DOE/EIS-0559
March 2024

DRAFT
Environmental Impact Statement
for Department of Energy Activities in Support of Commercial Production of High-Assay Low-Enriched Uranium (HALEU)

VOLUME 1

U.S. Department of Energy
Office of Nuclear Energy

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Cover Sheet

Lead Agency: U.S. Department of Energy (DOE)

Cooperating Agencies: None

Title: *Draft Environmental Impact Statement for Department of Energy Activities in Support of Commercial Production of High-Assay Low-Enriched Uranium (HALEU)* (the "HALEU EIS") (DOE/EIS-0559)

Location: Not Applicable

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This document is available on the HALEU EIS website (https://www.energy.gov/ne/haleu-environmental-impact-statement) and the DOE National Environmental Policy Act (NEPA) website (http://energy.gov/nepa/nepa-documents) for viewing and downloading.

Abstract: This *Environmental Impact Statement for the Department of Energy Activities in Support of Commercial Production of High-Assay Low-Enriched Uranium (HALEU)* evaluates the potential environmental impacts from activities associated with DOE's Proposed Action, which is to acquire, through procurement from commercial sources, HALEU enriched to at least 19.75 and less than 20 weight percent uranium-235 over a 10-year period of performance, and to facilitate the establishment of commercial HALEU fuel production. DOE's objective is to establish a temporary domestic demand for HALEU to support the availability of HALEU for civilian domestic commercial use and demonstration projects by engaging with industry and other stakeholders to enter into partnership and incentivize the establishment of a domestic HALEU fuel cycle (i.e., the HALEU supply chain).

Implementation of the Proposed Action may result in the modification of existing fuel cycle facilities or construction and operation of new facilities that would be used to encourage the commercialization of HALEU fuel production and the acquisition of up to 290 metric tons of HALEU. This EIS addresses the following fuel cycle activities: extraction and recovery of uranium ore (from domestic and/or foreign in-situ recovery [i.e., ISR] or conventional mining and milling sources); uranium conversion to uranium hexafluoride (UF_6) for input to enrichment facilities; enrichment to HALEU of from 19.75 to less than 20 weight percent uranium-235 in a U.S. Nuclear Regulatory Commission (NRC) Category II facility; HALEU deconversion from UF_6 to uranium oxide, metal, and other forms suitable for use in fuel fabrication in an NRC Category II facility; storage in an NRC Category II facility or facilities of the converted HALEU; transportation of materials between facilities; and DOE acquisition of up to 290 MT of HALEU. This EIS, to the extent practicable, addresses environmental impacts associated with the use of the HALEU that would occur after the Proposed Action activities, including fuel fabrication, use of HALEU in advanced reactors (and possibly test and demonstration reactors), and spent nuclear fuel storage and disposition.

The locations of potential HALEU fuel cycle facilities are subject to an ongoing procurement process, including responses to Requests for Proposals. Therefore, no sites have been identified for the location of HALEU fuel cycle facilities under the Proposed Action. Potential types of sites could be existing uranium fuel cycle facility locations, previously disturbed industrial locations (brownfield sites), and undisturbed locations (greenfield sites). The different characteristics of these site types were incorporated into the assessment as a possible range of environmental impacts. If the Proposed Action is undertaken and contracts are awarded thereunder, the awardee(s) will be required to apply to and obtain licenses/permits from appropriate regulatory authorities (e.g., the NRC, other Federal agency, or Agreement States) and these regulatory agencies will be required to comply with applicable NEPA requirements or State equivalents. At that time, DOE expects that site-specific environmental analysis would be conducted by the relevant regulatory agency.

In addition to the Proposed Action, the No Action Alternative is also evaluated in this HALEU EIS.

***Preferred Alternative*:** The Preferred Alternative is the Proposed Action to acquire, through procurement from commercial sources, HALEU enriched to at least 19.75 and less than 20 weight percent uranium-235 over a 10-year period of performance, and to facilitate the establishment of commercial HALEU fuel production.

