	7	0.004	2	0.001	2×10^{-7}	0.4
Truck (10% intact)[e]								
Paducah[c,e]	2,730	8,757,000	0.1	6×10^{-5}	0.3	2×10^{-4}	4×10^{-8}	0.4
Portsmouth[d,e]	1,420	5,299,000	0.06	4×10^{-5}	0.2	1×10^{-4}	3×10^{-8}	0.2
Train/Truck (volume-reduced)[c,d]								
Paducah[c]	5,170	2,510,000	20	0.001	2	0.001	2×10^{-7}	0.2
Portsmouth[d]	2,680	1,380,000	1	0.0008	1	0.0007	3×10^{-7}	0.2
Train/Truck (10% intact)[c,e]								
Paducah[c,e]	2,820	1,223,000	0.1	0.00006	0.1	0.00008	4×10^{-7}	0.08
Portsmouth[d,e]	1,470	679,000	0.1	0.0008	0.1	0.0007	8×10^{-7}	0.1

Key: LCF = latent cancer fatality.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because NNSS does not have a rail yard, the waste would be transported from a nearby rail yard (Barstow, California) to NNSS via truck.

[d] There are 4,920 truck shipments for the Paducah wastes and 2,550 truck shipments for the Portsmouth wastes, in addition to the regular train shipments of 250 and 130 from Paducah and Portsmouth, respectively.

[e] The intact cylinders represent transport of 10 percent of the total empty and heel cylinders, which are 83,000 (69,000 plus 14,000). The calculated doses and risks are based on the information provided in Table 4-29 of this *DU Oxide SEIS*, assuming that the intact cylinders are transported two per truck and 60 per train. The train shipments to NNSS includes 2,730 truck shipments for Paducah and 1,420 truck shipments for Portsmouth in addition to 90 and 50 train shipments from Paducah and Portsmouth, respectively.

Note: To convert kilometers to miles multiply by 0.62137.

Table 4-33 Total Population Transportation Risks for Shipment of CaF_2 to the Nevada National Security Site under the Hydrogen Fluoride Neutralization Option[a]

Origin	Paducah		Portsmouth	
Mode of Transport	**Truck**	**Train**	**Truck**	**Train**
Number of shipments[b]	32,400	810	13,600	340
Total distance (one-way [km])[c]	104,015,000	38,380,000	50,555,000	18,231,000
Traffic fatalities (round trip)	4.8	1.96	2.25	0.55

[a] Although shipped to a LLW disposal facility, the CaF_2 would likely have little or no radioactivity; therefore, there would be negligible doses to the transportation crew and the public.

[b] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[c] Because NNSS does not have a direct rail line connection, every train transport requires four shipments of truck transport from an intermodal facility to NNSS. The cited distances are the sum of truck and train transport distances.

Impacts from Incident-Free Transport of Radioactive Waste

The potential radiological impacts on transport crews and populations along the routes are shown in Tables 4-28 through 4-33. The tables include the results of shipping all DU oxide and other wastes to NNSS. As shown in Tables 4-28 through 4-33, transportation of the DU oxide dominates the risks. Therefore, the impacts of shipping empty and heel cylinders and ancillary LLW and MLLW to NNSS are not discussed further. In addition, CaF_2 is not discussed further because this material would contain little or no radioactivity, and therefore would not result in work or public exposure.

Transport of DU oxide in cylinders results in the maximum impact on the transportation crew compared to transport of DU oxide in bulk bags, because there are more transports using cylinders. As detailed in Table 4-30, the transport of DU oxide in bulk bags could result in one LCF to crew members. For truck transport, the calculated LCF risk over the duration of the project would be 0.16, or 1 chance in about 6 of developing a single LCF among the transportation crew. For truck/train transport, the calculated LCF risk over the duration of the project would be 0.08, or 1 chance in about 13 of developing a single LCF among the transportation crews.

Transport of DU oxide in cylinders results in the maximum impact on the general population compared to transport of DU oxide in bulk bags. Under this Alternative, as detailed in Table 4-28, the dose to the general population likely would not result in an LCF. For truck transport of DU oxide in cylinders, the calculated LCF risk over the duration of the project would be 0.4, or 1 chance in 2.5 of a single LCF in the exposed population. For truck/train transport, the calculated LCF risk over the duration of the project would be 0.1, or 1 chance in 10 of a single LCF in the exposed population.

The total radioactive dose received by an MEI (a resident along the route near the NNSS), hypothetically assumed to be exposed to every DU oxide truck shipment over the duration of the project, would be about 2.14 millirem, resulting in an increased risk of developing an LCF of 1×10^{-6}, or 1 chance in 780,000. Assuming that shipments would occur over 34 years, the average annual dose to this individual would be 0.063 millirem, which is 0.063 percent of DOE's limit in DOE Order 458.1 of 100 millirem a year, for exposure to a member of the public.

Impacts of Transportation Accidents Involving Radioactive Waste

Two sets of analyses were performed to evaluate potential radiological transportation accident impacts: (1) all reasonably foreseeable accidents (total transportation accidents) and (2) maximum reasonably foreseeable accidents (accidents with a radioactive release probabilities greater than 1×10^{-7} [1 chance in 10 million] per year). As indicated in Tables 4-28 through 4-30 considering all reasonably foreseeable accidents, transport of radioactive waste would likely not result in any LCFs, but there could be nonradiological fatalities due to traffic accidents under the truck and train transportation options.

For maximum reasonably foreseeable accidents, transportation accident probabilities were calculated for all route segments (that is, rural, suburban, and urban), and maximum consequences were determined for those shipment routes with a likelihood-of-release frequency exceeding 1 chance in 10 million per year. For DU oxide shipped under this alternative, the maximum reasonably foreseeable transportation accident with the highest consequence would involve truck transport in an urban area (see Appendix B, Table B-7). The maximum probability of this truck accident involving transport of DU oxide to NNSS would be 5.3×10^{-7} per year in an urban area, or approximately 1 chance in 1.8 million each year. The consequences of the truck transport accident, if it occurred, in terms of population and MEI dose would be about 7.7 person-rem and 0.0064 rem, respectively. These doses would likely result in no (calculated value of 0.005) additional LCFs among the exposed population and a risk of 4×10^{-6} that the MEI would develop an LCF. When the annual frequency of the accident occurring is taken into account, the increased risk of a single LCF in the exposed population would be negligible (calculated value of 3×10^{-9}).

Vehicle Emissions

Transport of DU Oxide to NNSS would result in emissions from trains or trucks. It is expected that an average of 24 train shipments would occur annually from each of Paducah and Portsmouth. For shipment by truck only, it is expected that Paducah and Portsmouth would each ship up to 1,440 truckloads per year. The intact empty and heel cylinders could be shipped via train in 4 annual shipments, or via truck in 125 annual shipments. Transport of CaF_2 via train is assumed to be an additional 24 and 15 shipments annually from Paducah and Portsmouth, respectively. Shipment of CaF_2 via truck would result in an additional 953 and 616 shipments from Paducah and Portsmouth, annually.

The quantity of DU oxide in each truck or train shipment would vary depending on whether cylinders or bulk bags are used. If bulk bags were to be used, the total number of truck shipments of DU oxide would decrease, but the number of empty and heel cylinders to be shipped for disposal would increase. If the empty and heel cylinder were shipped intact, the total number of train shipments under the bulk bag shipment scenario would be more than the number of shipments utilizing DU oxide in cylinders. The analysis below represents the most conservative scenario (i.e., the largest quantity of emissions), and all other potential shipping scenarios would generate lower levels of emissions of both criteria pollutants and GHGs.

Train/Truck Option

Emissions were calculated to provide an estimate of the annual criteria pollutant emissions associated with shipments via train from each site to NNSS. It was estimated that locomotives would travel approximately 2,000 miles (3,300 kilometers) per train shipment from Paducah to Barstow, California, and approximately 2,400 miles (3,800 kilometers) from Portsmouth to Barstow, California. Emissions were calculated using emission factors for tier 2 line haul locomotives derived from the EPA's *Emission Factors for Locomotives* (EPA 2009).

Because there is no direct rail access to NNSS, shipments via train would travel to Barstow, California, where they would be transported approximately 200 miles (330 kilometers) from Barstow to the NNSS facility. **Table 4-34** presents annual emissions associated with both the train and truck portions of the shipments.

Table 4-34 Criteria Pollutant Emissions from Transportation via Train to Barstow, California, and Truck to NNSS[a]

Material	Mode of Transport	Site	Criteria Pollutant Emissions (tons/year)					
			CO	NO_x	PM_{10}	$PM_{2.5}$	SO_x	VOC
Ancillary LLW and MLLW	Truck	Paducah	0.02	0.05	0.00	0.00	0.00	0.00
		Portsmouth	0.01	0.03	0.00	0.00	0.00	0.00
		Total emissions	*0.03*	*0.08*	*0.00*	*0.00*	*0.00*	*0.01*
	Train	Paducah	0.09	0.34	0.01	0.01	0.01	0.02
		Portsmouth	0.11	0.41	0.01	0.01	0.01	0.02
		Total emissions	*0.19*	*0.75*	*0.03*	*0.03*	*0.01*	*0.04*
DU oxide in cylinders	Truck	Paducah	0.69	1.96	0.07	0.07	0.00	0.20
		Portsmouth	0.69	1.96	0.07	0.07	0.00	0.20
		Total emissions	*1.37*	*3.92*	*0.14*	*0.13*	*0.01*	*0.41*
	Train	Paducah	2.11	8.17	0.30	0.29	0.15	0.45
		Portsmouth	2.54	9.81	0.36	0.35	0.18	0.54
		Total emissions	*4.65*	*17.98*	*0.65*	*0.63*	*0.33*	*0.99*
14,000 empty and heel cylinders	Truck	Paducah	0.06	0.17	0.01	0.01	0.00	0.02
		Portsmouth	0.06	0.17	0.01	0.01	0.00	0.02
		Total emissions	*0.12*	*0.34*	*0.01*	*0.01*	*0.00*	*0.04*
	Train	Paducah	0.35	1.36	0.05	0.05	0.02	0.08
		Portsmouth	0.42	1.63	0.06	0.06	0.03	0.09
		Total emissions	*0.77*	*3.00*	*0.11*	*0.11*	*0.05*	*0.17*
DU oxide in bulk bags	Truck	Paducah	0.29	0.82	0.03	0.03	0.00	0.09
		Portsmouth	0.20	0.56	0.02	0.02	0.00	0.06
		Total emissions	*0.48*	*1.38*	*0.05*	*0.05*	*0.00*	*0.14*
	Train	Paducah	1.32	5.11	0.19	0.18	0.09	0.28
		Portsmouth	1.06	4.09	0.15	0.14	0.07	0.23
		Total emissions	*2.38*	*9.19*	*0.33*	*0.32*	*0.17*	*0.51*
69,000 empty and heel cylinders	Truck	Paducah	0.32	0.92	0.03	0.03	0.00	0.10
		Portsmouth	0.25	0.71	0.03	0.02	0.00	0.07
		Total emissions	*0.57*	*1.63*	*0.06*	*0.05*	*0.00*	*0.17*
	Train	Paducah	2.02	7.83	0.28	0.28	0.14	0.43
		Portsmouth	1.80	6.95	0.25	0.24	0.13	0.38
		Total emissions	*3.82*	*14.78*	*0.54*	*0.52*	*0.27*	*0.82*
CaF_2	Truck	Paducah	0.45	1.30	0.05	0.04	0.00	0.14
		Portsmouth	0.29	0.84	0.03	0.03	0.00	0.09
		Total emissions	*0.75*	*2.13*	*0.08*	*0.07*	*0.00*	*0.22*
	Train	Paducah	2.11	8.17	0.30	0.29	0.15	0.45
		Portsmouth	1.58	6.13	0.22	0.22	0.11	0.34
		Total emissions	*3.70*	*14.30*	*0.52*	*0.50*	*0.26*	*0.79*
Grand Total (DU Oxide in Cylinders)			**7.45**	**28.82**	**1.05**	**1.02**	**0.53**	**1.59**
Grand Total (DU Oxide in Bulk Bags)			**8.69**	**33.61**	**1.22**	**1.19**	**0.61**	**1.86**

Key: CaF2 = calcium fluoride; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

[a] Because there is no direct rail access to NNSS, shipments via train would travel to Barstow, California, where they would be transported approximately 200 miles (330 kilometers) from Barstow to the NNSS facility. The “Grand Total” emissions are the sum of truck and train transport emission.

Truck Option

Annual criteria pollutant emissions were calculated based on estimated shipments from each facility to NNSS (see **Table 4-35)**. Analysis estimated approximately 2,000 miles (3,300 kilometers) per truck shipment from Paducah to NNSS and approximately 2,400 miles (3,800 kilometers) per shipment from Portsmouth to NNSS via truck. Emissions were derived using the emission factors for heavy-duty diesel vehicles in the EPA's MOVES2014a. MOVES is the U.S. Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator. It is used to create emission factors or emission inventories for both onroad motor vehicles and nonroad equipment (EPA 2015).

Under the truck option, emissions of all criteria pollutants would be less than 72 tons (65 metric tons) annually for all shipments from Paducah and Portsmouth combined. These emissions would be spread across a large area, so it is not useful to compare to NEI baseline emissions for any particular AQCR. Although the EPA does separately track commercial versus other mobile sources of criteria pollutants, the national on-road emissions associated with heavy-duty diesel vehicles and heavy-duty gasoline vehicles from the 2014 NEI (EPA 2019) are provided for comparison in Table 4-9. Because the criteria pollutant emissions from transportation of wastes to NNSS are so small in comparison to overall U.S. heavy-duty vehicle emissions, the emissions are not likely to contribute to any significant impact on air quality.

Emissions of all criteria pollutants would be less than 34 tons (31 metric tons) annually for all shipments from Paducah and Portsmouth combined. Emissions would be spread across a large area, so it is not useful to compare to NEI baseline emissions for any particular AQCR. However, because the emissions are so small in comparison to overall locomotive and vehicle transportation emissions, the emissions are not likely to contribute to any significant impact on air quality.

Table 4-35 Criteria Pollutant Emissions Transportation via Truck to NNSS

Material	Site	Criteria Pollutant Emissions (tons/year)					
		CO	**NO$_x$**	**PM$_{10}$**	**PM$_{2.5}$**	**SO$_x$**	**VOC**
Ancillary LLW and MLLW	Paducah	0.17	0.48	0.02	0.02	0.00	0.05
	Portsmouth	0.14	0.41	0.01	0.01	0.00	0.04
	Total emissions	*0.31*	*0.88*	*0.03*	*0.03*	*0.00*	*0.09*
DU oxide (cylinders)	Paducah	6.88	19.61	0.72	0.66	0.04	2.04
	Portsmouth	8.72	24.86	0.91	0.83	0.06	2.59
	Total emissions	*15.59*	*44.47*	*1.62*	*1.49*	*0.10*	*4.63*
14,000 empty and heel cylinders	Paducah	0.60	1.70	0.06	0.06	0.00	0.18
	Portsmouth	0.72	2.04	0.07	0.07	0.00	0.21
	Total emissions	*1.31*	*3.74*	*0.14*	*0.13*	*0.01*	*0.39*
DU oxide (bulk bags)	Paducah	2.88	8.20	0.30	0.28	0.02	0.85
	Portsmouth	2.36	6.72	0.25	0.23	0.02	0.70
	Total emissions	*5.23*	*14.92*	*0.54*	*0.50*	*0.03*	*1.56*
69,000 empty and heel cylinders	Paducah	3.24	9.23	0.34	0.31	0.02	0.96
	Portsmouth	2.97	8.47	0.31	0.28	0.02	0.88
	Total emissions	*6.21*	*17.70*	*0.65*	*0.59*	*0.04*	*1.85*
CaF$_2$	Paducah	4.54	12.96	0.47	0.43	0.03	1.35
	Portsmouth	3.52	10.05	0.37	0.34	0.02	1.05
	Total emissions	*8.07*	*23.01*	*0.84*	*0.77*	*0.05*	*2.40*
Grand Total (DU Oxide in Cylinders)		**25.28**	**72.11**	**2.63**	**2.42**	**0.16**	**7.52**
Grand Total (DU Oxide in Bulk Bags)		**21.13**	**60.25**	**2.2**	**2.02**	**0.13**	**6.29**

Key: CaF2 = calcium fluoride; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Greenhouse Gases

Estimating approximately 2,000 miles (3,300 kilometers) per train shipment from Paducah to Barstow, California, approximately 233 tons (211 metric tons) of GHG emissions (measured as CO_2e) would be produced annually (CNR 2016) (**Table 4-36**). Estimating approximately 2,400 miles (3,800 kilometers) per train shipment from Portsmouth to Barstow, California, approximately 199 tons (180 metric tons) of GHG emissions would be produced annually (CNR 2016). Total annual GHG emissions from shipping DU oxide and other wastes to the disposal facilities by train would be 432 tons (392 metric tons), which would be minimal in terms of the national GHG emissions from railway transportation, which total 43.5 million tons (41.1 million metric tons) annually (EPA 2018d).

Because there is no direct rail access to NNSS, shipments would be transferred at Barstow, California, to trucks (DOE 2013a). Estimating approximately 200 miles (330 kilometers) via truck from Barstow, California, to NNSS, GHG emissions would be approximately 862 and 746 tons (782 and 677 metric tons) for shipments from Paducah and Portsmouth, respectively, or 1,607 total tons [1,458 metric tons] annually, which would be minimal in terms of the national annual GHG emissions from truck transportation, which total 467.4 million tons (424.0 million metric tons) annually (EPA 2018d). Thus, the total GHG emissions for the train/truck option would be 1,095 and 944 tons (933 and 856 metric tons) per year from Paducah and Portsmouth, respectively, with an annual total for both sites of 2,039 tons per year (1,850 metric tons per year). This amount would be minimal in terms of the national annual GHG emissions from combined truck and train transportation, which total 512.7 million tons (465.1 million metric tons) annually (EPA 2018d).

Table 4-36 Annual GHG Emissions from the Transport of DU Oxide to the Nevada National Security Site

	GHG Emissions (tons per year CO_2e)			
	Train/Truck Option			
Site	Train	Truck	Total	Truck Option
Paducah[a]	233	862	1,095	8,618
Portsmouth[a]	199	746	944	8,946
Total	**432**	**1,607**	**2,039**	**17,564**
National Train Emissions[b]	45,300,000			NA
National Truck Emissions[c]	467,400,000			467,400,000
Total National Train/Truck Emissions	**512,700,000**			**NA**

Key: CO_2e = carbon dioxide equivalents; GHG = greenhouse gas; NA = not applicable.

[a] The train/truck and truck options both include emissions from truck shipment for disposal of LLW, MLLW, and empty and heel cylinders as discussed in Section 4.1.2 for the No Action Alternative.

[b] Source: CNR 2016

[c] Source: EPA 2018d

For shipment by truck only, it is expected that estimating approximately 2,000 miles (3,300 kilometers) per truck shipment from Paducah to NNSS, approximately 8,618 tons (7,818 metric tons) of GHG emissions would be produced annually (CNR 2016). Estimating approximately 2,400 miles (3,800 kilometers) per truck shipment from Portsmouth to NNSS, approximately 8,946 tons (8,116 metric tons) of GHG emissions would be produced annually (CNR 2016). Total annual

GHG emissions from shipping DU oxide and other wastes to the disposal facilities by truck would be 17,564 tons [15,934 metric tons]), which would be minimal in terms of the national GHG emissions from truck transportation, which are 467.4 million tons (424.0 million metric tons) annually (EPA 2018d).

4.3.3 Impacts on Disposal Capacity at the Nevada National Security Site

This section describes the impacts on the disposal capacity at NNSS. Other potential environmental impacts of disposal at NNSS are not analyzed in this *DU Oxide SEIS*. As long as the waste to be disposed of is within the authorized capacity and waste acceptance criteria of the disposal facility, it is assumed that the impacts of disposal would have been considered and found to be acceptable as part of the performance assessment and authorization process. Chapter 5, Section 5.4.2, briefly describes applicable laws and regulations for disposal of waste at NNSS. Additional information on applicable laws and regulations, and the impacts of disposal of LLW at NNSS, are presented in the NNSS SWEIS (DOE 2013a).