***Public Involvement*:** DOE issued a Notice of Intent to prepare this EIS in the *Federal Register* (FR) (88 FR 36573) on June 5, 2023, to solicit public input on the scope and environmental issues to be addressed in this HALEU EIS. Virtual scoping meetings were held on June 21, 2023. All written and oral comments that were received by DOE have been considered in the preparation of this Draft EIS. Comments on this Draft EIS will be accepted for 45 days after the U.S. Environmental Protection Agency publishes the Notice of Availability of this EIS in the Federal Register. Comments can be either emailed to HALEU-EIS@nuclear.energy.gov or mailed to:

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Opportunities to provide oral comments at public hearings will be announced in news media and at https://www.energy.gov/ne/haleu-environmental-impact-statement at a later date. Comments received during the comment period will be considered during the preparation of the Final EIS. Comments received after the close of the comment period will be considered to the extent practicable.

Reader's Guide

This Reader's Guide is intended to help readers navigate this Environmental Impact Statement (EIS) and does not on its own provide sufficient information regarding the Proposed Action. For a brief overview of the EIS and a summary of impacts, please review the Summary. For full impact analyses, please review the EIS and its Appendices.

Proposed Action Overview

As you read this EIS, keep in mind that under the Proposed Action, the U.S. Department of Energy (DOE) would acquire a particular type of uranium that is not widely produced by the commercial market at this time. Under the Proposed Action, DOE would acquire a limited quantity of high-assay low-enriched uranium (HALEU) to encourage commercial producers to invest in the necessary fuel cycle infrastructure and gear up production to provide the amount of HALEU expected to be needed for commercial use or demonstration projects.

DOE's ***Proposed Action*** is to acquire, through procurement from commercial sources, HALEU enriched to at least 19.75 and less than 20 weight percent uranium-235 over a 10-year period of performance, and to facilitate the establishment of commercial HALEU fuel production.

Various companies would perform the activities to produce the HALEU that DOE proposes to acquire. In 2023 and early 2024, DOE released Requests for Proposals (RFPs) for companies to consider what needs to be done to provide HALEU to DOE. While the Requests for Proposals support DOE's Proposed Action to acquire HALEU, similar activities are already well established within the existing uranium fuel economy, and a sizable body of information already exists that evaluates the potential environmental consequences of those activities. In this EIS, DOE used that existing information to estimate potential environmental impacts associated with the Proposed Action to acquire HALEU. Note: This EIS uses "impacts" and "environmental consequences" interchangeably.

Associated Activities

DOE has considered the activities of a uranium-based fuel cycle and determined that the production of HALEU would involve the following activities. The process starts with **mining and milling** or in-situ recovery of uranium ore. The uranium ore is **converted** into a form that can be **enriched**. The enriched uranium hexafluoride would then need to be **deconverted** into a form that can be used for fuel fabrication. The various uranium forms would be **stored** until needed for each of these activities. The uranium forms also would need to be **transported** between the different facilities where these activities are performed.

So, the production of HALEU under DOE's Proposed Action would require the following activities:

- Uranium mining and milling
- Uranium conversion
- Uranium enrichment to HALEU
- HALEU deconversion
- HALEU storage
- Transportation of uranium between activity locations

Increasing the concentration of uranium-235 is called **enrichment**, which is one of six activities in the HALEU fuel cycle associated with the Proposed Action.

In addition to the activities above, there are several reasonably foreseeable activities that could result from implementation of the Proposed Action—HALEU could be used for fuel fabrication and used in HALEU-fueled reactors. When no longer usable as an energy source, the HALEU would be managed as spent nuclear fuel. While not specifically a part of the Proposed Action, the impacts from these reasonably foreseeable activities are acknowledged and addressed to the extent practicable in this EIS.

The activities performed under DOE's Proposed Action, if implemented, have a long history of being conducted safely and none are unique to the production of HALEU, having been conducted for other uranium forms and improved over many decades. Extensive environmental analyses have been completed for facilities that perform uranium mining and milling, conversion, enrichment, deconversion, storage, and transportation activities, as well as fuel fabrication, use of uranium fuel in reactors, and spent nuclear fuel management.

Analytical Approach – The Use of Existing NEPA Evaluations and Information

Analytical Approach: Existing NEPA documentation for uranium fuel cycle activities and facilities where those activities have historically taken place was carefully examined to estimate the potential impacts of each of the activities associated with the Proposed Action.