As indicated in **Table 4-37**, the disposal of DU oxide, ancillary LLW and MLLW from storage and maintenance of DU oxide containers, empty and heel cylinders, and CaF_2, would not exceed the NNSS LLW disposal capacity, even if NNSS received all DU oxide and other waste from both Paducah and Portsmouth. The volumes of DU oxide, LLW and MLLW from storage and maintenance of DU oxide containers, empty and heel cylinders, and CaF_2 are the same as those stated in Section 4.2.3.

Table 4-37 Waste Volumes and Percent of Disposal Capacities under the Disposal of Waste at the Nevada National Security Site Alternative

Waste			Waste Volume (cubic yards)[a]	Disposal Capacity (cubic yards)[b]	Percent of Disposal Capacity[b]
LLW – DU oxide	In cylinders[c]		386,000 [c]	1,778,000	22
	Bulk Bag Option	In bulk bags	386,000	1,778,000	22
		Volume-reduced empty and heel cylinders	38,600	1,778,000	2.2
LLW – empty and heel cylinders			78,300 [d]	1,778,000	4.4
Ancillary LLW[e]			230	1,778,000	0.013
Ancillary MLLW[e]			1.5	148,000	0.00010
LLW – CaF_2 option			225,000	1,778,000	13

Key: DU = depleted uranium; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NNSS = Nevada National Security Site; RWMC = Radioactive Waste Management Complex.

[a] Source: PPPO 2018

[b] The disposal capacity for LLW and MLLW at the Area 5 Radioactive Waste Management Complex is assumed to be 48 million cubic feet (1.36 million cubic meters) and 4 million cubic feet (113,000 cubic meters) (see Chapter 3, Table 3-28). It is assumed that DU oxide waste would be disposed of in the Area 5 LLW disposal units.

[c] Determined assuming 66,982 DU oxide cylinders each measuring 4 feet (1.2 meters) in diameter and 12 feet (3.7 meters) long; plus approximately 161 cubic yards (123 cubic meters) of DU oxide in drums.

[d] The listed volume of the empty and heel cylinders is the envelope volume of the cylinders. Waste volumes may be significantly reduced if the cylinders were volume-reduced (e.g., compacted or shredded) at the disposal facilities or a separate waste treatment facility.

[e] It is assumed for analysis that all waste from storage and maintenance of DU oxide containers from both Paducah and Portsmouth would be disposed of at NNSS. Waste volumes from oxide storage and maintenance were determined assuming these activities would last for 76 years (44 years of storage and 32 years of shipping) at Paducah and 47 years (32 years of storage and 15 years of shipping) at Portsmouth.

Note: To convert cubic yards to cubic meters, multiply by 0.76456.

As shown in Table 4-22, the total volume of the DU oxide would represent about 22 percent of the LLW disposal capacity at the Area 5 Radioactive Waste Management Complex of 1.78 million cubic yards (1.36 million cubic meters) (as presented in DOE's December 30, 2014, ROD [79 FR 78421] for the NNSS SWEIS [DOE 2013a]). In addition, if DU oxide were disposed of in bulk bags, it would result in a similar disposal volume as DU oxide in cylinders, and therefore similar impacts on the capacity of the disposal facility. The volume-reduced empty and heel cylinders generated as a result of disposal of DU oxide in bulk bags would generate an additional waste stream estimated at 38,600 cubic yards or 2.2 percent of disposal capacity at NNSS.

Disposal at NNSS of empty and heel cylinders would represent about 4.4 percent of the NNSS LLW disposal capacity. The small quantities of ancillary LLW and MLLW from storage and maintenance of DU oxide cylinders would represent very small fractions of the NNSS LLW and MLLW disposal capacities. Disposal at NNSS of all CaF_2 would represent about 13 percent of the NNSS LLW disposal capacity. If all LLW associated with the Proposed Action were shipped to NNSS, it would represent about 39 percent of LLW disposal capacity.

DOE would coordinate with NNSS with respect to shipment scheduling to ensure that the appropriate personnel and equipment would be available to safely manage waste receipts. NNSS is capable of receiving waste only by truck shipment. Assuming NNSS received DU oxide cylinders from both Paducah and Portsmouth, the site could conservatively receive an average of 12 trucks per day, assuming all oxide was shipped from Paducah and Portsmouth by truck. This frequency of delivery could be addressed at NNSS under the current operational capability (equipment and personnel). Assuming the cylinders were delivered by train to an intermodal location to be transferred to trucks for delivery to NNSS, it could require multiple days for all cylinders from a given train shipment to be transported by truck from the intermodal location to NNSS. One of the features of the DU oxide shipments that would lead to efficient and timely disposal operations is their expected uniformity in terms of container shape, size, and waste content (see Section 4.2.3). Truck and train shipments would be scheduled to ensure the proper mix of personnel and equipment.

Similar to the discussion in Section 4.2.3, DOE expects that deliveries of empty and heel cylinders would be readily managed at NNSS given its existing personnel and equipment configuration. There would be an average of one truck delivery of intact empty and heel cylinders every work day from Paducah and Portsmouth. As discussed in Section 4.1.3, the projected volume of empty and heel cylinders could be reduced by volume reduction activities (e.g., compaction or shredding) at the disposal facility or a separate treatment facility. In addition, the void space within the cylinders would need to be addressed; this could be accomplished through volume reduction or other measures. Otherwise, assuming the same number of intact empty and heel cylinders was shipped by train from both Paducah and Portsmouth, trains with the cylinders would arrive about 8 times per year. Assuming 6 empty and heel cylinders per railcar and 10 railcars per train, each train shipment would contain 60 cylinders to be offloaded and transferred by truck to the designated disposal unit.

Also similar to the discussion in Section 4.2.3, the projected volumes of wastes generated from storage and maintenance of DU oxide cylinders are very small and could be managed at NNSS given its existing personnel and equipment configuration. The annual generation rate of LLW from these activities from both Paducah and Portsmouth could be sent to NNSS in a total of two truckloads. Annual volumes of MLLW could be shipped in a single 55-gallon drum from Paducah and a single 55-gallon drum from Portsmouth.

Similar to the discussion in Section 4.2.3, if HF cannot be sold and needs to be converted to CaF_2 and sent to a disposal facility, there would be an average of six truck deliveries (one bag per truck) of CaF_2 every work day from Paducah and Portsmouth. This was based on the assumption that only one bag would be transported on each truck. Otherwise, assuming the same number of bulk bags was shipped by train from both Paducah and Portsmouth, trains would arrive about one or two per work week.

4.4 DISPOSAL OF DEPLETED URANIUM OXIDE AND OTHER WASTES AT WASTE CONTROL SPECIALISTS

As described in Section 2.2.2.3, under the WCS Disposal Alternative, DU oxide and other wastes would be disposed of at WCS near Andrews, Texas. This section presents the estimated potential environmental impacts for this alternative including: (1) impacts from storage of DU oxide at Paducah and Portsmouth until shipment to WCS (Section 4.4.1); (2) impacts from transportation of DU oxide and other radioactive waste to WCS (Section 4.4.2); and (3) impacts on the LLW and MLLW disposal capacities at WCS (Section 4.4.3).

Many of the environmental impacts would be similar regardless of which disposal site (Energy*Solutions*, NNSS or WCS) receives the wastes from Paducah and Portsmouth. Therefore, some portions of the discussion of disposal of wastes at WCS (Section 4.4) refers back to sections of the Energy*Solutions* discussion (Section 4.2) rather than repeating the same information.

4.4.1 Impacts at Paducah and Portsmouth

DU oxide would be stored at Paducah and Portsmouth until it is shipped to WCS for disposal. The impacts of storage at Paducah and Portsmouth would be the same as the impacts described in Section 4.2.1 for the Disposal at Energy*Solutions* Alternative.

4.4.2 Transport of Depleted Uranium Oxide and Other Wastes to Waste Control Specialists

This section summarizes the potential impacts associated with the shipment of DU oxide and other wastes from Paducah and Portsmouth to WCS under incident-free and accident conditions. Section 4.2.2 summarizes the general transportation assumptions. Details of the analysis methodology and analytical results are presented in Appendix B.

Table 4-38 summarizes the potential transportation impacts from disposal of DU oxide at WCS. As indicated in Table 4-21, all risk values are less than one, except for nonradiological accident risk associated with train or truck shipments. This means that no LCFs would be expected during transport by truck or train, but a small number of traffic fatalities could result from nonradiological accidents. This is the result of the large number of transports over 34 years.

As discussed in Section 4.2.2, DU oxide cylinders could be shipped in ABC railcars instead of gondola railcars. The annual and total impacts of shipping in ABC railcars would be similar to or less than those of shipping in gondola railcars.

Table 4-38 Total Risks to Crew Members and the Public from Transporting Depleted Uranium Oxide in Cylinders to Waste Control Specialists

			Incident-Free				Accident	
			Crew		Population			
Origin	Number of Shipments[a]	One-way Kilometers Traveled	Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck								
Paducah	46,200	78,300,000	93	0.06	243	0.1	1×10^{-4}	6
Portsmouth	22,900	52,300,000	63	0.04	160	0.1	1×10^{-4}	4
Train								
Paducah	770	1,500,000	47	0.03	77	0.05	2×10^{-3}	0.7
Portsmouth	380	1,100,000	37	0.02	58	0.04	2×10^{-3}	0.4

Key: LCF = latent cancer fatality; nonrad = nonradiological; WCS= Waste Complex Specialists.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

Note: To convert kilometers to miles multiply by 0.62137.

Tables 4-39 and 4-40 summarize potential transportation impacts for shipment of empty and heel cylinders and other LLW and MLLW to WCS. Table 4-39 shows the transportation impacts assuming the empty and heel cylinders are transported intact. As indicated in Tables 4-39 and 4-30, all risk values are less than one. This means that no LCFs would be expected during transport by truck or train.

Table 4-39 Total Risks to Crew Members and the Public from Transporting Empty and Heel Cylinders to Waste Control Specialists

			Incident-Free				Accident	
			Crew		Population			
Origin	Number of Shipments[a]	One-way Kilometers Traveled	Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck								
Paducah	4,242	7,900,000	0.09	5×10^{-5}	0.2	1×10^{-4}	8×10^{-8}	0.5
Portsmouth	2,759	6,300,000	0.08	5×10^{-5}	0.2	1×10^{-4}	8×10^{-8}	0.4
Train								
Paducah	140	280,000	0.09	5×10^{-5}	0.1	8×10^{-5}	8×10^{-7}	0.07
Portsmouth	90	270,000	0.04	5×10^{-5}	0.1	8×10^{-5}	9×10^{-7}	0.1

Key: LCF = latent cancer fatality; nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

Note: To convert kilometers to miles multiply by 0.62137.

DOE is also considering the option of transporting DU oxide using bulk bags, consistent with the analysis presented in the 2004 EISs (DOE 2004a, 2004b). It is estimated that there would be 20,500 and 9,070 truck shipments and 513 and 227 train shipments from Paducah and Portsmouth, respectively, using consistent assumptions as those used in the 2004 EISs. Therefore, because the amount of DU oxide evaluated in this *DU Oxide SEIS* is larger than that evaluated in the 2004

EISs, the bulk bag shipment numbers presented in this SEIS are proportionally larger than those cited in the 2004 EISs. If the bulk bags are used, the empty and heel cylinders also need to be transported to the disposal sites. It is assumed that the cylinders would be volume-reduced and packaged 10 to a 20-foot (6-meter) intermodal container and transported one container per truck and two containers per railcar with 10 railcars per train. The 2004 EISs also considered that about 10 percent of the cylinders could not be accepted at the Energy*Solutions* site; therefore, these cylinders would be transported intact to NNSS. The risks of transporting the volume-reduced cylinders and those for the intact cylinders are calculated using the same assumptions used in Table 4-39 above.

Table 4-40 Annual Risks to Crew Members and the Public from Transporting Ancillary Low-Level Radioactive Waste and Mixed Level Radioactive Waste to Waste Control Specialists

Origin	Number of Shipments	One-way Kilometers Traveled	Incident-Free[a]				Accident[a]	
			Crew		Population			
			Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck[c]								
Paducah	1	1,700	2×10^{-4}	1×10^{-7}	1×10^{-4}	9×10^{-8}	4×10^{-14}	1×10^{-4}
Portsmouth	1	2,300	3×10^{-4}	2×10^{-7}	2×10^{-4}	1×10^{-7}	8×10^{-14}	2×10^{-4}

Key: LCF = latent cancer fatality; nonrad = nonradiological.

[a] Total risks can be estimated by multiplying by the maximum duration of the storage period for this alternative (76 years [44 + 32) for Paducah and 47 years (32 +15) for Portsmouth)

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because of the small amount of waste requiring shipment to the waste management facility, train transport would be inefficient and was not considered.

Note: To convert kilometers to miles multiply by 0.62137.

Tables 4-41 and **4-42** summarize the potential transportation impacts for shipping DU oxide in bulk bags, and the empty and heel cylinders to the WCS site, respectively. As indicated in Tables 4-40 and 4-41, all radiological risk values are less than 1. This means that no LCFs are expected to occur during transport by truck or train.

Furthermore, the impacts from the transport of CaF_2 from neutralization of HF to a LLW disposal facility are also estimated. It is estimated that there would be 32,400 truck shipments or 811 train shipments from Paducah and 13,600 truck shipments or 339 train shipments from Portsmouth to WCS. Although conservatively considered LLW for purposes of disposal, CaF_2 has such low levels of radiation it would provide a negligible dose to the crew and the public during transport. The estimated traffic fatalities from these shipments are summarized in **Table 4-43**.

Table 4-41 Total Risks to Crew Members and the Public from Transporting Depleted Uranium Oxide in Bulk Bags to Waste Control Specialists

Origin	Number of Shipments[a]	One-way Kilometers Traveled	Incident-Free				Accident	
			Crew		Population			
			Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck								
Paducah	20,500	34,800,000	45	0.03	151	0.09	1×10^{-4}	3
Portsmouth	9,070	20,700,000	27	0.02	89	0.05	1×10^{-4}	1
Train								
Paducah	510	1,000,000	41	0.02	60	0.04	3×10^{-3}	0.5
Portsmouth	230	700,000	29	0.02	42	0.03	3×10^{-3}	0.3

Key: LCF = latent cancer fatality; nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

Note: To convert kilometers to miles, multiply the kilometer numbers by 0.6215.

Table 4-42 Total Risks to Crew Members and the Public from Transporting Empty and Heel Cylinders to Waste Control Specialists

Origin	Number of Shipments[a]	One-way Kilometers Traveled	Incident-Free				Accident	
			Crew		Population			
			Dose (person-rem)	LCF[b]	Dose (person-rem)	LCF[b]	Radiological Risk[b]	Nonrad Risk[b]
Truck (volume-reduced to WCS)								
Paducah	4,920	8,300,000	6	0.004	2	0.001	4×10^{-7}	0.6
Portsmouth	2,550	5,800,000	4	0.003	2	0.001	4×10^{-7}	0.4
Truck (10% intact to NNSS)								
Paducah	2,730	8,758,800	0.1	0.00006	0.3	0.0002	4×10^{-8}	0.4
Portsmouth	1,420	5,298,000	0.06	0.00004	0.2	0.0001	3×10^{-8}	0.2
Train (volume-reduced to WCS)								
Paducah	250	500,000	0.7	0.0004	1	0.0007	6×10^{-7}	0.2
Portsmouth	130	380,000	0.5	0.0003	0.9	0.0005	7×10^{-7}	0.2
Train/Truck (10% intact to NNSS)[c,d]								
Paducah	2,820	1,223,000	0.1	0.00006	0.1	0.00008	4×10^{-7}	0.08
Portsmouth	1,470	679,000	0.1	0.0008	0.1	0.0007	8×10^{-7}	0.1

Key: LCF = latent cancer fatality; NNSS = Nevada National Security Site; Nonrad = nonradiological.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Risk is expressed in terms of LCF, except for nonradiological risk, where it refers to the number of traffic accident fatalities. Radiological risk is calculated for one-way travel, while nonradiological risk is calculated for two-way travel. Accident dose-risk can be calculated by dividing the risk values by 0.0006 (DOE 2003). The values were rounded to one non-zero digit.

[c] Because NNSS does not have a rail yard, the waste would be transported from a nearby rail yard (Barstow, California) to NNSS via truck.

[d] The intact cylinders represent transport of 10 percent of the total empty and heel cylinders, which are 83,000 (69,000 plus 14,000). The calculated doses and risks are based on the information provided in Table 4-22 of this *DU Oxide SEIS*, assuming that the intact cylinders are transported two per truck and 60 per train. These cylinders are transported to NNSS, when the disposal facility is other than NNSS. The train shipments to NNSS include 2,730 truck shipments from Paducah and 1,420 truck shipments from Portsmouth in addition to 90 and 50 train shipments from Paducah and Portsmouth, respectively.

Note: To convert kilometers to miles multiply by 0.62137.

Table 4-43 Total Population Transportation Risks for Shipment of CaF_2 to the Waste Control Specialists Site under the Hydrogen Fluoride Neutralization Option[a]

Origin	Paducah		Portsmouth	
Mode of Transport	**Truck**	**Train**	**Truck**	**Train**
Number of shipments[a]	32,400	810	13,600	340
Total distance (one-way [km])[b]	49,968,000	16,259,000	30,949,000	9,991,000
Traffic fatalities (round trip)	3.66	0.77	2.17	0.45

Key: km = kilometer.

[a] The number of shipments was rounded to the nearest 10 when greater than 1,000 and to the nearest 5 when less than 1,000.

[b] Although shipped to a LLW disposal facility, the CaF_2 would likely have little or no radioactivity; therefore, there would be negligible doses to the transportation crew and the public.

Impacts from Incident-Free Transport of Radioactive Waste

The potential radiological impacts on transport crews and populations along the routes are shown in Tables 4-38 through 4-40. The tables include the results of shipping all DU oxide and other wastes to WCS. As shown in Tables 4-38 through 4-40, transportation of DU oxide dominates the risks. Therefore, the impacts of shipping empty and heel cylinders and ancillary LLW and MLLW to WCS are not discussed further. In addition, CaF_2 is not discussed further because this material would contain little or no radioactivity, and therefore would not result in worker or public exposure.

Transport of DU oxide in cylinders results in the maximum impact on the transportation crew compared to transport of DU oxide in bulk bags, because there would be more shipments using cylinders. Transport of DU oxide to WCS would likely not result in any LCFs to crew members, as detailed in Table 4-38. For truck transport, the calculated LCF risk over the duration of the project would be less than 0.1, or less than 1 chance in about 10 of a single LCF among the transportation crews. For train transport, the calculated LCF risk over the duration of the project would be less than 0.05, or less than 1 chance in about 20 of a single LCF among the transportation crews.

Transport of DU oxide in cylinders results in the maximum impact on the general population compared to transport of DU oxide in bulk bags, because there would be more shipments using cylinders. However, as detailed in Table 4-38, the dose to the general population would likely not result in an LCF. For truck transport of DU oxide, the calculated LCF risk over the duration of the project would be 0.2, or 1 chance in 5 of a single LCF in the exposed population. For train transport, the calculated LCF risk over the duration of the project would be 0.1, or 1 chance in about 10 of a single LCF in the exposed population.

The total radioactive dose received by an MEI (a resident along the route near WCS), hypothetically assumed to be exposed to every DU oxide truck shipment over the duration of the project, would be about 2.14 millirem, resulting in an increased risk of developing an LCF of 1×10^{-6}, or 1 chance in 780,000. Assuming that shipments would occur over 32 years, the average annual dose to this individual would be 0.063 millirem, which is 0.063 percent of DOE's limit in DOE Order 458.1 of 100 millirem a year, for exposure to a member of the public.

Impacts of Transportation Accidents Involving Radioactive Waste

Two sets of analyses were performed to evaluate potential radiological transportation accident impacts: (1) all reasonably foreseeable accidents (total transportation accidents) and (2) maximum reasonably foreseeable accidents (accidents with radioactive release probabilities greater than 1×10^{-7} [1 chance in 10 million] per year). As indicated in Tables 4-38 through 4-40, considering all reasonably foreseeable accidents, transport of radioactive waste would likely result in no LCFs, but there could be nonradiological fatalities due to traffic accidents under the truck and train transportation options.

For maximum reasonably foreseeable accidents, transportation accident probabilities were calculated for all route segments (that is, rural, suburban, and urban), and consequences were determined for those shipment routes with a likelihood-of-release frequency exceeding 1 chance in 10 million per year. For DU oxide shipped under this alternative, the maximum reasonably foreseeable transportation accident with the highest consequence would involve train transport in an suburban area (see Appendix B, Table B-7). The probability of this train accident involving transport of DU oxide to WCS would be 4.1×10^{-6} per year in an urban area, or 1 chance in 244,000 each year. The consequences of the truck transport accident, if it occurred, in terms of population and MEI dose would be about 11 person-rem and 0.039 rem, respectively. These doses would likely result in no (calculated value of 0.007) additional LCFs among the exposed population and a risk of 2×10^{-5} that the MEI would develop an LCF. When the annual frequency of the accident occurring is taken into account, the increased risk of a single LCF in the exposed population would be negligible (calculated value of 3×10^{-8}).

Vehicle Emissions

Transport of DU oxide and other radioactive wastes to WCS would result in emissions from trains or trucks. It is expected that Paducah and Portsmouth would each make 24 train shipments of DU oxide annually. For shipment by truck, it is expected that Paducah and Portsmouth would each ship up to 1,440 truckloads per year. The intact empty and heel cylinders could be shipped via train in 4 annual shipments or via truck in 125 annual shipments. Transport of CaF_2 via train is assumed to be an additional 24 and 15 shipments annually from Paducah and Portsmouth, respectively. Shipment of CaF_2 via truck would result in an additional 953 and 616 shipments from Paducah and Portsmouth, annually.

The quantity of DU oxide in each truck or train shipment would vary depending on whether cylinders or bulk bags are used. If bulk bags were to be used, the total number of truck shipments of DU oxide would decrease, but the number of empty and heel cylinders to be shipped for disposal would increase. If the empty and heel cylinder were shipped intact, the total number of train shipments under the bulk bag shipment scenario would be more than the number of shipments utilizing DU oxide in cylinders. The analysis below represents the most conservative scenario (i.e., the largest quantity of emissions), and all other potential shipping scenarios would generate lower levels of emissions of both criteria pollutants and GHGs.

Train Option

Emissions were calculated to provide an estimate of the annual criteria pollutant emissions associated with shipments via train from Paducah and Portsmouth to WCS. It was estimated that locomotives would travel approximately 1,000 miles (1,700 kilometers) per shipment from Paducah to WCS and approximately 1,400 miles (2,300 kilometers) from Portsmouth to WCS. Emissions were calculated using emission factors for tier 2 line haul locomotives derived from the EPA's *Emission Factors for Locomotives* (EPA 2009).

Emissions of all criteria pollutants would be less than 23 tons (21 metric tons) annually for all shipments from Paducah and Portsmouth combined (see **Table 4-44**). Emissions would be spread across a large area, so it is not useful to compare to NEI baseline emissions for any particular AQCR. However, because the emissions are so small in comparison to overall vehicle emissions on both urban and rural highways and roads, the emissions are not likely to contribute to any significant impact on air quality.

Table 4-44 Criteria Pollutant Emissions from Transportation via Train to Waste Control Specialists

Material	Site	Criteria Pollutant Emissions (tons/year)					
		CO	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**VOC**
Ancillary LLW and MLLW	Paducah	0.09	0.34	0.01	0.01	0.01	0.02
	Portsmouth	0.11	0.41	0.01	0.01	0.01	0.02
	Total emissions	*0.19*	*0.75*	*0.03*	*0.03*	*0.01*	*0.04*
DU oxide in cylinders	Paducah	1.06	4.09	0.15	0.14	0.07	0.23
	Portsmouth	1.48	5.72	0.21	0.20	0.10	0.32
	Total emissions	*2.54*	*9.81*	*0.36*	*0.35*	*0.18*	*0.54*
14,000 empty and heel cylinders	Paducah	0.18	0.68	0.02	0.02	0.01	0.04
	Portsmouth	0.25	0.95	0.03	0.03	0.02	0.05
	Total emissions	*0.42*	*1.63*	*0.06*	*0.06*	*0.03*	*0.09*
DU oxide in bulk bags	Paducah	0.66	2.55	0.09	0.09	0.05	0.14
	Portsmouth	0.62	2.38	0.09	0.08	0.04	0.13
	Total emissions	*1.28*	*4.94*	*0.18*	*0.17*	*0.09*	*0.27*
69,000 empty and heel cylinders	Paducah	1.01	3.92	0.14	0.14	0.07	0.22
	Portsmouth	1.05	4.05	0.15	0.14	0.07	0.22
	Total emissions	*2.06*	*7.97*	*0.29*	*0.28*	*0.15*	*0.44*
CaF_2	Paducah	1.06	4.09	0.15	0.14	0.07	0.23
	Portsmouth	0.92	3.58	0.13	0.13	0.07	0.20
	Total emissions	*1.98*	*7.66*	*0.28*	*0.27*	*0.14*	*0.42*
Grand Total (DU Oxide in Cylinders)		**5.13**	**19.85**	**0.72**	**0.70**	**0.36**	**1.10**
Grand Total (DU Oxide in Bulk Bags)		**5.93**	**22.95**	**0.83**	**0.81**	**0.42**	**1.27**

Key: CaF2 = calcium fluoride; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Truck Option

Annual criteria pollutant emissions were calculated based on an estimated shipments from each facility to WCS (see **Table 4-45**). Analysis estimated approximately 1,000 miles (1,700 kilometers) per truck shipment from Paducah to WCS and approximately 1,400 miles (2,300 kilometers) per shipment from Portsmouth to WCS via truck. Emissions were derived using the emission factors for heavy-duty diesel vehicles in the EPA's MOVES2014a. MOVES is the EPA Motor Vehicle Emission Simulator. It is used to create emission factors or emission inventories for both onroad motor vehicles and nonroad equipment (EPA 2015).

Under the truck option, emissions of all criteria pollutants would be less than 39 tons (35 metric tons) annually for all shipments from Paducah and Portsmouth combined. These emissions would be spread across a large area, so it is not useful to compare to NEI baseline emissions for any particular AQCR. Although the EPA does separately track commercial versus other mobile sources of criteria pollutants, the national on-road emissions associated with heavy-duty diesel vehicles and heavy-duty gasoline vehicles from the 2014 NEI (EPA 2019) are provided for comparison in Table 4-9. Because the criteria pollutant emissions from transportation of wastes to WCS are so small in comparison to overall U.S. heavy-duty vehicle emissions, the emissions are not likely to contribute to any significant impact on air quality.

Table 4-45 Criteria Pollutant Emissions from Transportation via Truck to Waste Control Specialists

Material	Site	Criteria Pollutant Emissions (tons/year)					
		CO	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**SO_x**	**VOC**
Ancillary LLW and MLLW	Paducah	0.08	0.24	0.01	0.01	0.00	0.02
	Portsmouth	0.08	0.24	0.01	0.01	0.00	0.02
	Total emissions	*0.17*	*0.48*	*0.02*	*0.02*	*0.00*	*0.05*
DU oxide (cylinders)	Paducah	3.43	9.79	0.36	0.33	0.02	1.02
	Portsmouth	4.81	13.71	0.50	0.46	0.03	1.43
	Total emissions	*8.24*	*23.50*	*0.86*	*0.79*	*0.05*	*2.45*
14,000 empty and heel cylinders	Paducah	0.30	0.85	0.03	0.03	0.00	0.09
	Portsmouth	0.42	1.19	0.04	0.04	0.00	0.12
	Total emissions	*0.72*	*2.04*	*0.07*	*0.07*	*0.00*	*0.21*
DU oxide (bulk bags)	Paducah	1.44	4.10	0.15	0.14	0.01	0.43
	Portsmouth	1.38	3.92	0.14	0.13	0.01	0.41
	Total emissions	*2.81*	*8.02*	*0.29*	*0.27*	*0.02*	*0.84*
69,000 empty and heel cylinders	Paducah	1.62	4.62	0.17	0.15	0.01	0.48
	Portsmouth	1.73	4.94	0.18	0.17	0.01	0.51
	Total emissions	*3.35*	*9.56*	*0.35*	*0.32*	*0.02*	*1.00*
CaF_2	Paducah	2.27	6.48	0.24	0.22	0.01	0.68
	Portsmouth	2.06	5.86	0.21	0.20	0.01	0.61
	Total emissions	*4.33*	*12.34*	*0.45*	*0.41*	*0.03*	*1.29*
Grand Total (DU Oxide in Cylinders)		**13.45**	**38.36**	**1.40**	**1.29**	**0.09**	**4.00**
Grand Total (DU Oxide in Bulk Bags)		**11.37**	**32.44**	**1.18**	**1.09**	**0.07**	**3.38**

Key: CaF2 = calcium fluoride; CO = carbon monoxide; NO_2 = nitrogen dioxide; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compounds.

Greenhouse Gases

Estimating approximately 1,000 miles (1,700 kilometers) per train shipment from Paducah to WCS, approximately 116 tons (105 metric tons) of GHG emissions (measured as CO_2e) would be produced annually (CNR 2016) (see **Table 4-46**). Estimating approximately 1,400 miles (2,300 kilometers) per train shipment from Portsmouth to WCS, approximately 116 tons (105 metric tons) of GHG emissions would be produced annually (CNR 2016). Total annual GHG emissions from shipping DU oxide and other wastes to the disposal facilities by train would be

Table 4-46 Annual GHG Emissions from the Transport of DU Oxide to Waste Control Specialists

Site	GHG Emissions (tons per year CO_2e)	
	Train Option	Truck Option
Paducah[a]	116	4,309
Portsmouth[b]	116	5,219
Total	**232**	**9,528**
National Train Emissions[c]	45,300,000	NA
National Truck Emissions[c]	NA	467,400,000

Key: CO_2e = carbon dioxide equivalents; GHG = greenhouse gas; NA = not applicable.

[a] The train and truck options both include emissions from truck shipment for disposal of LLW, MLLW, and empty and heel cylinders as discussed in Section 4.1.2 for the No Action Alternative.

[b] Source: CNR 2016

[c] Source: EPA 2018d

232 tons (210 metric tons), which would be minimal in terms of the national GHG emissions from railway transportation, which total 45.3 million tons (41.1 million metric tons) annually (EPA 2018d).

Estimating approximately 1,000 miles (1,700 kilometers) per truck shipment from Paducah to WCS, approximately 4,309 tons (3,909 metric tons) of GHG emissions would be produced annually (CNR 2016). Estimating approximately 1,400 miles (2,300 kilometers) per shipment from Portsmouth to WCS, approximately 5,219 tons (4,734 metric tons) of GHG emissions would be produced annually (CNR 2016). Total annual GHG emissions from truck shipments (9,528 tons [8,644 metric tons]) would be minimal in terms of the national GHG emissions from truck transportation, which total 467.4 million tons (424.0 million metric tons) annually (EPA 2018d).

4.4.3 Impacts on Disposal Capacity at Waste Control Specialists

This section describes the impacts on the disposal capacity at WCS. Other potential environmental impacts of disposal at WCS are not analyzed in this *DU Oxide SEIS*. As long as the waste to be disposed of is within the authorized capacity and waste acceptance criteria of the disposal facility, it is assumed that the impacts of disposal have been considered and found to be acceptable as part of the licensing and permitting process for the facility. Chapter 5, Section 5.4.3, briefly describes the licenses and permits held by WCS. WCS operating licenses and permits are available for review at http://www.wcstexas.com/facilities/licenses-and-permits/.

The disposal of DU oxide, ancillary LLW and MLLW from storage and maintenance of DU oxide cylinders, empty and heel cylinders, and CaF_2, would not exceed the disposal capacity for the WCS FWF, even if WCS received this waste from both Paducah and Portsmouth. The volumes of DU oxide, waste from storage and maintenance of DU oxide cylinders, empty and heel cylinders, and CaF_2, would be the same as those stated in Section 4.2.3.

Table 4-47 shows the waste volumes and percent of disposal capacity under the Disposal of Waste at Waste Control Specialists Alternative. As shown in Table 4-47, delivery of all DU oxide to WCS would represent about 40 percent of the disposal capacity of the FWF. In addition, if DU oxide were disposed of in bulk bags, it would result in a similar disposal volume as DU oxide in cylinders, and therefore similar impacts on the capacity of the disposal facility. The volume-reduced empty and heel cylinders generated as a result of disposal of DU oxide in bulk bags would generate an additional waste stream estimated at 38,600 cubic yards or 4 percent of disposal capacity at WCS.

Disposal of empty and heel cylinders would represent about 8.2 percent of the disposal capacity of the FWF. The small quantities of ancillary LLW and MLLW from storage and maintenance of DU oxide cylinders would represent only small fractions of the disposal capacity for the FWF. Disposal at WCS of all CaF_2 would represent about 24 percent of the LLW disposal capacity of the FWF. If all waste associated with the Proposed Action were shipped to WCS, it would represent about 72 percent of the LLW disposal capacity of the FWF.

Similar to the discussion for Energy*Solutions* (Section 4.2.3), DOE would coordinate shipment scheduling with WCS to ensure that the appropriate personnel and equipment are available to safely manage waste receipts. WCS routinely receives waste by both truck and train delivery. Assuming WCS received DU oxide from both Paducah and Portsmouth, WCS could conservatively receive an average of 12 trucks per day, assuming all oxide was delivered by truck, or 4 trains a month, assuming all oxide was delivered by train. DOE expects that WCS would have little difficulty in accommodating either shipment mode. DOE expects that an average of 12 trucks per day or 4 trains per month would be within the range of truck and train shipments that routinely arrive at WCS. The small quantity of DU oxide shipped in drums could be delivered in a few annual truck loads or with the train shipments of DU oxide cylinders which would be easily managed at WCS.

Table 4-47 Waste Volumes and Percent of Disposal Capacities under the Disposal of Waste at Waste Control Specialists Alternative

Waste			Waste Volume (cubic yards)[a]	Disposal Capacity (cubic yards)[b]	Percent of Disposal Capacity
LLW – DU oxide	In cylinders[c]		386,000[c]	955,000	40
	Bulk bag option	In bulk bags	386,000	955,000	40
		Volume-reduced empty and heel cylinders	38,600	955,000	4
LLW – empty and heel cylinders			78,300[d]	955,000	8.2
Ancillary LLW[e]			230	955,000	0.024
Ancillary MLLW[e]			1.5	955,000	0.00016
LLW – CaF_2 option			225,000	955,000	24

Key: DU = depleted uranium; FWF = Federal Waste Facility; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste.

[a] Source: PPPO 2018.

[b] It is assumed that LLW, MLLW, and DU oxide waste would be disposed of in the FWF at WCS, which has a total capacity of about 963,000 cubic yards (736,000 cubic meters), of which about 7,550 cubic yards (5,780 cubic meters) had been used as of August 2016 (see Chapter 3, Table 3-29).

[c] Determined assuming 69,000 DU oxide cylinders each measuring 4 feet (1.2 meters) in diameter and 12 feet (3.7 meters) long; plus approximately 161 cubic yards (123 cubic meters) of DU oxide in drums.

[d] The listed volume of the empty and heel cylinders is the envelope volume of the cylinders. Waste volumes may be significantly reduced if the cylinders were volume-reduced (e.g., compacted or shredded) at the disposal facilities or a separate waste treatment facility.

[e] It is assumed for analysis that all waste from storage and maintenance of DU oxide cylinders from both Paducah and Portsmouth would be disposed of at WCS. Waste volumes from oxide storage and maintenance were determined assuming these activities would last for 76 years (44 years of storage and 32 years of shipping) at Paducah and 47 years (32 years of storage and 15 years of shipping)at Portsmouth.

Note: To convert cubic yards to cubic meters, multiply by 0.76456.

Similar to the discussion in Section 4.2.3, DOE expects that deliveries of empty and heel cylinders would be readily managed at WCS given its existing personnel and equipment configuration. There would be an average of one truck delivery of intact empty and heel cylinders every work day from Paducah and Portsmouth. As discussed in Section 4.1.3, the projected volume of empty and heel cylinders could be reduced by volume reduction activities (e.g., compaction or shredding) at the disposal facility or a separate treatment facility. In addition, the void space within the cylinders would need to be addressed; this could be accomplished through volume reduction or other measures. Otherwise, assuming the same number of intact empty and heel cylinders was shipped by train from both Paducah and Portsmouth, trains with the cylinders would arrive about 8 times per year. Assuming 6 empty and heel cylinders per railcar and 10 railcars per train, each train shipment would contain 60 cylinders to be offloaded and transferred to the designated disposal unit.

As also discussed in Section 4.2.3, the projected volumes of waste from DU oxide storage and maintenance activities are very small and could be managed at WCS given its existing personnel and equipment configuration. The annual generation rate of LLW from these activities from both Paducah and Portsmouth could be sent to WCS in a total of two truckloads. Annual volumes of MLLW could be shipped in a single 55-gallon drum from Paducah and a single 55-gallon drum from Portsmouth.

Similar to the discussion in Section 4.2.3, if HF cannot be sold and needs to be converted to CaF_2 and sent to a disposal facility, there would be an average of six truck deliveries per work day or one to two train deliveries per work week of CaF_2 from Paducah and Portsmouth.

4.5 CUMULATIVE IMPACTS

4.5.1 Issues and Assumptions

CEQ regulations define cumulative impacts as the effects on the environment that result from implementing the Proposed Action or any of its alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the other actions (40 CFR 1508.7). Thus, the cumulative impacts of an action can be viewed as the total impact on a resource, ecosystem, or human community of that action and all other activities affecting that resource irrespective of the source. Noteworthy cumulative impacts can result from individually small, but collectively significant, effects of all actions.

Cumulative impacts were assessed by combining the effects of alternative activities evaluated in this *DU Oxide SEIS* with the effects of other past, present, and reasonably foreseeable actions in the ROI. These actions may occur at different times and locations and may not be truly additive. The effects were combined irrespective of the time and location of the impact, to envelop any uncertainties in the projected activities and their effects. This approach produces a conservative estimation of cumulative impacts for the activities considered.

As described in Chapter 4, Sections 4.1.1 and 4.2.1, the alternatives evaluated in this *DU Oxide SEIS* would cause little to no impacts on site infrastructure; air quality and noise; geology and soils; water, biotic, and cultural resources; socioeconomics; land use; aesthetics, and environmental justice, near Paducah and Portsmouth. Because the alternatives would produce little or no impacts on these resource areas, they would not substantially contribute to cumulative impacts. Thus, this section analyzes cumulative impacts on the remaining areas of public and occupational health and safety and waste management for the Paducah (Section 4.5.2) and Portsmouth (Section 4.5.3). In addition, nationwide cumulative impacts on transportation air quality and climate change are discussed in Section 4.5.4.

Also note that under the Action Alternatives, the impacts of management of the DU oxide at Paducah and Portsmouth would cease after the material is shipped off site for reuse or disposal. This is in contrast to the No Action Alternative, where storage of the DU oxide at Paducah and Portsmouth was assumed to occur for 100 years and could continue indefinitely.

On November 19, 2019, DOE published the *Supplement Analysis (SA) for Bulk Hydrogen Storage Construction and Operation at the Paducah and Portsmouth DUF$_6$ Sites* (DOE/EIS-0359-SA-02 and EIS-0360-SA-02) (DOE 2019). The action analyzed in that SA, installation and operation of a bulk hydrogen storage backup supply to the plant hydrogen supply system at each conversion facility such that uninterrupted hydrogen supply is maintained for plant operations, would not affect the quantity of DU oxide conversion product or other materials that would be dispositioned in the action analyzed in this *DU Oxide SEIS*, would not substantially change the impacts of conversion facilities operation, and therefore would not substantially contribute to cumulative impacts.