This EIS presents the potential environmental consequences of the Proposed Action (i.e., the impacts from each of those HALEU production, storage, and transportation activities) and discusses the potential impacts of HALEU fuel fabrication, use in reactors, and the resulting spent nuclear fuel management. DOE is in the process of requesting proposals from commercial vendors regarding HALEU procurement and enrichment and deconversion services. Site-specific details will only be available after proposals are received and evaluated in response to the relevant RFPs. While this EIS will provide information that could be used to identify impacts from the construction and operation of HALEU fuel cycle facilities, the selection of specific locations and facilities will not be a part of the Record of Decision for this EIS. The decisions to be supported are whether or not to acquire HALEU from commercial sources and to facilitate commercial HALEU fuel production capability.

One of the main contributing factors to the significance of the environmental impacts is where the facilities are located. To determine the potential environmental consequences, DOE evaluated the existing National Environmental Policy Act (NEPA) documentation for uranium fuel cycle facilities used in the low-enriched uranium (LEU) fuel cycle. Some of the HALEU activities (mining and milling and conversion) are no different from their corresponding LEU fuel cycle activities, using the same processes and having the same feed and product material. Others (enrichment and deconversion) are different but similar. While the feed and product materials differ only in the enrichment of the materials, the processes employed are the same. However, some adjustments need to be implemented to address criticality safety controls for HALEU that are not the same as for LEU and depleted uranium. From an environmental impact perspective, these adjustments are minor.

Sixteen resources are considered in this EIS:

- land use
- visual and scenic resources
- geology and soils
- water resources
- air quality
- ecological resources
- historic and cultural resources
- infrastructure
- noise
- waste management
- public and occupational health – normal operations
- public and occupational health – facility accidents
- traffic
- socioeconomics
- environmental justice
- human health – transportation

Therefore, the existing NEPA evaluations for those activities and facilities where those activities take place were carefully examined to extrapolate the potential impacts of each of the activities being evaluated in this HALEU EIS.

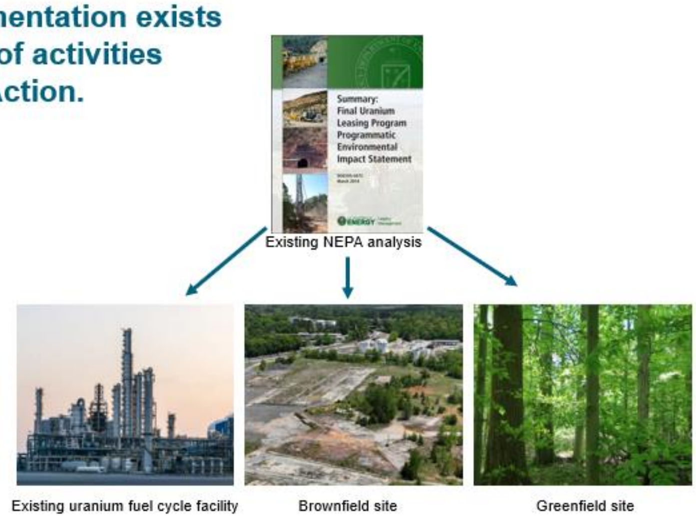
Since the Proposed Action is to acquire HALEU from commercial sources, those commercial sources could propose a range of scenarios for producing HALEU. Those scenarios could include the use of existing uranium fuel cycle facilities (also referred to as an **existing** facility or existing site) with modifications and/or expansions, construction and operation of a new facility at an existing industrial site (also referred to as a previously disturbed or **brownfield** site), and/or the construction and operation of a new facility at a previously undisturbed site (also referred to as a **greenfield** site).

Extensive NEPA evaluation documentation exists for environmental consequences of activities similar to those of the Proposed Action.

Existing uranium fuel cycle facilities – Many of the existing facilities that produce LEU and HEU could be modified or expanded to produce HALEU.

Other industrial (brownfield) sites – Operation of HALEU production facilities at other industrial sites likely would result in similar impacts to performing these activities at existing uranium fuel cycle facilities.

Undeveloped (greenfield) sites – Operation of HALEU production facilities on previously undeveloped lands would likely result in similar impacts to performing these activities at an existing uranium fuel cycle facility.