4.5.2 Paducah Site

DOE's mission involves the following ongoing activities at Paducah (DOE 2004a, 2017a):

- Continued management of DUF$_6$ cylinders,
- Operation of the DUF$_6$ to DU oxide Conversion Facility,
- Storage and management of cylinders containing DU oxide conversion product,
- Waste Management, and
- Decontamination, Decommissioning, and Demolition of facilities
- Environmental Remediation.

The affected environment information presented in Chapter 3 of this *DU Oxide SEIS* reflects the impacts of ongoing activities at Paducah. Reasonably foreseeable future activities that are being considered for Paducah include:

- Disposal of waste in an on-site disposal facility,
- Land and facilities transfers,
- Conversion of additional commercially generated DUF$_6$, and
- Construction of a laser enrichment facility.

4.5.2.1 Disposal of Waste in an On-Site Disposal Facility

DOE is addressing options for management of waste that will be generated from further cleanup of Paducah. Cleanup of Paducah is estimated to generate 3.6 million cubic yards (2.8 million cubic meters) of demolition debris, metals, soils, asbestos and other material (see Table 3-10 in Chapter 3). DOE is using the CERCLA process to make a decision on disposition of this waste. DOE is evaluating three alternatives: (1) No Action (no changes to current waste disposal practices); (2) Off-Site Disposal; and (3) On-Site Disposal. The On-Site Disposal Alternative includes on-site disposal in a CERCLA waste disposal facility (PPPO 2016). Sufficient information is not available on the environmental impacts of the various disposal alternatives to include in this cumulative impacts analysis.

4.5.2.2 Land and Facilities Transfers

In the *Paducah Gaseous Diffusion Plant Final Environmental Assessment for Potential Land and Facilities Transfers, McCracken County, Kentucky* (DOE 2015b), DOE evaluated the potential transfer of GDP property to one or more entities for uses that could be different from its current use. The Proposed Action would reduce the footprint of the Paducah Site, which would reduce the cost to maintain the site. In December 2015 DOE issued a Finding of No Significant Impact (FONSI) for the Proposed Action (DOE 2015i).

4.5.2.3 Conversion of Additional Commercially Generated DUF_6

As described in Chapter 1, Section 1.4, commercial uranium enrichment facilities may request that DOE disposition their DUF_6. Section 3113(a) of the USEC Privatization Act (42 U.S.C. §§ 2297h-11(a)) and Section 66 of the Atomic Energy Act of 1954 (as amended), requires DOE to accept commercial DUF_6 that has been determined to be LLW, for disposal upon request and reimbursement of cost by any generator licensed by NRC to operate a uranium enrichment facility.

To estimate the contribution to cumulative impacts from the potential management of commercial DUF_6 at Paducah, DOE has assumed that 150,000 metric tons (approximately 12,500 cylinders) of commercial DUF_6 would be managed. The detailed analysis of the impacts of the receipt, handling, conversion, storage, and disposal of commercial DUF_6 is presented in Appendix C of this SEIS. Where appropriate, the impacts of the management of commercial DUF_6 at Paducah are summarized in this cumulative impacts analysis.

4.5.2.4 Construction and Operation of a Laser Enrichment Facility

In November, 2016, DOE announced that GE-Hitachi Global Laser Enrichment is evaluating construction of a laser enrichment facility adjacent to the Paducah Site. DOE has agreed to sell DU to GE-Hitachi Global Laser Enrichment over a 40-year period which would be enriched at a proposed facility to produce uranium-235 to be used for production of fuel for commercial nuclear power reactors. GE-Hitachi Global Laser Enrichment would finance, construct, own and operate the Paducah Laser Enrichment Facility adjacent to Paducah. The facility would be a commercial uranium enrichment facility licensed by NRC. The construction and operation of the billion-dollar facility could bring approximately 800 to 1,200 jobs to the local community (PPPO 2016). Although, sufficient information is not available to determine the environmental impacts of this proposal, it would not be expected to exceed the impacts of historic operations at Paducah.

4.5.2.5 Other Off-Site Actions

Other actions occurring near Paducah that could contribute to current and future cumulative impacts include:

- Electrical power generation at the TVA's Shawnee Power Plant,
- Electrical power generation at the Electric Energy, Inc., power plant (Joppa Plant) in Joppa, Illinois,
- Conversion of uranium ore to UF_6 at the Honeywell International, Inc., uranium conversion plant in Metropolis, Illinois, and
- Development of the Ohio River Triple Rail Megasite.

The Tennessee Valley Authority (TVA) Shawnee Fossil Plant abuts the northeastern boundary of Paducah and has nine active generating units that burn about 9,600 tons (8,700 metric tons) of coal per day. The Shawnee Fossil Plant produces electricity by heating water in coal-fired boilers to produce steam that flows into a turbine that spins a generator to make electricity. The Shawnee Fossil Plant generates about 8 billion kilowatt-hours of electricity a year, enough to supply 540,000 homes (DOE 2015b). TVA has recently installed scrubbers and Selective Catalytic Reduction systems at two of the Shawnee Fossil Plant's units to control emissions (TVA 2018). These systems are expected to reduce emissions of NO_x and SO_2 by approximately 22 percent. On April 17, 2015, the EPA established national criteria and schedules for the management and closure of Coal Combustion Residuals (coal ash) facilities (80 FR 21302). The Shawnee Fossil Plant's approximately 200 acre (81 hectares) special waste landfill will be closed pursuant to these regulations (TVA 2016).

Electric Energy operates a six-unit coal-fired generating plant in Joppa, Illinois, (Joppa Plant) with a total generating capacity of 1,086 MW, and two gas turbines with a total capacity of approximately 74 MW. Eight miles (13 kilometers) of 161 kV transmission lines connect the Joppa Plant and Paducah (FERC 2013). The Joppa Plant is approximately 4.5 miles (7.2 kilometers) northwest of the nearest boundary of Paducah.

Honeywell's Metropolis Works converts uranium ore into UF_6. UF_6 is used to produce enriched uranium for use as fuel in nuclear power plants. The site is located on approximately 950 acres (384 hectares) of land in Massac County, Illinois. Plant operations are conducted in a fenced, restricted area covering approximately 59 acres (24 hectares) in the north-central portion of the site. The Metropolis Works operates under a license from NRC. The facility has the capacity to convert approximately 15,000 metric tons (16,500 tons) of uranium per year from ore concentrates into UF_6 (Enercon 2017). Honeywell's Metropolis Works employed 250 people (Honeywell 2016). As a result of a downward trend in the uranium fuel market, Honeywell temporarily idled production of the Metropolis Works in November 2017, while maintaining minimal operations to support a future restart should business conditions improve. Because of this, the company intended to reduce the full-time workforce at the plant by 170 positions (Honeywell 2018; PPPO 2018). However, for purposes of conservative cumulative impacts analysis, DOE has assumed that

Honeywell's Metropolis Works will continue to operate. The Metropolis Works is approximately 2.5 miles (4 kilometers) northeast of the nearest boundary of Paducah.

Paducah Economic Development, which is the economic development agency for Paducah and McCracken County, has identified 1,112 acres (450 hectares) of previously undeveloped land adjacent and to the northeast of Paducah as a location for a future development called the Ohio River Triple Rail Megasite. The TVA Shawnee Fossil Plant lies to the west of this site. The proposed development would include industrial and commercial uses. As proposed, development activities would include construction of a rail spur and a barge dock. No details are available of specific proposals for development (DOE 2015b; PED 2018). Therefore, analysis of the impacts of this future action would be speculative.

4.5.2.6 Results

The results of the cumulative impacts analyses for Paducah are summarized in **Table 4-48**. The second and third data columns of the table summarize the results of the assessment of impacts of alternatives presented in Sections 4.1.1 and 4.2.1 of this *DU Oxide SEIS*. The fourth and fifth data columns summarize the results of the impacts from the two scenarios for conversion of commercial DUF_6 that were evaluated and presented in Appendix C of this SEIS. The next column summarizes the impacts from other actions at Paducah and in the vicinity, particularly the impacts from DD&D of the conversion capabilities. The last two data columns identify the anticipated cumulative impacts of the alternatives when added to existing conditions and other reasonably foreseeable actions. For conservative analysis, the cumulative impacts for both the No Action and Action Alternatives include the impacts from conversion of commercial DUF_6 (that is, it is assumed that cumulative impacts for the Action Alternatives include the impacts from the commercial Conversion and Disposal Scenario, while the cumulative impacts for the No Action Alternative include the impacts from the commercial Conversion and Storage Scenario.

Table 4-48 Annual Cumulative Impacts at the Paducah Site

Impact Category	Existing Conditions[a]	*DU Oxide SEIS* Alternatives[b]		Commercial Conversion Scenarios[c]		Other Actions[d]	Cumulative Impacts[e]	
		Action Alternatives	No Action Alternative	Conversion and Disposal	Conversion and Storage		Action Alternatives	No Action Alternative
Public and Occupational Safety and Health								
Worker dose[f] (person-rem/yr)	6.2	3.6	1.2	16	17	14.7[g]	40.5	39.1
Worker LCF	0 (0.004)	0 (2×10^{-3})	0 (7×10^{-4})	0 (0.01)[j]	0 (0.01)[j]	0 (0.01)[g]	0 (0.01)	0 (0.01)
Public dose (person-rem/yr)	0.89	0.01	0.01	0.003	0.003	3.81[g]	4.7	4.7
Public LCF	0 (0.0005)	0 (5×10^{-6})	0 (5×10^{-6})	0 (2×10^{-6})	0 (2×10^{-6})	0 (0.002)[g]	0 (0.003)	0 (0.003)
Off-site MEI dose (millirem/yr)	4.5	5.0	5.0	0.2	0.2	0.57[g]	6.1[h,i]	6.1[h,i]
Waste Management								
LLW (including empty and heel cylinders and CaF_2) (yd^3/yr)	210	6,030[j]	6,030[j]	5,180	5,180	92[k]	6,030[l]	6,030[l]
MLLW (yd^3/yr)	1.4	0.014	0.014	0.014	0.014	52[k]	52[l]	52[l]

Key: DD&D = decontamination, decommissioning, and demolition; DU = depleted uranium; LCF = latent cancer fatality; LLW = low-level radioactive waste; MEI = maximally exposed individual; MLLW = mixed low-level radioactive waste; OSWDF = On-Site Waste Disposal Facility; SEIS = supplemental environmental impact statement; yd^3 = cubic yard; yr = year.

[a] Based on information presented in Chapter 3, Section 3.1, of this *DU Oxide SEIS*.

[b] Based on results presented in Chapter 4, Sections 4.1.1 and 4.2.1 of this *DU Oxide SEIS*.

[c] Impacts from the conversion of 150,000 metric tons (165,000 tons) of commercial DUF_6 and storage or disposal of the converted commercial DU oxide (see Appendix C of this *DU Oxide SEIS*).

[d] Includes impacts of other actions as described in Section 4.5.2 of this *DU Oxide SEIS*.

[e] Cumulative impacts equal the sum of the impacts of the management alternative and other past, present, and reasonably foreseeable future actions. The cumulative impacts of the Action Alternatives include the sum of existing conditions; *DU Oxide SEIS* alternatives – Action Alternatives; commercial conversion scenarios – Conversion and Disposal; and other actions. The cumulative impacts of the No Action Alternative include the sum of existing conditions; *DU Oxide SEIS* alternatives – No Action Alternative; commercial conversion scenarios – Conversion and Storage; and other actions. This is a conservative assumption because some site activities are counted twice and some will not occur concurrently. For example: (1) LLW and MLLW from existing conditions include wastes generated from conversion of DOE DUF_6 to DU oxide and (2) conversion of DOE DUF_6 to DU oxide may not occur in the same years that conversion of commercial DUF_6 to DU oxide would occur.

[f] Includes involved and noninvolved worker doses.

[g] Impacts from operation of the Honeywell Metropolis Works, a uranium conversion facility in Metropolis, Illinois (Enercon 2017; NRC 2006).

[h] The MEI doses occur at different locations for different facilities. Therefore, adding the MEI doses is a very conservative estimate of potential cumulative doses to an MEI.

[i] The off-site MEI dose reported in Section 3.1.6 of this SEIS for existing conditions and in Sections 4.1.1.6 and 4.2.1.6 for each of the alternatives includes the same direct radiation dose from cylinders stored in the cylinder yard (4.2 millirem per year). When calculating the cumulative MEI dose, this direct exposure was only counted once.

[j] The increased generation of LLW during the alternatives primarily reflects the assumed increased generation of LLW in the form of empty and heel cylinders and CaF_2 (PPPO 2018). DU oxide is not considered in this estimate because it is a resource until shipped off site for disposal.

[k] Reflects generation of LLW and MLLW from DD&D of the oxide conversion capability (DOE 2004a). Approximately 3.2 million cubic yards (2.5 million cubic meters) of lightly contaminated LLW, 70,708 cubic yards (54,060 cubic meters) of MLLW, and 356 cubic yards (272 cubic meters) of TSCA waste could be generated from future environmental restoration and DD&D activities over the period from 2018 through 2065 (see Chapter 3, Table 3-10). DOE is currently evaluating the potential to dispose of 3.2 million cubic yards of lightly contaminated LLW in the OSWDF.

[l] The scenarios for conversion of commercial DUF_6 were not added to the cumulative annual impacts because the majority of these activities would not take place at the same time as the management of DOE DU oxide. Therefore, only the maximum values among the *DU Oxide SEIS* alternatives, other actions such as conversion capability DD&D, and the commercial conversion scenarios were used in the totals.

Sources: DOE 2004a; PPPO 2018

Human Health During Normal Operations

For the No Action and the Action Alternatives, impacts to human health and safety would be low. As shown in Table 4-47, the cumulative collective radiological exposure to the off-site population would be well below the maximum DOE dose limit of 100 millirem per year to the off-site MEI for both the No Action and Action Alternatives and below the limit of 25 millirem per year specified in 40 CFR 190 for uranium fuel cycle facilities. Doses to individual involved workers would be below the regulatory limit of 5,000 millirem per year (10 CFR Part 835) and less than an administrative limit of 2,000 millirem per year (DOE 2017f).

As described in Chapter 4, Sections 4.1.1 and 4.2.1, impacts associated with chemical exposure are expected to be very small under the No Action and Action Alternatives. Impacts from the cumulative exposure to chemicals are unlikely due to regulations that limit the release of hazardous chemicals, and the distances to other potential sources of these chemicals. The calculation of cumulative impacts is not possible because of the absence of necessary measures (chemical concentrations or hazard indices) for the other actions.

Human Health Under Accident Scenarios

For the No Action and the Action Alternatives, doses and consequences of releases of radiological materials were considered for a range of accidents from likely (occurring an average of 1 or more times in 100 years) to extremely rare (occurring an average of less than once in a million years). Because of the low probability of two accidents happening at the same time, the consequences of these accidents are not considered to be cumulative. The probability of likely accidents occurring at the same time is very low, even for the most frequently expected accidents, because this risk is the product of their fractional probabilities (1 in 100 years multiplied by 1 in 100 years equals both occurring 1 in 10,000 years [$0.01 \times 0.01 = 0.0001$]). In the unlikely event that two facility accidents from the likely category occurred at the same time, the consequences for the public would be low. The additive impacts would result in no chemical effects and no LCFs (DOE 2004a).

Waste Management

Cumulative annual waste generation is presented in Table 4-48. As described in Section 3.1.8, Paducah would continue to generate a variety of wastes from ongoing activities. Radioactive wastes (primarily LLWs) would be generated from management of DUF_6 cylinders and other site activities including conversion of DUF_6 to DU oxide. As described in Sections 4.1.1.8 and 4.2.1.8, the alternatives evaluated in this *DU Oxide SEIS* would generate small quantities of ancillary LLW and MLLW, LLW in the form of empty and heel cylinders, and potentially LLW from conversion of HF to CaF_2. Additional ancillary LLW and MLLW, and CaF_2 would be generated if DOE converts 150,000 metric tons (165,000 tons) of commercial DUF_6 to DU oxide and then stores or disposes of the oxide. As addressed in Section 3.1.8, these wastes would be shipped to off-site facilities for treatment and/or disposal. After DUF_6 to DU oxide conversion activities are complete, the conversion capability would be deactivated, decontaminated, and demolished. These wastes would be treated and/or disposed of in authorized facilities that are operating at that time.

Paducah activities will continue to generate waste from environmental restoration and DD&D activities: in the future generation rates could exceed current levels. Remediation of Paducah is being conducted in accordance with the CERCLA process. Through this process, DOE has projected that environmental restoration and DD&D activities at Paducah will generate approximately 3.6 million cubic yards (2.752 million cubic meters) of demolition debris, metals, soils, asbestos, and other material (see Table 3-10 in Chapter 3). Much of this waste is expected to be classified as LLW. Alternatives for on- or off-site disposal of this waste are being considered in accordance with the CERCLA process (DOE 2016d).

The cumulative quantities of wastes generated from activities at Paducah would be managed using existing and new on-site and off-site capabilities and would not be expected to result in substantial cumulative impacts to the waste management infrastructure. See Section 4.5.4 for a discussion of cumulative impacts of waste disposal at Energy*Solutions*, NNSS, and WCS.

4.5.3 Portsmouth Site

Ongoing actions at Portsmouth include (DOE 2004b, 2016c):

- Continued management of DUF_6 cylinders,
- Operation of the DUF_6 to DU oxide Conversion Facility,
- Storage and management of cylinders containing DU oxide conversion product,
- Decontamination, Decommissioning, and Demolition,
- Waste management, and
- Environmental remediation, including operation of the OSWDF.

The affected environment information presented in Chapter 3 of this *DU Oxide SEIS* reflects the impacts of ongoing activities at Portsmouth. Centrus Energy Corp. (Centrus), formerly USEC, Inc., operated the American Centrifuge Plant, a small-scale demonstration centrifuge for uranium enrichment at Portsmouth since 2006 (DOE 2017c). In 2016, Centrus Energy announced that it would shut down the American Centrifuge Plant (Balusik 2016). More than 230 employees worked at the plant at the time the announcement was made (Balusik 2017). The American Centrifuge Plant is shut down (PPPO 2018). Because this is a relatively recent development, much of the affected environment information presented in Chapter 3 of this *DU Oxide SEIS* still reflects the impacts of operation of this facility. This will not have a substantive affect on the analysis or conclusions in this SEIS.

On January 23, 2020, DOE/NNSA amended DOE’s previous decision (69 FR 44649) and will install the fourth DUF_6 conversion line, analyzed in the 2004 Portsmouth EIS, and will slightly alter the process when reacting the DUF_6 to produce DUF_4 (85 FR 3903). The resulting DUF_4 will be provided to a commercial vendor for additional processing. This decision does not affect the quantity of DUF_6 to be converted, and a negligible amount, of approximately 2 percent, of the DU oxide product would be replaced with DUF_4. Co-products of the conversion process would remain substantially unchanged, although slightly less HF would be generated during conversion to DUF_4 as compared to conversion to DU oxide. The total amount of DU planned for transport would remain largely unchanged from quantities evaluated in the 2004 Portsmouth EIS; however, the form of a small percentage of the transported material would change. Non-accident radiological impacts from handling/transportation of DUF_4 and DU oxide are comparable. This potential change would not represent a substantial change relevant to environmental concerns. The proposed conversion to DUF_4 would slightly reduce the actual DU oxide quantity that would need to be transported and dispositioned (i.e., sold, re-used or disposed of as waste) under the proposed action in this *DU Oxide SEIS*, as a quantity of DUF_6 would be converted to DUF_4 instead of DU oxide. Because the same amount of total DU (in the form of DU oxide and DUF_4) will be transported from Portsmouth, the cumulative impacts analyzed in this *DU Oxide SEIS* would remain substantially the same.

Reasonably foreseeable future activities that are being considered for Portsmouth include (DOE 2004b):

- Disposal of waste in an on-site disposal facility,
- Land and facilities transfer, and
- Conversion of additional commercially generated DUF_6.

4.5.3.1 Disposal of Waste in an On-Site Disposal Facility

Approximately 1.36 million cubic yards (1.04 million cubic meters) of demolition waste will need a disposal pathway (see Table 3-23 in Chapter 3). The Portsmouth Site-wide Waste Disposition ROD, approved in June 2015, identifies the selected alternative for disposing of waste expected to be produced from DD&D of Portsmouth (DOE 2015g). Under the selected alternative for the Portsmouth Sitewide Waste Disposition ROD (DOE 2015b), the majority of DD&D wastes would remain at Portsmouth in a state-of-the-art OSWDF designed to safely isolate the contaminants present in the waste and to prevent them from being released to the environment. Any waste that cannot meet the waste acceptance criteria for the OSWDF would be shipped off site for disposal. I It is anticipated that 107,000 cubic yards (81,800 cubic meters) of the waste will be shipped off site for disposal and another 110,000 cubic yards (84,100 cubic meters) of material may be a candidate for recycling and/or reuse. The on-site facility will be designed to have a total waste capacity of approximately 5 million cubic yards (3.8 million cubic meters). About 100 acres (40 hectares) will be dedicated to the OSWDF (DOE 2015g, 2017a; PPPO 2016).

The OSWDF was the selected remedy in a ROD in accordance with the Ohio EPA Director’s Final Findings and Orders and pursuant to DOE’s CERCLA authority. This *DU Oxide SEIS* is not a CERCLA action. As such, the DU oxide is not authorized for disposal in the OSWDF. DOE has no plans to dispose of DU oxide in the OSWDF.

4.5.3.2 Land and Facilities Transfers

In the *Conveyance of Real Property at the Portsmouth Gaseous Diffusion Plant in Pike County, Ohio* (DOE 2017d), DOE evaluated the potential transfer of GDP property to one or more entities for uses that could be different from its current use. The Proposed Action would reduce the footprint of Portsmouth, which would reduce the cost to maintain the site. In June 2017 DOE issued a Finding of No Significant Impact (FONSI) for the Proposed Action (DOE 2017e).

4.5.3.3 Conversion of Additional Commercially Generated DUF6

As described in Section 4.5.2.4, DOE may dispose of 150,000 metric tons of commercial DUF_6. For purposes of analysis in this *DU Oxide SEIS* and as a conservative measure of impacts, DOE assumes that the entire mass of commercial DUF_6 could be managed at Paducah or Portsmouth. The detailed analysis of the impacts of the receipt, handling, conversion, storage, and disposal of commercial DUF_6 is presented in Appendix C of this SEIS. Where appropriate, the impacts of the management of commercial DUF_6 at Portsmouth are summarized in this cumulative impacts analysis.

4.5.3.4 Other Off-Site Actions

Other actions occurring near Portsmouth that could contribute to current and future cumulative impacts include new industrial park projects in the ROI: Sarah James Industrial Park and Gettles Industrial Park (Jackson County); Zahn’s Corner and Pike County Manufacturing Center (Pike County); Gateway Industrial Park (Ross County); and Ohio River Industrial Park, Haverhill Industrial Park, and the 522 Site (Scioto County) (DOE 2014a). Because of the distance and nature of the activities that could occur at these industrial parks, they are unlikely to contribute to cumulative impacts in this *DU Oxide SEIS*.

4.5.3.5 Results

The results of the cumulative impacts analyses for Portsmouth are summarized in **Table 4-49**. The second and third data columns of the table summarize the results of the assessment of impacts of alternatives presented in Sections 4.1.1and 4.2.1 of this *DU Oxide SEIS*. The fourth and fifth data columns summarize the results of the impacts from the two scenarios for conversion of commercial DUF_6 that were evaluated and presented in Appendix C of this SEIS. The next column summarizes the impacts from other actions at Portsmouth and in the vicinity, particularly the impacts from DD&D of the conversion capability. The last two data columns identify the anticipated cumulative impacts of the alternatives when added to existing conditions and other reasonably foreseeable actions. For conservative analysis, the cumulative impacts for both the No Action and Action Alternatives include the impacts from conversion of commercial DUF_6 (that is, it is assumed that cumulative impacts for the Action Alternatives include the impacts from the commercial Conversion and Disposal Scenario while the cumulative impacts for the No Action Alternative include the impacts from the commercial Conversion and Storage Scenario.

Table 4-49 Annual Cumulative Impacts at the Portsmouth Site

		Impacts of *DU Oxide SEIS* Alternatives[b]		Commercial Conversion Scenarios[c]			Cumulative Impacts[e]	
Impact Category	**Existing Conditions[a]**	**Action Alternatives**	**No Action Alternative**	**Conversion and Disposal**	**Conversion and Storage**	**Impacts of Other Actions[d]**	**Action Alternatives**	**No Action Alternative**
Public and Occupational Safety and Health								
Worker dose[f] (person-rem/yr)	2.5	3.8	0.76	13	13	No Data	19.3	16.3
Worker LCF	$0 (3\times10^{-4})$	$0 (2.3\times10^{-3})$	$0 (4.6\times10^{-4})$	0 (0.008)	0 (0.008)	No Data	0 (0.01)	0 (0.01)
Public dose (person-rem/yr)	0.22	0.002	0.002	2×10^{-3}	2×10^{-3}	No Data	0.22	0.22
Public LCF	$0 (1\times10^{-4})$	$0 (1.2\times10^{-6})$	$0 (1.2\times10^{-6})$	$0 (9\times10^{-7})$	$0 (9\times10^{-7})$	No Data	$0 (1\times10^{-4})$	$0 (1\times10^{-4})$
Off-site MEI dose (millirem/yr)	1.1	1.3	1.3	0.4	0.4	No Data	2.8[h]	2.8[h]
Waste Management								
LLW (including empty and heel cylinders and CaF_2) (yd^3/yr)	160	4,470[h]	4,470[h]	4,0200	4,020	92[i]	4,470[i]	4,470[i]
MLLW (yd^3/yr)	1.0	0.010	0.010	0.010	0.010	52[i]	52[i]	52[i]

Key: DD&D = decontamination, decommissioning, and demolition; DU = depleted uranium; LCF = latent cancer fatality; LLW = low-level radioactive waste; MEI = maximally exposed individual; MLLW = mixed low-level radioactive waste; OSWDF = On-Site Waste Disposal Facility; SEIS = supplemental environmental impact statement; yd^3 = cubic yard; yr = year.

[a] Based on information presented in Chapter 3, Section 3.2 of this *DU Oxide SEIS*.

[b] Based on results presented in Chapter 4, Sections 4.1.1 and 4.2.1 of this *DU Oxide SEIS*. No action impacts were considered over 100 years. Action Alternative impacts were considered for 22 or 32 years, whichever had the greatest impacts.

[c] Impacts from the conversion of 150,000 metric tons (165,000 tons) of commercial DUF_6 and storage or disposal of the converted commercial DU oxide (see Appendix C of this SEIS).

[d] Includes impacts of other actions as described in Section 4.5.3. The impacts of other future actions on public and occupational safety and health is unknown, but would be limited by compliance with applicable regulations.

[e] Cumulative impacts equal the sum of the impacts of the management alternative and other past, present, and reasonably foreseeable future actions. The cumulative impacts of the Action Alternatives include the sum of existing conditions; *DU Oxide SEIS* alternatives – Action Alternatives; commercial conversion scenarios – Conversion and Disposal; and other actions. The cumulative impacts of the No Action Alternative include the sum of existing conditions; *DU Oxide SEIS* alternatives – No Action Alternative; commercial conversion scenarios – Conversion and Storage; and other actions. This is a conservative assumption because some site activities are counted twice and some will not occur concurrently. For example: (1) LLW and MLLW from existing conditions include wastes generated from conversion of DOE DUF_6 to DU oxide and (2) conversion of DOE DUF_6 to DU oxide may not occur in the same years that conversion of commercial DUF_6 to DU oxide would occur.

[f] Includes involved worker and noninvolved worker doses.

[g] The MEI doses occur at different locations for different facilities operations. Therefore, adding the MEI doses is a very conservative estimate of potential cumulative doses to an MEI.

[h] The increased generation of LLW during the alternatives primarily reflects the assumed increased generation of LLW in the form of empty and heel cylinders and CaF_2 (PPPO 2018). DU oxide is not considered in this estimate because it is a resource until shipped off site for disposal.

[i] Reflects generation of LLW and MLLW from DD&D of the oxide conversion capability (DOE 2004b). Approximately 1.26 million cubic yards (0.96 million cubic meters) of lightly contaminated LLW, and 100 cubic yards (76 cubic meters) of MLLW are estimated to be generated from future environmental restoration and DD&D activities (see Chapter 3, Table 3-23). Approximately 1.14 million cubic yards (0.87 million cubic meters) of LLW are estimated to be disposed of in the OSWDF.

[j] The scenarios for conversion of commercial DUF_6 were not added to the cumulative annual impacts because the majority of these activities would not take place at the same time as the management of DOE DU oxide. Therefore, only the maximum values among the *DU Oxide SEIS* alternatives, other actions such as conversion capability DD&D, and the commercial conversion scenarios were used in the totals.

Sources: DOE 2004b; PPPO 2018

Human Health During Normal Operations

For the No Action and the Action Alternatives, impacts to human health and safety would be low. As shown in Table 4-49, the cumulative collective radiological exposure to the off-site population would be well below the maximum DOE dose limit of 100 millirem per year to the off-site MEI for both alternatives and below the limit of 25 millirem per year specified in 40 CFR 190 for uranium fuel cycle facilities. Doses to individual involved workers would be below the regulatory limit of 5,000 millirem per year (10 CFR Part 835) and less than an administrative limit of 2,000 millirem per year (DOE 2017f).

As described in Chapter 4, Sections 4.1.1 and 4.2.1, impacts associated with chemical exposure are expected to be very small under the No Action and Action Alternatives. Impacts from the cumulative exposure to chemicals are unlikely due to regulations that limit the release of hazardous chemicals, and the distances to other potential sources of these chemicals. The calculation of cumulative impacts is not possible because of the absence of necessary measures (chemical concentrations or hazard indices) for the other actions.

Human Health During Accident Scenarios

For the No Action and the Action Alternatives, doses and consequences of releases of radiological materials were considered for a range of accidents from likely (occurring an average of 1 or more times in 100 years) to extremely rare (occurring an average of less than once in a million years). Because of the low probability of two accidents happening at the same time, the consequences of these accidents are not considered to be cumulative. The probability of likely accidents occurring at the same time is very low, even for the most frequently expected accidents, because this risk is the product of their fractional probabilities (1 in 100 years multiplied by 1 in 100 years equals both occurring 1 in 10,000 years [$0.01 \times 0.01 = 0.0001$]). In the unlikely event that two facility accidents from the likely category occurred at the same time, the consequences for the public would be low. The additive impacts would result in no chemical effects and no LCFs (DOE 2004b).

Waste Management

Cumulative annual waste generation is presented in Table 4-49. As described in Section 3.2.8, Portsmouth would continue to generate a variety of wastes from ongoing activities. Radioactive wastes (primarily LLW) would be generated from management of DUF_6 cylinders, and other site activities including conversion of DUF_6 to DU oxide. As addressed in Section 3.2.8, these wastes would be shipped to off-site facilities for treatment and/or disposal. As described in Sections 4.1.1.8 and 4.2.1.8, the alternatives evaluated in this *DU Oxide SEIS* would generate small quantities of ancillary LLW and MLLW, LLW in the form of empty and heel cylinders, and potentially CaF_2. Additional ancillary LLW and MLLW, and CaF_2 would be generated if DOE converts 150,000 metric tons (165,000 tons) of commercial DUF_6 to DU oxide and then stores or disposes of the oxide. After DUF_6 to DU oxide conversion activities are complete, the conversion capability would be deactivated, decontaminated, and demolished. These wastes would be treated and/or disposed of in authorized facilities that are operating at that time.

Portsmouth will continue to generate waste from environmental restoration and DD&D activities, and future generation rates could exceed current levels. In June 2015, DOE issued a ROD for management of a variety of wastes from environmental restoration and DD&D activities at Portsmouth. The ROD calls for disposal of mostly lighly contaminated LLW in a new on-site disposal cell and off-site disposal or recycle of some wastes (DOE 2015g). Approximately 1.14 million cubic yards (0.87 million cubic meters) of LLW is estimated to be disposed of in the OSWDF. It is anticipated that 107,000 cubic yards (84,100 cubic meters) of the waste will be shipped off site for disposal and another 110,000 cubic yards (84,100 cubic meters) of material may be a candidate for recycling and/or reuse (DOE 2015g). This waste could be generated, depending upon funding, over a 10- to 12-year period (DOE 2014a).

The cumulative quantities of wastes generated from activities at Portsmouth would be managed using existing and new on-site and off-site capabilities and would not be expected to result in substantial cumulative impacts on the waste management infrastructure. See Section 4.5.4 for a discussion of cumulative impacts of waste disposal at Energy*Solutions*, NNSS, and WCS.

4.5.4 Cumulative Impacts on Disposal Site Capacity

As described in **Table 4-50**, the cumulative impacts of disposal of DU oxide and other wastes would not exceed the capacities of any evaluated disposal facility, even if each facility received all DU oxide and other waste from both Paducah and Portsmouth. However, as discussed in Sections 4.5.2.1 and 4.5.3.1, about 3.6 million cubic yards (2.75 million cubic meters) of waste from environmental restoration and DD&D activities may be generated at Paducah as well as about 1.36 million cubic yards (1.04 million cubic meters) at Portsmouth. At this time, the total quantities of LLW and MLLW that would be generated from these activities and that could require off-site disposition is uncertain, but initial estimates indicate 9,559 cubic yards (7,308 cubic meters) of LLW and 70,708 cubic yards (54,061 cubic meters) of MLLW from Paducah and approximately 53,600 cubic yards (40,980 cubic meters) of additional LLW and MLLW from Portsmouth would be disposed of at off-site facilities, such as Energy*Solutions*, NNSS, and WCS. In the unlikely event that most of this future DD&D waste was LLW or MLLW that would require off-site disposition, the total quantity of waste that could be disposed of at any single facility could challenge that facility’s disposal capacity. Impacts on any facility’s capacity could be reduced by distributing waste shipments to multiple disposal facilities, or by developing additional capacity at one or more disposal facilities.

Table 4-50 Cumulative Impacts on Radioactive Waste Disposal Capacity (cubic yards)

		Wastes Generated at Paducah and Portsmouth						Cumulative Total (Percent of Capacity in Parenthesis)[e]	
			DU Oxide SEIS Alternatives[c]		Commercial Conversion Scenarios				
Waste	Facility Capacity[a]	Existing Operations[b]	Action Alternatives	No Action Alternative	Conversion and Disposal	Conversion and Storage	Other Actions[d]	Action Alternatives	No Action Alternative
Energy*Solutions*									
LLW – DU oxide	Dedicated cell	NA	386,000	0	69,900	0	NA	456,000 (100) [f]	0 (NA)
LLW – includes empty and heel cylinders	4,200,000	14,300	78,500	78,700	4,200	4,200	520	97,500 (2.3)	95,600 (2.3)
LLW – CaF_2	4,200,000	NA	225,000	225,000	40,600	40,600	NA	266,000 (6.4)	266,000 (6.4)
MLLW	358,000	92	1.5	2.4	0.70	1.4	290	380 (0.10)	380 (0.10)
Nevada National Security Site									
LLW – DU oxide	1,800,000	NA	386,000	0	69,900	0	NA	456,000 (25)	0 (NA)
LLW – includes empty and heel cylinders	1,800,000	14,300	78,500	78,700	4,200	4,200	520	97,500 (5.5)	95,600 (5.5)
LLW – CaF_2	1,800,000	NA	225,000	225,000	40,600	40,600	NA	266,000 (15)	266,000 (15)
MLLW	148,000	92	1.5	2.4	0.70	1.4	290	380 (0.26)	380 (0.26)
Waste Control Specialists									
LLW – DU oxide	955,000	NA	386,000	0	69,900	0	NA	456,000 (48)	0 (NA)
LLW – includes empty and heel cylinders	955,000	14,300	78,500	78,700	4,200	4,200	520	97,500 (10)	97,600(11)
LLW – CaF_2	955,000	NA	225,000	225,000	40,600	40,600	NA	266,000 (28)	266,000 (28)
MLLW	955,000	92	1.5	2.4	1.1	1.4	290	380 (0.04)	380 (0.04)

Key: DOE = U.S. Department of Energy; DU = depleted uranium; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NA = not applicable; SEIS = supplemental environmental impact statement.

[a] Based on information presented in Chapter 3, Sections 3.3, 3.4, and 3.5 of this *DU Oxide SEIS*.

[b] Based on current generation rates for LLW and MLLW as described in Chapter 3, Sections 3.1.8 and 3.2.8, except for empty and heel cylinders, for 44 and 32 years, respectively, for Paducah and Portsmouth. Current waste generation is due to on-site activities including DU oxide conversion and ongoing remediation and decontamination and decommissioning activities.

[c] Based on results presented in Chapter 4, Sections 4.1, 4.2, 4.3, and 4.4 of this *DU Oxide SEIS*. No Action Alternative impacts were considered over 100 years. Action Alternative impacts were considered for operations over 44 or 32 years, respectively, for Paducah and Portsmouth. Wastes include those from DU oxide management and from disposal as LLW of empty and heel cylinders.

[d] Reflects waste from decontamination and decommissioning of the oxide conversion capabilities at Paducah and Portsmouth (DOE 2004a, 2004b). Additional waste will be generated from future environmental restoration and DD&D activities at Paducah and Portsmouth. Initial estimates indicate 9,559 cubic yards (7,308 cubic meters) of additional LLW and 70,708 cubic yards (54,061 cubic meters) of MLLW from Paducah and approximately 53,600 cubic yards (40,980 cubic meters) of additional LLW and MLLW from Portsmouth would be disposed of at off-site facilities, such as Energy*Solutions*, NNSS, and WCS (see Section 4.5.4).

[e] Cumulative impacts equal the sum of the impacts of the alternative and other past, present, and reasonably foreseeable future actions. Volumes and projected impacts on waste disposal facility capacities reflect the assumption that each facility receives all LLW and MLLW from both Paducah and Portsmouth. The Action Alternatives were summed with waste from the Conversion and Disposal Scenario; the No Action Alternative was summed with waste from the Conversion and Storage Scenario.

[f] There would be no impacts on disposal capacity at Energy*Solutions* from disposal of DU oxide because, as described in Chapter 3, Section 3.3, of this *DU Oxide SEIS*, the disposal unit that would receive the DU oxide would be separate from the other disposal units at the site and, would be designed to receive all DU oxide that may be sent from both Paducah and Portsmouth.

Notes: To convert cubic yards to cubic meters, multiply by 0.76456.

4.5.5 Nationwide and Global Cumulative Impacts

This section evaluates cumulative impacts for nationwide radioactive material transportation and global climate change.

4.5.5.1 Nationwide Radioactive Material Transportation

As shown in **Table 4-51**, train and truck shipments associated with the alternatives evaluated in this *DU Oxide SEIS* could result in maximum doses (and LCFs) to workers of 145 person-rem (0 [0.09] LCF), and to the public of 217 person-rem (0 [0.1] LCF) (if cylinder packagings are used). Maximum doses (and LCFs) for truck transportation would be 276 person-rem (0 [0.2] LCF) to workers, and 723 person-rem (0 [0.4] LCF) to the public (if cylinder packagings are used). Based on the cumulative impacts analysis presented in Table 4-50 of the *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement* (DOE 2015a) other past, present, and reasonably foreseeable radioactive material transport activities could result in population doses (and LCFs) for workers and the public of 421,300 person-rem (253 LCFs) and 436,800 person-rem (262 LCFs), respectively. Therefore, the impacts of transportation activities related to the actions evaluated in this *DU Oxide SEIS* would be very small in comparison and would not appreciably add to cumulative impacts.