Specific locations and facilities will not be selected in the decision document (i.e., a Record of Decision) for this EIS and ***site-specific impacts will not be addressed in DOE's analysis.*** The modification, construction, and operation of uranium fuel cycle facilities would be subject to U.S. Nuclear Regulatory Commission, other Federal agency, or Agreement State licensing, including NEPA review, and potentially other Federal and state permitting. To estimate potential impacts associated with the Proposed Action, this EIS leverages the extensive existing NEPA documentation's impact assessments previously identified for the various fuel cycle activi ties and presents the relative impacts associated with performing these activities at existing facilities, b rownfield sites, or greenfield sites.

This EIS adopts the NRC impact assessment categories from most of the NEPA documents that were used as the basis for the impact analysis:

- **SMALL –** The environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
- **MODERATE** – The environmental effects are sufficient to alter noticeably, but not destabilize, important attributes of the resource.
- **LARGE** – The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

Structure and Content of the Document

The ***Summary*** provides a concise summary of the HALEU EIS. The Summary highlights key information from the EIS, including the purpose and need, the Proposed Action, the analytical approach, and potential environmental consequences of the Proposed Action.

Chapter 1 introduces background information on the need for HALEU and the Proposed Action.

Chapter 2 provides an overview of alternatives evaluated, a description of each HALEU activity, a description of facilities that have historically conducted or are capable of conducting each activity, and a high-level summary of the impacts associated with each activity. Table 2.6-1 presents a "quick-reference" comparison of impacts under each HALEU activity associated with placement of HALEU fuel cycle facilities at existing fuel cycle facilities, brownfield sites, and greenfield sites. Impacts are characterized in alignment with the standard ratings used by the U.S. Nuclear Regulatory Commission: SMALL, MODERATE, or LARGE. Chapter 2 also presents a summary of environmental consequences of the Proposed Action and No Action Alternative, as well as a brief overview and comparison of cumulative effects.

Chapter 3, Affected Environment and Environmental Consequences, describes the assumptions that DOE used for this analysis, the general analysis methodology for determining impact ratings by utilizing existing NEPA evaluations, and any exceptions to that general methodology. Chapter 3 presents the impacts of constructing and operating HALEU facilities under the Proposed Action by activity and siting scenario (i.e., existing site, brownfield site, greenfield site). This chapter further expands on impacts for resources that decision-makers need to consider because they are characterized as having potential MODERATE and LARGE impact ratings. (Resources characterized with SMALL impacts are addressed in the Appendices.)

Chapter 3 presents potential impacts of constructing and operating a new HALEU facility at existing sites, at brownfield sites, and at greenfield sites, which were extrapolated from and expand on existing NEPA evaluations.

Chapter 4*, *Cumulative Effects, addresses cumulative effects associated with the Proposed Action. These effects typically consider past, present, and reasonably foreseeable actions. However, as site selection is not a decision to be supported by this EIS, specific regions of influence would be speculative and so in depth, cumulative effects analysis is not possible for most resources. However, some impacts are more specifically discussed in Chapter 4, such as those from radioactive material transportation and spent nuclear fuel management, ozone depletion, and climate change since these impacts would be cumulative across all HALEU activities, are not site dependent, and with regards to ozone depletion and climate change are potentially global in nature.

Appendices contain additional information supporting the main body of the EIS. Appendix A, *Environmental Consequences Supporting Information*, includes details about the activity-specific analysis methodology and precise lists of the existing NEPA documents used to determine potential impacts for each respective HALEU activity. Appendix A also presents further supporting details for resources with potential MODERATE and LARGE impact ratings by discussing those potential impacts that contributed to the impact assessment of MODERATE or LARGE. In Appendix B, *Facility NEPA Documentation*, readers can find a discussion of the extent of existing NEPA coverage available (or not available) for each activity, as well as a breakdown of various reference materials by activity and existing facility location. Appendix C, *Federal Register Notices*, presents a copy of the published notice of intent to prepare this EIS.

See Appendix A for a detailed description of the activity-specific analysis methodology and each of the activity-specific NEPA evaluations that helped inform the activity-specific analysis.