Table 4-51 Cumulative Impacts of Transportation

Parameter	Action Alternatives[a]			Commercial DUF_6[c]			Other Actions[d]	Cumulative Impact[e]
	Energy*Solutions*	NNSS[b]	WCS	Energy*Solutions*	NNSS[b]	WCS		
Train – Incident-free[f]								
Crew Dose (person-rem)	100	145	84	21	30	20	421,000	421,200
Crew LCF	0 (0.06)	0 (0.09)	0 (0.05)	0 (0.01)	0 (0.02)	0 (0.01)	253	253
Population Dose (person-rem)	135	217	135	29	43	32	436,000	436,300
Population LCF	0 (0.08)	0 (0.1)	0 (0.08)	0 (0.02)	0 (0.03)	0 (0.02)	262	262
Train – Accidents[f]								
Traffic Fatalities	1	2	1	0(0.4)	0(0.4)	0(0.3)	NA[g]	NA[g]
Truck – Incident-free[f]								
Crew Dose (person-rem)	224	276	155	46	55	34	421,000	421,300
Crew LCF	0 (0.1)	0 (0.2)	0 (0.09)	0 (0.03)	0 (0.03)	0 (0.02)	253	253
Population Dose (person-rem)	591	723	403	118	144	88	436,000	436,800
Population LCF	0 (0.4)	0 (0.4)	0 (0.2)	0 (0.07)	0 (0.09)	0 (0.05)	262	262
Truck – Accidents[f]								
Traffic Fatalities	11	11	10	2	2	2	NA[g]	NA[g]

Key: LCF = latent cancer fatality; NA = not applicable; NNSS=Nevada National Security Site; WCS= Waste Control Specialists.

[a] Based on results presented in Chapter 4, Sections 4.2, 4.3, and 4.4 of this *DU Oxide SEIS*.

[b] Because NNSS lacks a direct rail connection for waste delivery, train analyses include calculation of potential impacts associated with train transportation between both Portsmouth and Paducah and an intermodal facility, as well as truck transports for shipments from the intermodal facility to NNSS. For purposes of analysis and consistent with NNSS SWEIS (DOE 2013a), the intermodal facility was assumed to be the rail yard in Barstow, California.

[c] The impacts of transportation of wastes related to DOE management and disposal of 150,000 metric tons of commercial DUF_6 are described in Appendix C, Section C.7.3. The maximum values for Paducah or Portsmouth are used for this table.

[d] Includes impacts of all other actions as described in the *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement* (DOE 2015a). Includes information from the 2004 Paducah and Portsmouth conversion facility environmental impact statements (DOE 2004a, 2004b). These values are rounded to three significant figures.

[e] Cumulative impacts equal the sum of the impacts of the alternative and other past, present, and reasonably foreseeable future actions. The cumulative impacts represent the maximum values.

[f] These values correspond to impacts of using cylinders for DU oxide transportation. They include the impacts from transporting the DU oxide and the 14,000 empty and heel cylinders.

[g] Information on traffic fatalities for other actions was not estimated in the *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement* (DOE 2015a). For general comparison, over 32,000 traffic fatalities occur annually in the United States (DOE 2015a).

4.5.5.2 Global Climate Change

The natural greenhouse effect is the process by which part of terrestrial radiation is absorbed by gases in the atmosphere, warming the Earth’s surface and atmosphere. This greenhouse effect and the Earth’s radiation balance are affected largely by water vapor, carbon dioxide, and trace gases, which absorb infrared radiation and are referred to as GHGs (DOE 2015a).

The Intergovernmental Panel on Climate Change (IPCC) identifies increases in atmospheric concentrations of certain gases as a cause of changes in the Earth’s atmospheric energy balance and an influence on global climate. Warming of the global climate is referred to as global warming. Water vapor (approximately 1 percent of the atmosphere) is the most common and dominant GHG; only small amounts of water vapor are produced as the result of human activities. The principal GHGs resulting from human activities are carbon dioxide, methane, nitrous oxide, and halocarbons. Halocarbons include chlorofluorocarbons; hydrofluorocarbons, which are replacing chlorofluorocarbons as refrigerants; and perfluorocarbons, which are byproducts of aluminum smelting. Other gases of concern include sulfur hexafluoride, which is widely used in insulation for electrical equipment. These gases are released in different quantities and have different potencies in their contributions to global warming. EPA considers carbon dioxide, methane, nitrous oxide, and fluorinated gases (e.g., hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) as the primary GHGs as defined by EPA under Section 202(a) of the Clean Air Act (see Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act, 74 FR 66495, December 15, 2009).

Sources of anthropogenic carbon dioxide include combustion of fossil fuels such as natural gas, oil, gasoline, and coal. The IPCC estimates that carbon dioxide atmospheric levels have risen by more than 35 percent since the preindustrial period (beginning in 1750) as a result of human activities. Emissions of other GHGs have also risen (IPCC 2007). While annual U.S. GHG emissions have increased overall since 1990, U.S. GHG emissions have been decreasing since 2010 (EPA 2018d). Emissions of GHGs are stated in terms of equivalent emissions of carbon dioxide (CO_2e) based on their global warming potential.

The IPCC lists potential impacts from warming of the climate system, including expansion of seawater volume; decreases in mountain glaciers and snow cover resulting in sea-level rise; changes in arctic temperatures and ice; changes in precipitation, ocean salinity, and wind patterns; and changes in extreme weather (IPCC 2007).

The release of anthropogenic GHGs and their potential contribution to climate change are inherently cumulative phenomena. Cumulative impacts of the emission of carbon dioxide and other GHGs from the alternatives addressed in this *DU Oxide SEIS*, and other activities at Paducah and Portsmouth and throughout the region, would contribute to the changes related to global climate discussed above. As described in this chapter, the alternatives considered in this *DU Oxide SEIS* could produce various quantities of carbon dioxide from the activities under analysis. Specifically, the emission estimates for the alternatives account for mobile source emissions from waste shipments. Emissions from employee vehicles are not considered because there would be no new jobs associated with the Proposed Action, and the numbers of employees associated with the alternatives are minimal (i.e., 16 FTEs at Paducah and 12 FTEs at Portsmouth).

The GHGs emitted by the activities analyzed in this *DU Oxide SEIS* would add a small increment to emissions of these gases in the United States and the world. Overall GHG emissions in the United States during 2014 totaled about 7.57 billion tons (6.87 billion metric tons) of CO_2e (EPA 2016e). By way of comparison, the maximum annual CO_2e emissions under the *DU Oxide SEIS* alternatives would be approximately 17,564 tons (15,934 metric tons), an exceedingly small percentage of the United States' total emissions. Emissions from the Proposed Action could contribute in a small way to the climate change impacts described above. At present, there is no methodology that would allow DOE to estimate the specific impacts this increment of climate change would produce in the vicinity of a site or elsewhere.

The IPCC has concluded that emissions of GHGs and the impacts on global climate and the resulting environmental, economic, and social consequences could be significant (IPCC 2007). It has been projected that widespread impacts due to climate change in North America may include warmer and/or fewer cold days and nights; warmer and/or more hot days and nights; increased frequency and intensity of heat waves, heavy precipitation events, droughts, and tropical cyclones activity; and increased incidence and/or magnitude of extreme high sea level (IPCC 2013). Impacts of particular concern in the Midwestern United States could include continued warming in all seasons and an increase in the rate of warming. The increased frequency, duration, and intensity of droughts, flooding, heat waves, and other extreme weather events is likely. In the next few decades, longer growing seasons and rising carbon dioxide levels could increase yields of some crops, though those benefits could be offset by extreme weather events (Pryor et al. 2014). Of particular concern for both Paducah and Portsmouth is their proximity to the Ohio River which means that increases in extreme precipitation and/or flood events could impact the facilities. The increase in temperature could result in increased heat stress for people, decreased forest growth and crop productivity, long-term damage to infrastructure, decline in dissolved oxygen in surface waters, increases in fish kills and loss of aquatic species diversity, and decline in production of livestock. Changes in the distribution of native plants and animals may occur, threatened and endangered species may be lost, native species may be displaced by invasive species, and more frequent and intense wildfires may occur. Some of these effects may eventually necessitate adaptation of activities at Paducah and Portsmouth (Pryor et al. 2014).

4.6 MITIGATION

The regulations promulgated by the Council on Environmental Quality to implement the procedural provisions of the National Environmental Policy Act (42 U.S.C. § 4321) require an EIS (likewise an SEIS) to include a discussion of appropriate mitigation measures (40 CFR 1502.14(f) and 16(h)). The term *mitigation* includes the following (40 CFR 1508.20):

- Avoiding the impact altogether by not taking a certain action or parts of an action.
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing or providing substitute resources or environments.

In general, activities associated with this Proposed Action would follow standard practices such as Best Management Practices (BMPs) for minimizing impacts on environmental resources as required by regulations, permits, or guidelines. Standard practices that are protective of the air, water, land, and other natural and cultural resources affected by DOE operations would be implemented in accordance with an environmental management system established pursuant to DOE Order 436.1, *Departmental Sustainability*, which was prepared to incorporate the requirements of Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*.[59]

As described in Sections 4.1 through 4.5, the impacts of the alternatives evaluated in this *DU Oxide SEIS* are not expected to produce impacts that would require mitigation. Nevertheless, **Table 4-52** identifies general types of mitigation measures that could be used to further reduce impacts. These mitigation measures could be applied if practical and cost effective. Because transporting the DU oxide cylinders to a disposal site is the activity with the largest potential for impacts, a number of transportation mitigation measures are described in more detail below:

- The impacts of combustion air emissions from transportation vehicles could be reduced by use of low-sulfur fuels. Noise could be minimized by ensuring vehicles are in optimal condition, and for trucks, by rules that discourage engine braking.
- Potential transportation impacts could be minimized by transporting DU oxide containers and other wastes only during periods of light traffic volume, providing vehicle escorts, avoiding high-population areas, avoiding high-accident areas, and providing additional training for drivers and emergency response personnel.

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[59] Section 16 of EO 13693, "Planning for Federal Sustainability in the Next Decade," revokes Executive Order 13514.

- Impacts on workers and the public from non-incident exposure during transportation could be minimized by adding additional radiation shielding.

- The consequences of an accident could be reduced by reducing the quantity of DU oxide transported in each shipment. This change would have adverse impacts by necessitating more shipments.

- In addition, although the probabilities of occurrence for high consequence transportation accidents are extremely low, emergency response plans and procedures are in place to minimize the impacts should a transportation accident occur.

Table 4-52 Potential Mitigating Measures

	Resource Area											
Mitigating Measure	**Land Use**	**Geology and Soils**	**Water Resources**	**Air Quality, Climate, and Noise**	**Biotic Resources**	**Human Health**	**Cultural Resources**	**Socioeconomics**	**Site Infrastructure**	**Waste Management**	**Transportation**	**Environmental Justice**
Use of low sulfur fuels				●	●	●						●
Dust suppression measures		●		●	●	●	●					●
Silencers/mufflers, rules discouraging truck engine braking, hearing protection programs				●		●	●					●
Water conservation practices			●		●				●	●		
Spill prevention and control measures		●	●		●	●	●			●		●
Personal protective equipment				●		●					●	
Confinement and shielding systems				●		●					●	
Emergency preparedness and response plans						●					●	●
Rad Con Program and ALARA						●					●	●
High-efficiency electric equipment/off-peak use									●			
Waste minimization				●		●				●	●	●
Public outreach and training						●						●
Scheduling								●	●		●	

4.7 UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts are those impacts that cannot be mitigated by choices associated with the alternatives evaluated in this *DU Oxide SEIS*. They are impacts that would be unavoidable, no matter which options were selected.

The DU oxide containers currently in storage would require continued monitoring and maintenance under all alternatives. These activities would result in the exposure of workers in the vicinity of the containers to low levels of radiation. The radiation exposure of workers would be minimized, but some level of exposure would be unavoidable. As described in Sections 4.1 through 4.5, the radiation doses to workers are estimated to be well within public health standards and DOE guidance under all alternatives. Radiation exposures of workers would be monitored and kept to achieve ALARA goals.

Container monitoring and maintenance activities would also emit air pollutants, such as vehicle exhaust and dust (PM_{10}), and produce small amounts of LLW, TSCA waste, MLLW, and sanitary waste. Concentrations of air emissions during monitoring and maintenance activities are estimated to be within applicable standards and guidelines, and waste generation would not appreciably affect waste management operations at Paducah and Portsmouth.

Under all alternatives, workers would have a potential for accidental on-the-job injuries and fatalities that would be unrelated to radiation or chemical exposures. These would be a consequence of unanticipated events in the work environment, typical of all workplaces. The chance of fatalities and injuries occurring would be minimized by conducting all work activities in as safe a manner as possible, in accordance with occupational health and safety rules and regulations. However, the chance of these types of impacts cannot be completely avoided.

4.8 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The major irreversible and irretrievable commitments of natural and man-made resources related to the alternatives analyzed in this *DU Oxide SEIS* are discussed below. A commitment of a resource is considered irreversible when the primary or secondary impacts from its use limit the future options for its use. An irretrievable commitment refers to the use or consumption of a resource that is neither renewable nor recoverable for later use by future generations.

The decisions to be made in the ROD following the publication of this *DU Oxide SEIS* would commit resources required for implementing the selected alternative. Three major resource categories would be committed irreversibly or irretrievably under the alternatives considered in this SEIS: land, labor and materials, and energy.

4.8.1 Land

Land that is occupied by cylinder storage yards could ultimately be returned to another productive use if the areas underwent DD&D activities. When no longer needed, DOE could DD&D the storage yards. Appropriate CERCLA and/or NEPA reviews would be conducted before initiation of DD&D actions. After DD&D, the storage yards could be reused or removed. Examples of future use of these tracts of land, although beyond the scope of this *DU Oxide SEIS*, could include other industrial uses, and restoring them for unrestricted use. Therefore, the commitment of this land would not necessarily be irreversible However, the land used to dispose of DU oxide and other wastes is likely to be an irretrievable commitment because wastes in belowground disposal areas are not anticipated to be removed, the land could not be restored, and the site could not be used for other purposes.

4.8.2 Labor and Materials

Human resources (labor), once consumed, are irretrievable. The irreversible and irretrievable commitment of labor and material resources for the SEIS alternatives would include labor and materials consumed or reduced to unrecoverable forms of waste. **Table 4-53** shows the estimated consumption of labor and materials under the alternatives evaluated in this *DU Oxide SEIS*. Consumption of the labor shown in Table 4-53, although irreversible and irretrievable, would not constitute a major drain on local labor resources. Substantial quantities of steel would be used in the form of DU oxide containers and empty and heel cylinders that would be disposed of rather than being recycled. Consumption of steel, although irreversible and irretrievable, would not involve a resource in short supply in the United States. Only small quantities of materials are expected to be needed during container storage and maintenance, and during container loading for transport.

Table 4-53 Irreversible and Irretrievable Commitment of Resources

Activity	No Action Alternative	Transport DU Oxide		
		to NNSS	to Energy*Solutions*	to WCS
Labor				
Full-time equivalent (person-years)[a]	2,800	1,780	1,780	1,780
Material				
Steel in disposed containers (tons)	18,200[b]	108,000	108,000	108,000
Energy				
Electricity (megawatt-hours)	33.4	20.5	20.5	20.5
Diesel fuel (gallons)[c]				
Train Transportation	188,000,000	490,000,000	398,000,000	285,000,000
Truck Transportation	20,400,000	46,100,000	37,800,000	26,600,000
Gasoline (gallons)	416,000	256,000	256,000	256,000

Key: DU = depleted uranium; NNSS = Nevada National Security Site; WCS = Waste Control Specialists.

[a] Does not include transportation workers.

[b] Assumes steel in the DU oxide cylinders would not be irreversibly committed until disposed.

[c] Includes diesel fuel for cylinder handling and loading equipment at Paducah and Portsmouth, and for truck or train transportation vehicles for transportation to a disposal site, as applicable.

Source: Tables 4-1 and 4-2 and Section 4.2.1.1 of this SEIS

4.8.3 Energy

The irretrievable commitment of energy resources during DU oxide container storage, maintenance, handling, and transportation would include the consumption of electricity and fossil fuels (i.e., diesel fuel, gasoline) used for equipment operation, and transportation vehicles (see Table 4-53). Consumption of energy, although irreversible and irretrievable, would not constitute a permanent drain on local resources or involve any energy source in critically short supply in the United States.

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

The relationship between short-term uses of the environment and long-term productivity for key environmental resources is described in the following paragraphs. For this *DU Oxide SEIS*, *short-term* is considered the period of storage of DU oxide cylinders at Paducah and Portsmouth under the Action Alternatives, and the period of transportation of the DU oxide to the disposal facilities; that is, the time when most short-term (or temporary) environmental impacts would occur. *Long-term* is considered to be anything longer than *short-term*, including the 100 year period DU oxide would be stored at Paducah and Portsmouth under the No Action Alternative.

Under the alternatives evaluated in this *DU Oxide SEIS*, there would be no facility construction, and therefore, no impacts from construction. As described in Chapter 2, Section 2.1.3, storage of DU oxide on approximately 83 acres at Paducah and 23 acres at Portsmouth under the No Action Alternative, would result in the continued exclusion of terrestrial and aquatic habitats from natural productivity.

Under the Action Alternatives, DU oxide containers would be maintained in the storage yards until shipped off site for disposal. Therefore, the amount of DU oxide stored in the storage yards would be reduced over time and eventually eliminated as the last cylinders are shipped to a disposal site. When no longer needed, DOE could DD&D the storage yards. After DD&D, the storage yards could be reused or removed. If a decision is made to entirely remove the storage yards, the areas could be restored to long-term productivity as functioning habitat for plants and animals. If the storage yards are not entirely removed, the areas could be put to a productive industrial use.

As a result of the activities at the cylinder storage yards, air emissions and water discharges could introduce small amounts of radiological and chemical constituents to the environment. These emissions could result in additional environmental loading and human and biological exposure, but are not expected to impact DOE’s ability to continue to comply with air and water quality or exposure standards (see Sections 4.1.1 and 4.2.1). Future cleanup of the storage yards would be expected to occur in accordance with CERCLA regulations. Decisions on the level of cleanup would be made as part of the CERCLA process. DOE expects that future cleanup of the storage yards, would leave behind minimal residual environmental contamination from previous air and water emissions and the storage yards could be returned to productive uses. Therefore, minor effects on long-term productivity are expected.

In addition, transportation workers and the public could be exposed to small doses of radiation during non-incident transportation of DU oxide and other wastes to a disposal site (see Sections 4.1.2, 4.2.2, 4.3.2, and 4.4.2). These impacts are not expected to impact long-term human health and the environment.

As described in Section 4.2.2, no LCFs would be expected from radiation exposure during a transportation accident, but fatalities could occur due to trauma during the accident. In the unlikely event of a transportation accident that releases DU oxide, environmental impacts could result and transportation workers and the public could be exposed to radiation and chemical hazards (see Section 4.2.2). Emergency response to such an accident would be swift and cleanup would occur in accordance with regulatory requirements. Under the scenario evaluated in Section 4.2.2, impacts from the accidental release of DU oxide would not be expected to impact long-term human health and the environment.

Water would be used to meet the needs of personnel maintaining the DU oxide cylinder storage yards (see Sections 4.1.1.1 and 4.1.1.4). After use and treatment, this water would be released through permitted outfalls into surface water streams. The withdrawal, use, and treatment of water are not likely to affect the long-term productivity of this resource.

In addition, labor and other resources would be committed to operation of the DU oxide cylinder storage yards and transport of the cylinders to the disposal site (see Section 4.8). These short-term uses of these resources are not expected to impact the long-term productivity of the environment.

Disposal of wastes would require space at a disposal facility (see Sections 4.1.2, 4.2.2, 4.3.2, and 4.4.2). The space required for waste disposal would impact the long-term productivity of the land areas comprising the disposal facility. As long as the waste to be disposed of is within the authorized capacity and waste acceptance criteria of the disposal facility, it is assumed the impacts of disposal were considered and found to be acceptable as part of the licensing and permitting process.

4.10 POLLUTION PREVENTION AND WASTE MINIMIZATION

Activities described in this *DU Oxide SEIS* would be conducted in accordance with all applicable pollution prevention and waste minimization requirements. Pollution prevention is designed to reduce the risk to public health, safety, welfare, and the environment through source reduction techniques and environmentally acceptable recycling processes. The Pollution Prevention Act of 1990 (42 U.S.C. §§ 11001–11050) established a national policy that pollution should be prevented or reduced at the source, whenever feasible. The act indicates that when pollution cannot be prevented, polluted products should be recycled in an environmentally safe manner. Disposal or other releases into the environment should be employed only as a last resort. Executive Order 12856, *Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements*, and DOE Order 450.1, *Environmental Protection Program General Environmental Protection Program*, implement the provisions of the Pollution Prevention Act of 1990. Pollution prevention measures could include source reduction, recycling, treatment, and disposal. The emphasis would be on source reduction and recycling to prevent the creation of wastes (i.e., waste minimization).

Waste minimization is the reduction, to the extent feasible, of the generation of waste, especially radioactive and hazardous waste. Waste minimization techniques include technology modifications, changes in input materials, product changes, and good operating practices. An example of waste minimization would be to substitute nonhazardous materials, when possible, for materials that contribute to the generation of hazardous or mixed waste.

DOE already has aggressive pollution prevention and waste minimization programs in place and actively pursues substitution of nonhazardous materials for hazardous materials. Because of the limited scope of the activities evaluated in this *DU Oxide SEIS*, there are limited opportunities for implementation of additional pollution prevention and waste minimization measures. As described in Sections 4.1.1.2 and 4.1.1.4, there would be no routine releases of radioactive or hazardous materials to air or water from storage and maintenance activities at Paducah and

Portsmouth. Any releases from cylinder breaches would be contained and rapidly cleaned up. Therefore, there is little opportunity for implementation of additional pollution prevention measures.

As described in Section 4.1.1.8, a substantial quantity of empty and heel cylinders could be generated. Thorough decontamination of the cylinders to a level that would allow disposal as nonradioactive waste or allow recycling would generate a relatively large volume of wastewater and residues that would require treatment and disposal. In addition, decontamination would consume labor, energy, and other material resources. Therefore, disposal of empty and heel cylinders as LLW is more cost effective and potentially produces less impact than decontamination and recycling or disposal as nonhazardous waste. Crushing or shredding the cylinders could be implemented to reduce the volume of space that would be required at the disposal facility.

5 APPLICABLE STATUTORY REQUIREMENTS AND REGULATORY STANDARDS

5.1 OVERVIEW

This chapter provides a summary of the statutory requirements and regulatory standards that are potentially applicable to the storage, shipment, and disposal activities addressed in this *DU Oxide SEIS*. These requirements and standards originate from a number of sources. Federal and state statutes define broad environmental and safety programs and provide authorization to agencies to carry out the mandated programs. More specific requirements are established through regulations at the Federal and state level. DOE has established additional regulations and management directives (DOE Orders) that are applicable to DOE activities, facilities, and contractors. Regulations often include requirements for permits and consultations, which provide for in-depth, facility-specific oversight of the activities proposed.

Federal, state and local requirements applicable to the activities addressed in this *DU Oxide SEIS* may differ based on the alternatives considered. These potential differences are related to Federal and state agencies' authority and jurisdiction for regulating certain activities. The agencies involved, and the corresponding requirements, while similar, may be different between federally owned sites and commercially owned sites.

This distinction in agency regulatory oversight is important in this *DU Oxide SEIS*, as the alternatives described in Chapter 2 involve both federally owned sites as well as commercially owned sites. As described in Chapter 2, the No Action Alternative would result in continued storage of depleted uranium (DU) oxide at both Paducah and Portsmouth Sites (Paducah and Portsmouth). In one of the Action Alternatives, disposal of DU oxide would occur at the Nevada National Security Site (NNSS). Paducah, Portsmouth, and NNSS are federally owned. Different requirements apply to the two commercial sites being considered under the other two Action Alternatives, Energy*Solutions* near Clive, Utah, and WCS near Andrews, Texas.

This chapter summarizes the environmental and health and safety requirements for the storage, transportation and disposal activities considered in this *DU Oxide SEIS*, and distinguishes among the regulatory requirements at each facility of interest where appropriate.

5.2 DU OXIDE STORAGE

As described in Chapter 2, Section 2.2.1, under the No Action Alternative, DU oxide would continue to be stored at Paducah and Portsmouth. The Atomic Energy Act of 1954 (AEA) (42 U.S.C. § 2011 et seq.), as amended, provides the basic statutory framework for DOE's use and management of radioactive materials. DOE has issued a series of orders to establish a system of standards and requirements to ensure safe operation of DOE facilities.

DOE exercises its authority over working conditions at its facilities through an extensive program of internal oversight and a system of DOE regulations and directives that require DOE and its contractors to comply with relevant worker protection standards and regulations (e.g., 29 CFR Part 1910, "*Occupational Safety and Health Standards*"), and impose additional radiation and chemical exposure standards developed by DOE (DOE Order 440.1B Change 2). Most of DOE's worker radiation protection regulations are located in 10 CFR Part 835, "*Occupational Radiation Protection*." Pertinent DOE directives are listed in site-specific contract provisions. DOE facilities are required to comply with applicable health, safety, and environmental laws, orders, regulations, and national consensus standards and to develop and execute a radiation protection plan and an integrated safety management plan.

Storage activities would be conducted pursuant to numerous other Federal and state regulations, DOE Orders, and site management plans. These regulatory requirements may require a variety of permits, licenses, and other consents to be obtained. **Table 5-1** at the end of this chapter provides a summary list of potentially applicable permitting, reporting, and compliance requirements for activities at Paducah and Portsmouth. The status of each is indicated on the basis of currently available information. However, because DU oxide production and storage are in progress, and DOE has not made a decision to transport and dispose of the DU oxide, additional requirements may apply; alternatively, some requirements may not be applicable.

5.3 WASTE TRANSPORTATION

Under the Action Alternatives, DU oxide and other radioactive wastes would be transported from Paducah and Portsmouth to a LLW disposal facility. Transport of radioactive materials is regulated by DOT (49 CFR Part 171 through 180) and the NRC (10 CFR Part 71). Table 5-1 provides a summary of potentially applicable requirements for transporting DU oxide and other radioactive wastes. A more detailed discussion of these regulations is presented in DOT's *Radioactive Material Regulations Review* (RAMREG-12-2008) (DOT 2008).

DOT regulates hazardous materials transportation in interstate commerce by land, air, and water. DOT specifically regulates the carriers of radioactive materials and the conditions of transport, such as routing, handling and storage incident to transport, and vehicle and driver requirements to minimize transportation impacts. Other DOT regulations specify the maximum dose rate from radioactive material shipments. DOT also regulates the labeling, classification, and marking of radioactive material packaging. NRC transportation and packaging regulations are found in 10 CFR Part 71; manifesting requirements for disposal at LLW disposal facilities are found in 10 CFR Part 20.

The regulatory requirements for packaging and transporting radioactive materials are designed to achieve the following four primary objectives:

- Protect persons and property from radiation emitted from packages during transportation by imposing specific limitations on the allowable radiation levels.
- Contain radioactive material in the package (achieved by packaging design requirements based on performance-oriented packaging integrity tests and environmental criteria).
- Prevent nuclear criticality (an unplanned nuclear chain reaction that could occur as a result of concentrating too much fissile material in one place).
- Provide physical protection against theft and sabotage during transit.

The DOT and NRC performance based requirements for the packaging of radioactive materials promotes safety from radiological exposure during transportation. Packaging represents the primary barrier between the radioactive material being transported and the public, workers, and the environment. Transportation packaging for radioactive materials must be designed, constructed, and maintained to contain and shield its contents during normal transportation conditions. DU oxide shipped in the 48 inch diameter cylinders, bulk bags, and 55 gallon drums are expected to meet Industrial Packaging (IP-1) requirements. The type of packaging to be used is determined by the total radioactive hazard presented by the material within the packaging. Four basic types of packaging are used: Excepted, Industrial, Type A, and Type B. Specific requirements for these packages are detailed in 49 CFR Part 173, Subpart I. All packagings are designed to ensure that they can be handled safely. Packages must protect and retain their contents during incident-free transportation conditions. Excepted packagings are limited to the transport of materials that have extremely low levels of radioactivity and very low external radiation. Industrial packagings are used to transport materials that present a limited hazard to the public and the environment because of their low concentration of radioactive materials. There are 3 types of Industrial Packagings, IP-1, IP-2, and IP-3, with IP-3 being subject to the most rigorous requirements. Type A packagings, typically 55-gallon drums or standard waste boxes, are commonly used to transport radioactive materials with higher concentrations or amounts of radioactivity than Excepted or Industrial packaging. Type A packagings must maintain sufficient shielding to limit radiation exposure to handling personnel because of the higher radioactivity of their contents. Type B packagings are used to transport material with the highest radioactivity levels.

In addition, DOE Orders apply to transportation of radioactive materials. DOE Order 460.2A, "Departmental Materials Transportation and Packaging Management," states that DOE operations shall be conducted in compliance with all applicable international, Federal, state, local, and tribal laws, rules, and regulations governing materials transportation that are consistent with Federal regulations, unless exemptions are approved in accordance with DOE Order 460.1D, *Hazardous Materials Packaging and Transportation Safety*.

DOE Order 460.1D establishes safety requirements for the proper packaging and transportation of off-site shipments, and on-site transfers of hazardous materials, including radioactive materials. Off-site refers to any area within or outside a DOE site to which the public has free and uncontrolled access; on-site refers to any area within the boundaries of a DOE site or facility to which access is controlled. Transport of LLW that occurs entirely on DOE property to which public access is controlled at all times through the use of gates and guards, is subject to applicable DOE directives and transportation safety requirements set forth in 10 CFR Part 830, Subpart B, and Order 460.1D. DOE transport of LLW off site for disposal, over highways to which the public has access, would also be subject to applicable DOT and NRC requirements.

5.4 WASTE DISPOSAL

5.4.1 Low-Level Radioactive Waste Disposal Overview

Under the AEA, both DOE and NRC are authorized to regulate the disposal of LLW. DOE regulates LLW management and disposal at DOE sites, and NRC regulates (at a Federal level) LLW management and disposal at commercial sites. In addition, Section 274 of the AEA enables

NRC to delegate certain regulatory responsibilities (e.g., low-level radioactive waste disposal) to state regulatory agencies (see below).

DOE Order 435.1, *Radioactive Waste Management*, and DOE's associated *Radioactive Waste Manual* (DOE M 435.1-1) ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment. DOE radioactive waste management activities are required to be systematically planned, documented, executed, and evaluated.

Technical analyses (performance assessments) supporting LLW disposal authorizations at NNSS pursuant to DOE Order 435.1 are summarized in the NNSS SWEIS (DOE 2013a). In 2012, DOE approved an updated performance assessment to address disposal of DU at NNSS (NSTec 2012). DOE Order 435.1 requires performance assessments that demonstrate compliance with prescribed radiation dose limits for a period of 1,000 years following disposal, along with sensitivity analyses that address peak doses that could occur beyond 1,000 years. In addition, DOE Order 435.1 requires analyses that demonstrate compliance with prescribed limits on the long-term gaseous release of radon-isotopes from LLW disposal facilities.[60] See Chapter 9 of the NNSS SWEIS (DOE 2013a), for more information on laws, regulations and permits applicable to waste disposal at NNSS.

Federal regulatory authority over LLW disposal at commercial sites resides with NRC. Through its Agreement State Program, the NRC may delegate authority to states to regulate certain radioactive materials activities within their respective borders. Under the Agreement State Program, NRC has delegated most of its authority to license and regulate byproduct, source, and certain quantities of special nuclear materials to Utah and Texas including the authority to license and regulate LLW disposal facilities.

NRC operating licenses administered through the regulations in 10 CFR Part 61 establish the procedures, criteria, terms, and conditions for land disposal of LLW containing byproduct, source, and special nuclear material. These regulations, or compatible regulations for Agreement States, apply to LLW managed in commercial facilities, regardless of the generator. As a LLW generator, DOE would be required to meet the waste acceptance criteria of the disposal facilities licensed under this regulation or compatible Agreement State regulations.

Energy*Solutions*, near Clive, Utah, is licensed by the State of Utah to accept Class A LLW from generators through the United States. Energy*Solutions'* operating licenses and permits are available for review at https://customerportal.energysolutions.com/.

WCS, near Andrews, Texas, is licensed by the State of Texas to accept Class A, B, and C LLW from states (WCS Compact Waste Facility) comprising the Texas Compact (Texas and Vermont), and the Federal Government (WCS Federal Waste Facility). Out-of-compact waste generators may also access WCS (Compact Waste Facility) for Class A, B, and C LLW disposal. WCS facility operating licenses and permits are available for review at http://www.wcstexas.com/facilities/licenses-and-permits/.

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[60] One of the principal concerns for disposal of large quantities of depleted uranium as waste is the long-term gaseous release of radon isotopes.

5.4.2 Status of 10 CFR Part 61 Rulemaking

This *DU Oxide SEIS* evaluates DU oxide and other wastes disposed of as LLW at Energy*Solutions* near Clive, Utah; NNSS; or WCS near Andrews, Texas. Energy*Solutions* and WCS are licensed to dispose of LLW pursuant to state regulations compatible with NRC regulations in 10 CFR Part 61, while NNSS is authorized by DOE to dispose of LLW pursuant to DOE Order 435.1. Licenses and the disposal authorization statement include facility construction requirements, operational requirements including waste acceptance criteria,[61] and closure requirements.

Because of the potential for disposition of DU from conversion of DUF_6 at DOE facilities, and additional volumes of DU waste from uranium enrichment activities, Federal and state regulators and DOE have reviewed existing LLW disposal requirements for DU. A 2008 NRC technical analysis concluded that the safe disposal of DU was dependent on the geological, hydrological, and climate characteristics of the proposed site, and recommended site-specific technical analyses (e.g., performance assessments) to evaluate disposal of this material (NRC 2008).

In April 2010, the UDEQ issued revised radioactive waste disposal regulations addressing disposal of DU at disposal facilities in Utah. These revised regulations require additional technical analyses with a quantitative compliance period for comparison against regulatory dose limits for a minimum of 10,000 years, with additional qualitative analyses for the period of peak radiation dose. Energy*Solutions* prepared a technical analysis to support a proposed license amendment to authorize disposal of DU at its Utah disposal facility and submitted the analysis and proposed amendment to UDEQ for review (ES 2011). The UDEQ review is underway.

In August 2014, informed by a technical analysis prepared by WCS, which addressed the radiological impacts that could occur over a 1-million-year period following waste disposal, the TCEQ approved an amendment to the LLW disposal license for the WCS facility to authorize disposal of DU (WCS 2014).

On March 26, 2015 (80 FR 16082), NRC proposed to amend its regulations governing disposal of LLW, 10 CFR Part 61, to require new and revised site-specific technical analyses to address the disposal of unique waste streams such as significant quantities of DU. The technical analyses would address potential radiological impacts over three periods following waste disposal: the first 1,000 years; years 1,000 to 10,000; and the period after 10,000 years. On the same day NRC also issued draft guidance (NUREG-2175, *Guidance for Conducting Technical Analyses for 10 CFR Part 61*) for conducting the technical analyses required under the Part 61 regulations, including the analyses required under the proposed amendments (NRC 2015). NRC requested public comment on both the proposed amendments and the draft guidance document.[62] Subsequently, NRC published on October 17, 2017 (82 FR 48284) a supplemental proposed rule change for public comment. The proposed rule change would change the compliance period to 1,000 years, independent of radionuclide content. NRC staff are working on the revisions.

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[61] Waste acceptance critieria are derived from required technical analyses to assure that potential radiation doses over long periods of time following waste disposal (e.g., potentially thousands of years) would not exceed the limits prescribed in DOE Order 435.1 or state regulations compatible with 10 CFR Part 61.

[62] On August 27, 2015 (80 FR 51964), NRC extended the public comment period for the proposed rule revisions and the draft guidance until September 21, 2015.

Once the Part 61 amendments go into effect after being issued in final form, Agreement State regulators would have three years to promulgate compatible regulations. Because Utah and Texas are both Agreement States, the operators of the Energy*Solutions* facility in Utah and the WCS facility in Texas would prepare analyses for state regulatory approval in compliance with the compatible state regulations. It is expected that these analyses would be in the form of as-needed updates to the existing analyses. Informed by these analyses, the regulators would issue license amendments, as needed, to receive and dispose of the waste including any revisions to facility construction and operational requirements, and waste acceptance criteria, which may be needed to comply with amended regulatory requirements.

As described in Chapter 2, Section 2.2.1, under the No Action Alternative, DU oxide would continue to be stored at Paducah and Portsmouth. The AEA, as amended, provides the basic statutory framework for DOE's use and management of radioactive materials. DOE has issued a series of Directives (e.g., Orders and Manuals) to establish a system of standards and requirements to ensure safe operation of DOE facilities.

DOE exercises its authority over working conditions at its facilities through an extensive program of internal oversight and a system of DOE regulations and directives that require DOE and its contractors to comply with relevant worker protection standards and regulations (e.g., 29 CFR Part 1910, "*Occupational Safety and Health Standards*"), and impose additional radiation and chemical exposure standards developed by DOE (DOE Order 440.1B Change 2). Most of DOE's worker radiation protection regulations are located in 10 CFR Part 835, *Occupational Radiation Protection*. Pertinent DOE Directives are listed in site-specific contract provisions. DOE facilities are required to comply with applicable health, safety, and environmental laws, orders, regulations, and national consensus standards and to develop and execute a radiation protection plan and an integrated safety management plan.

Storage activities would be conducted pursuant to numerous other Federal and state regulations, DOE Orders, and site management plans. These regulatory requirements may require a variety of permits, licenses, and other consents to be obtained. Table 5-1 provides a summary list of potentially applicable permitting, reporting, and compliance requirements for activities at Paducah and Portsmouth. The status of each is indicated on the basis of currently available information. However, because DU oxide production and storage are in progress, and DOE has not made a decision to transport and dispose of the DU oxide, additional requirements may apply; alternatively, some requirements may not be applicable.

Table 5-1 Potentially Applicable Permitting, Reporting, and Compliance Requirements for Activities at the Paducah and Portsmouth Sites

License, Permit, or Other Consent	Responsible Agency	Authority	Relevance and Status
Water Resources Protection			
Kentucky Pollutant Discharge Elimination System (KPDES) Permit – Industrial Facility Storm Water: Required before making point source storm water discharges into waters of the state from an industrial site.	KDEP	Clean Water Act (CWA) (33 U.S.C. § 1251 et seq.); 40 CFR Part 122; 401 KAR 5:055 and 5:060	Storm water runoff would be discharged from the DU oxide storage yards at Paducah through an existing outfall covered by KPDES Permit Number KY0004049. Paducah has a required Storm Water Pollution Prevention Plan
National Pollutant Discharge Elimination System (NPDES) Permit – Industrial Facility Storm Water: Required before making point source storm water discharges into waters of the state from an industrial site.	OEPA	CWA (33 U.S.C. § 1251 et seq.); 40 CFR Part 122; OAC-3745-33-02, 3745-38-02, and 3745-38-06	Storm water runoff would be discharged from the DU oxide storage yards at Portsmouth through existing outfalls covered by NPDES Permit Numbers 0IO00000*ND and 0IS00034*BD. Portsmouth has a required Storm Water Pollution Prevention Plan
Groundwater Protection Plan: Required for conducting specified activities that may result in the pollution of groundwater.	KDEP	40 1 KAR 5:037	A groundwater protection plan has been developed and implemented for the Paducah Site (FRNP 2018b).
Waste Management and Pollution Prevention			
Registration and Hazardous Waste Generator Identification Number: Required before a person who generates over 220 lb (100 kg) per calendar month of hazardous waste ships the hazardous waste off site.	EPA; KDEP; OEPA	RCRA, as amended (42 U.S.C. § 6901 et seq.), Subtitle C; 401 KAR 32:010; OAC 3745-52-12	The Paducah Conversion Facility and Portsmouth Conversion Facility are small quantity generators (Paducah ID Number: KYR000051128; and Portsmouth ID Number: OHR000158121). Small quantity generator status also applies to activities for DU oxide management.

License, Permit, or Other Consent	Responsible Agency	Authority	Relevance and Status
Hazardous Waste Treatment, Storage, or Disposal Facility Permit: Required if hazardous or mixed waste will undergo nonexempt treatment by the generator, be stored on site by the generator of 2,205 lb (1,000 kg) or more of hazardous waste per month for longer than 90 days, be stored on site by the generator of between 220 and 2,205 lb (100 and 1,000 kg) of hazardous waste per month for longer than 180 days, be disposed of on site, or be received from off site for treatment or disposal.	EPA; KDEP; OEPA	RCRA, as amended (42 U.S.C. § 6901 et seq.), Subtitle C; 401 KAR 38:010, Section 4; OAC 3745-50-40	The Paducah Site currently holds Paducah Hazardous Waste Facility Permit number KY8-890-008-982. The Portsmouth Site currently holds Portsmouth Hazardous Waste Permit number 04-66-0680. Hazardous waste permits do not apply to DU oxide because DU oxide is not a hazardous waste. Aside from minor neutralization, the Paducah and Portsmouth Conversion Facilities perform no hazardous waste treatment on site. Any ancillary hazardous waste generated by DU oxide management would be disposed of off site.
Notification of PCB Waste Activity	EPA	TSCA, as amended (15 U.S.C. § 2601 et seq.); 40 CFR Part 761	The Portsmouth Site has an agreement with EPA Region 5 (no requirement/agreement for Paducah). EPA is notified annually of PCB related activities (e.g., PCB containers coming in and going out of Portsmouth, sampling and analysis, PCB paint removal/clean-up activities, and disposal). Conversion of cylinders coated with PCB containing paints requires notification in advance of placing the cylinders in the autoclaves.
Emergency Planning and Response			
List of Material Safety Data Sheets (MSDS): Submission of a list of MSDSs is required for hazardous chemicals (as defined in 29 CFR Part 1910) that are stored on site in excess of their threshold quantities.	Local Emergency Planning Commission; Kentucky Emergency Response Commission; Ohio State Emergency Response Commission	Emergency Planning and Community Right-to-Know Act of 1986, Section 311 (42 U.S.C. § 11021); 40 CFR 370.20; OAC 3750-30-15	Lists of MSDSs have been submitted for Paducah and Portsmouth. The lists are updated as needed.

License, Permit, or Other Consent	Responsible Agency	Authority	Relevance and Status
Annual Hazardous Chemical Inventory Report: Submission of the report is required when hazardous chemicals have been stored at a facility during the preceding year in amounts that exceed threshold quantities.	LEPC; Kentucky Emergency Response Commission; Ohio SERC; local fire department	EPCRA, Section 312 (42 U.S.C. § 11022); 40 CFR 370.25; 106 KAR 1:081; OAC 3750-30-01	DOE tenants at both Paducah and Portsmouth have submitted sitewide Annual Hazardous Chemical Inventory Reports. No hazardous chemicals would be stored in the DU oxide storage yards at either Paducah or Portsmouth.
Annual Toxic Release Inventory (TRI) Report: Required for facilities that have 10 or more full-time employees and are assigned certain Standard Industrial Classification (SIC) codes.	EPA	EPCRA, Section 313 (42 U.S.C. § 11023); 40 CFR Part 372	A TRI report is annually prepared at Paducah and Portsmouth and submitted to EPA. The report includes the quantities of DUF_6 processed, HF generated, emissions, hazardous chemicals transferred/dispositioned, on-site/off-site disposal, material recycled, and DU oxide in storage.
Transport of Radioactive Wastes and Conversion Products			
Certificate of Registration: Required to authorize the registrant to transport hazardous material or cause a hazardous material to be transported or shipped.	DOT	Hazardous Materials Transportation Act (HMTA), as amended by the Hazardous Materials Transportation Uniform Safety Act of 1990 and other acts (49 U.S.C. § 5101 et seq.); 49 CFR 107.608(b)	The Paducah and Portsmouth Sites have obtained DOT Hazardous Materials Registrations.
Packaging, Labeling, and Routing Requirements for Radioactive Materials: Required for packages containing radioactive materials that will be shipped by truck or train.	DOT	HMTA; AEA; 49 CFR Parts 172, 173, 174, 177, and 397	DOE will comply with DOT packaging, labeling, and routing requirements for shipments of radioactive materials.
Biotic Resources			
Threatened and Endangered Species Consultation: Required between the responsible Federal agencies and affected states to ensure that a project is not likely to (1) jeopardize the continued existence of any species listed at the Federal or state level as endangered or threatened or (2) result in destruction of critical habitat of such species.	DOE; U.S. Fish and Wildlife Service; KDFWR; Ohio Department of Natural Resources	Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 et seq.); KRS 150.183, 150.990, and 146.600–619; ORC 1531.25-26 and 1531.99	No species listed at the Federal or state level as endangered or Threatened, or the critical habitat of such a species, has been identified at Paducah or Portsmouth that would be affected by alternatives evaluated relative to the Proposed Action in this *DU Oxide SEIS*. See Chapter 3, Sections 3.1.5 and 3.2.5, for more information.

License, Permit, or Other Consent	Responsible Agency	Authority	Relevance and Status
Cultural Resources			
Archaeological and Historical Resources Consultation: Required before a Federal agency approves a project in an area where archaeological or historic resources might be located.	DOE; Advisory Council on Historic Preservation; Kentucky State Historic Preservation Officer (SHPO); Ohio SHPO	National Historic Preservation Act of 1966, as amended (16 U.S.C. § 470 et seq.); Archaeological and Historical Preservation Act of 1974 (16 U.S.C. §§ 469–469c-2); Antiquities Act of 1906 (16 U.S.C. § 431et seq.); Archaeological Resources Protection Act of 1979, as amended (16 U.S.C. §§ 470aa–mm)	DOE has coordinated with the Advisory Council on Historic Preservation and the Kentucky and Ohio SHPOs. For Paducah, a programmatic agreement (PA) calling for a complete cultural resource survey of Paducah, as well as the associated Cultural Resource Management Plan (CRMP), was developed and is in place. Surveys have been conducted at Portsmouth and many historic sites were identified, including some with potential NRHP eligibility, although none is located within the cylinder storage areas. See Chapter 3, Section 3.1.10 and 3.2.10, for more information.
Government-to-Government Tribal Consultation: Required to ensure that project activities have been designed to protect access to, physical integrity of, and confidentiality of traditional cultural and religious sites.	DOE	Religious Freedom Act of 1978 (42 U.S.C. §§ 1996 and 1996a); Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. § 3001 et seq.); National Historic Preservation Act of 1966, as amended (16 U.S.C. § 470f); 36 CFR Part 800, Subpart B; 43 CFR Part 10	DOE has conducted government-to-government consultations with Native American tribes in the area of Paducah and Portsmouth as part of preparing the 2004 EISs. No religious or sacred sites, burial sites, or resources significant to Native Americans have been identified to date. If religious or sacred sites, burial sites, or resources significant to Native Americans are identified, the appropriate Native American tribe(s) would be consulted. See Chapter 3, Section 3.1.10 and 3.2.10, for more information.
Other			
Environmental Impact Statement (EIS): Required to evaluate the potential environmental impacts of a proposed major Federal action that may significantly affect the quality of the human environment and to consider alternatives to the Proposed Action.	DOE	National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. § 4321 et seq.); 40 CFR Parts 1500–1508; 10 CFR Part 1021	The requirements of NEPA are satisfied for this Proposed Action by publication of this *DU Oxide SEIS*.

Key: AEA = Atomic Energy Act of 1954, as amended; CaF_2 = calcium fluoride; CFR = Code of Federal Regulations; CRMP = Cultural Resources Management Plan; CWA = Clean Water Act; DOE = U.S. Department of Energy; DOT = U.S. Department of Transportation; DU = depleted uranium; DUF_6 = depleted uranium hexafluoride; EIS = Environmental Impact Statement; EPA = U.S. Environmental Protection Agency; EPCRA = Emergency Planning and Community Right-to-Know Act; HF = hydrogen fluoride; HMTA = Hazardous Material Transportation Act; KAR = Kentucky Administrative Regulations; KDEP = Kentucky Department of Environmental Protection; KPDES = Kentucky Pollutant Discharge Elimination System; kg = kilogram; KRS = Kentucky Revised Statutes; lb = pound; LEPC = Local Emergency Planning Commission; LLW = low level radioactive waste; MSDS = Material Safety Data Sheet; NEPA = National Environmental Policy Act; NPDES = National Pollutant Discharge Elimination System; NRHP = National Register of Historic Places; OAC = Ohio Administrative Code; OEPA = Ohio Environmental Protection Agency; ORC = Ohio Revised Codes; PA = Programmatic Agreement; PCB = polychlorinated biphenyl; RCRA = Resource Conservation and Recovery Act; SEIS = supplemental environmental impact statement; SERC = State Emergency Response Commission; SHPO = State historic preservation officer; TRI = Toxic Release Inventory; SIC = Standard Industrial Classification; TSCA = Toxic Substances Control Act; U.S.C. = U.S. Code

Sources: DOE 2004a, 2004b, 2017a, 2017b, 2017c, 2017e; EPA 2016c, 2016d; FRNP 2018a; PPPO 2018

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8 GLOSSARY

Articulated Bulk Container railcar—The Articulated Bulk Container (ABC) railcar, is a 90-foot-long articulated spine-type railcar, designed to carry materials in 20- or 40-foot containers that can be double-stacked, depending on the weight of each container. An ABC railcar's gross load typically ranges between 359,000 and 429,000 pounds.

aquifer—A body of rock or sediment that is capable of transmitting groundwater and yielding usable quantities of water to wells or springs.

aquitard—A less-permeable, or impermeable, geologic unit in a stratigraphic sequence. Aquitards separate aquifers.

as low as reasonably achievable (ALARA)—An approach to radiation protection to manage and control worker and public exposures (both individual and collective) and releases of radioactive material to the environment to as far below applicable limits as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit, but a process for minimizing doses to as far below limits as is practicable.

background radiation—Radiation from (1) cosmic sources; (2) naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material); and (3) global fallout as it exists in the environment (e.g., from the testing of nuclear explosive devices).

beyond-design-basis accident—This term is used as a technical way to discuss accident sequences that are possible but were not fully considered in the design process because they were judged to be too unlikely. (In that sense, they are considered beyond the scope of design-basis accidents [e.g., fire, earthquake, spill, explosion] that a nuclear facility must be designed and built to withstand.) As the regulatory process strives to be as thorough as possible, "beyond-design-basis" accident sequences are analyzed to fully understand the capability of a design. These accidents are typically very low-probability, but high-consequence events. (See *design-basis accident*.)

criticality—The condition in which a system undergoes a sustained nuclear chain reaction.

decay (radioactive)—The decrease in the amount of any radioactive material with the passage of time, due to spontaneous nuclear disintegration (i.e., emission from atomic nuclei of charged particles, photons, or both).

depleted uranium—Uranium with a content of the fissile isotope uranium-235 of less than 0.7 percent (by weight) found in natural uranium, so that it contains more uranium-238 than natural uranium.

depleted uranium oxide—The oxidized form of depleted uranium primarily in the form of UO_2 or U_3O_8. The U_3O_8 form of depleted uranium oxide is the most stable form.

design-basis—For nuclear facilities, information that identifies the specific functions to be performed by a structure, system, or component and the specific values (or ranges of values) chosen for controlling parameters for reference bounds for design. These values may be (1) restraints derived from generally accepted, state-of-the-art practices for achieving functional goals; (2) requirements derived from analysis (based on calculation or experiment) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals; or (3) requirements derived from Federal safety objectives, principles, goals, or requirements.

design-basis accident—An accident postulated for the purpose of establishing functional and performance requirements for safety structures, systems, and components. (See *beyond-design-basis accident*.)

documented safety analysis (DSA)—A report that systematically identifies potential hazards within a nuclear facility, describes and analyzes the adequacy of measures to eliminate or control identified hazards, and analyzes potential accidents and their associated risks. Safety analysis reports are used to ensure that a nuclear facility can be constructed, operated, maintained, shut down, and decommissioned safely and in compliance with applicable laws and regulations. Safety analysis reports (or documented safety analyses per 10 CFR Part 830) are required for U.S. Department of Energy (DOE) nuclear facilities and as a part of applications for U.S. Nuclear Regulatory Commission (NRC) licenses. The NRC regulations or DOE orders and technical standards that apply to the facility type provide specific requirements for the content of safety analysis reports. (See *nuclear facility*.)

dose—A generic term meaning absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or committed equivalent dose. For ionizing radiation, the energy imparted to matter by ionizing radiation per unit mass of the irradiated material (e.g., biological tissue). The units of absorbed dose are the rad and the gray. In many publications, the rem is used as an approximation of the rad.

effective dose equivalent—The dose value obtained by multiplying the dose equivalents received by specified tissues or organs of the body by the appropriate weighting factors applicable to the tissues or organs irradiated, and then summing all of the resulting products. It includes the dose from radiation sources internal and external to the body. The effective dose equivalent is expressed in units of rem or sieverts.

enriched uranium—Uranium whose content of the fissile isotope uranium-235 is greater than the 0.7 percent (by weight) found in natural uranium. (See *highly enriched uranium* and *low-enriched uranium*.)

environmental impact statement (EIS)—The detailed written statement that is required by section 102(2)(C) of NEPA for a proposed major Federal action significantly affecting the quality of the human environment.

environmental justice—The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of Federal, state, local, and tribal programs and policies. Executive

Order 12898 directs Federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects of agency programs, policies, and activities on minority and low-income populations. (See *minority population* and *low-income population*.)

fissile material—Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning; namely, any material fissionable by low-energy (i.e., thermal or slow) neutrons. Fissile materials include uranium-233 and -235, and plutonium-239 and -241.

fugitive emissions—(1) Emissions that do not pass through a stack, vent, chimney, or similar opening where they could be captured by a control device, or (2) any air pollutant emitted to the atmosphere other than from a stack. Sources of fugitive emissions include pumps; valves; flanges; seals; area sources such as ponds, lagoons, landfills, and piles of stored material (such as coal); and road construction areas or other areas where earthwork is occurring.

gondola railcar—An open-topped railcar used for transporting bulk materials. Because of their low side walls, gondolas are suitable for the carriage of high-density cargos and bulky items.

half-life (radiological)—Time in which one-half of the atoms of a particular radionuclide disintegrate into another nuclear form. Half-lives for specific radionuclides vary from millionths of a second to billions of years.

hazard index—The hazard index (HI) is the sum of the hazard quotients for all chemicals to which an individual is exposed. A value less than 1 indicates that the exposed person is unlikely to develop adverse human health effects. The hazard quotient is a comparison of the estimated intake level of a chemical with its adverse effects level. It is expressed as a ratio of estimated intake level to adverse effects level.

hazardous material—A material, as defined by 49 CFR 171.8, that the Department of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

hazardous air pollutants—Air pollutants not covered by ambient air quality standards, but that may present a threat of adverse human health or environmental effects. Those specifically listed in 40 CFR 61.01 are asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride. More broadly, hazardous air pollutants are any of the 189 pollutants listed in or pursuant to Section 112(b) of the Clean Air Act.

ionizing radiation—Particles (alpha, beta, neutrons, and other subatomic particles) or photons (i.e., gamma, x-rays) emitted from the nucleus of unstable atoms as a result of radioactive decay. Such radiation is capable of displacing electrons from atoms or molecules in the target material (such as biological tissues), thereby producing ions.

isotope—Any of two or more variations of an element in which the nuclei have the same number of protons (and thus the same atomic number), but different numbers of neutrons so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties, but often different physical properties; e.g., carbon-12 and -13 are stable; carbon-14 is radioactive.

low-level radioactive waste (LLW)—Radioactive waste that is not high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in Section 11e.(2), (3), or (4) of the Atomic Energy Act of 1954, as amended.

maximally exposed individual (MEI)—A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (i.e., inhalation, ingestion, direct exposure, resuspension).

natural phenomena hazard—A category of events (e.g., earthquake, severe wind, tornado, flood, and lightning) that must be considered in the U.S. Department of Energy facility design, construction, and operations, as specified in DOE Order 420.1C.

nuclear criticality—See *criticality*.

person-rem—A unit of collective radiation dose applied to populations or groups of individuals; that is, a unit for expressing the dose when summed across all persons in a specified population or group. One person-rem equals 0.01 person-sieverts.

rad—A unit of radiation-absorbed dose (e.g., in body tissue). One rad is equal to an absorbed dose of 0.01 joules per kilogram.

radiation—See ionizing radiation.

radioactivity—Defined as a *process*: The spontaneous transformation of unstable atomic nuclei, usually accompanied by the emission of ionizing radiation.

—Defined as a *property*: The property of unstable nuclei in certain atoms to spontaneously emit ionizing radiation during nuclear transformations.

radionuclide—A radioactive element characterized according to its atomic mass and atomic number. Radionuclides can be manmade or naturally occurring, have a long half-life, and have potentially mutagenic, teratogenic, or carcinogenic effects on the human body.

radon—A colorless, odorless, naturally occurring, radioactive, inert, gaseous element formed by radioactive decay of radium atoms. The atomic number is 86.

region of influence (ROI)—The physical area that bounds the environmental, sociological, economic, or cultural features of interest for the purpose of analysis.

respirable size range—Airborne particles that can be transported through air and inhaled into the human respiratory system; commonly assumed to include particles 10-μm aerodynamic equivalent diameter and less.

roentgen—A unit of exposure to ionizing x-ray or gamma radiation equal to or producing 1 electrostatic unit of charge per cubic centimeter of air. It is approximately equal to 1 rad.

roentgen equivalent man (rem)—A unit of dose equivalent. The dose equivalent in rem equals the absorbed dose in rad in tissue multiplied by the appropriate quality factor and possibly other modifying factors. Rem refers to the dosage of ionizing radiation that will cause the same biological effect as one roentgen of x-ray or gamma ray exposure. One rem equals 0.01 sieverts.

security—An integrated system of activities, systems, programs, facilities, and policies for the protection of Restricted Data and other classified information or matter, nuclear materials, nuclear weapons and nuclear weapons components, and/or U.S. Department of Energy or contractor facilities, property, and equipment.

shielding—Any material or obstruction (e.g., bulkhead, wall, or other structure) that absorbs radiation, and thus tends to protect personnel or materials from the effects of ionizing radiation.

stabilize—To convert a compound, mixture, or solution to a nonreactive form.

supplemental environmental impact statement—A supplemental environmental impact statement is required when an agency makes substantial changes in the Proposed Action relevant to environmental concerns, or when there are significant new circumstances or information relevant to environmental concerns bearing on the Proposed Action, and is optional when an agency otherwise determines to supplement an EIS. (40 CFR 1502.9(c)). See environmental impact statement.

transuranic waste—Waste containing more than 100 nanocuries (3,700 becquerels) of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for (A) high-level radioactive waste; (B) waste that the U.S. Department of Energy has determined, with the concurrence of the U.S. Environmental Protection Agency, does not need the degree of isolation called for by 40 CFR Part 191; or (C) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.

uranium—A radioactive, metallic element with the atomic number 92. Uranium has 14 known isotopes, of which uranium-238 is the most abundant in nature. Uranium-235 is commonly used as a fuel for nuclear fission, and uranium-238 is transformed into fissionable plutonium-239 following its capture of a neutron in a nuclear reactor.

9 INDEX