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ACRONYMS, ABBREVIATIONS, AND CONVERSION CHART

%	percent
<	less than
AADT	average annual daily traffic
ACO	American Centrifuge Operating, LLC
ACP	American Centrifuge Plant
ANRs	advanced nuclear reactors
BMP	best management practices
BWXT	BWX Technologies, Inc.
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CISF	consolidated interim storage facilities
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DOE	Department of Energy
DOE-NE	DOE Office of Nuclear Energy
DU	depleted uranium
DUF_6	depleted uranium hexafluoride
EA	Environmental Assessment
EIS	Environmental Impact Statement
ET	Eastern Time
FFF	fuel fabrication facility
FMB	Feed Materials Building
FONSI	Finding of No Significant Impact
FR	Federal Register
g	gram
GE	General Electric
GEIS	Generic Environmental Impact Statement
GHG	greenhouse gas
GLE	Global Laser Enrichment
GNF-A	Global Nuclear Fuel – Americas
GWP	global warming potential
HALEU	high-assay low-enriched uranium
HEU	highly enriched uranium
HTGR	high-temperature gas-cooled reactor
IAEA	International Atomic Energy Agency
IIFP	International Isotopes Fluorine Products
INL	Idaho National Laboratory
IROFS	Items Relied on For Safety
ISFSI	independent spent fuel storage installation
ISP	Interim Storage Partners
ISR	in-situ recovery
kg	kilograms
kWh	kilowatt-hours
LCF	latent cancer fatality
LEU	low-enriched uranium
LEU+	uranium enriched 5% up to 10%
LWR	light water reactor
mg/m^3	milligrams per cubic meter
mrem	millirem
MSR	molten salt reactor
MT	metric tons
MT/yr	metric tons per year
MWe	megawatts electric
MW-h	megawatt-hour
NEF	National Enrichment Facility
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NFS	Nuclear Fuel Services
NOI	Notice of Intent
NRC	U.S. Nuclear Regulatory Commission
ODS	ozone-depleting substance
rem	roentgen equivalent man
RFI	*Request for Information Regarding the Establishment of a Program to Support the Availability of High-Assay Low-Enriched Uranium for Civilian Domestic Research, Development, Demonstration, and Commercial Use*
RFP	Request for Proposal
ROI	region of influence
SC-GHG	social cost of GHG
SNF	spent nuclear fuel
SNM	special nuclear material
SPE	Site Parameter Envelope
SWU	separative work unit
TRISO	tri-structural isotropic
U-235	uranium-235
U-238	uranium-238
U_3O_8	triuranium octoxide (uranium oxide) (yellowcake)
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U.S.	United States
U.S.C.	United States Code
UUSA	Urenco USA

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	4.46	Tons/acre	Tons/acre	0.224	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		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	0.000003069	Acre-feet
Acres	43,560	Square feet	Square feet	0.000022957	Acres
Square miles	640	Acres	Acres	0.0015625	Square miles

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}

Chapter 1
INTRODUCTION AND PURPOSE AND NEED

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1. INTRODUCTION AND PURPOSE AND NEED

1.0 Introduction

The United States (U.S.) Department of Energy (DOE), in accordance with the National Environmental Policy Act (NEPA) and in compliance with Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations [CFR] 1500 et seq.)[1] and DOE NEPA Implementing Procedures (10 CFR 1021), has prepared this Environmental Impact Statement (EIS) in support of activities associated with DOE's Proposed Action to acquire through procurement from commercial sources, high-assay low-enriched uranium (HALEU)[2] and to facilitate the establishment of commercial HALEU fuel production. The Proposed Action would address Section 2001(a)(2)(D)(v) of the Energy Act of 2020 (Title 42 United States Code [U.S.C.] Section 16281; 134 Statute 2454; Public Law 116-260 Division Z).

DOE's objective is to establish a temporary domestic demand for HALEU to support the availability of HALEU for civilian domestic research, development, demonstration, and commercial use by engaging with industry and other stakeholders to enter into partnership and incentivize the establishment of a domestic HALEU fuel cycle (i.e., the HALEU supply chain).

> DOE's ***Proposed Action***, as fully discussed in Section 1.4, is to acquire, through procurement from commercial sources, HALEU enriched to at least 19.75 and less than 20 weight percent uranium-235 over a 10-year period of performance, and to facilitate the establishment of commercial HALEU fuel production.

Figure 1.0-1 presents an overview of the various activities that are addressed in this EIS. The Proposed Action includes the procurement of uranium, which would entail mining and milling, conversion services, enrichment services, deconversion services, storage, and transportation[3] services.

DOE acknowledges that fuel fabrication, advanced reactor operations, and spent nuclear fuel storage and disposition, while not specifically part of the Proposed Action, are reasonably foreseeable activities that could result from successful implementation of the Proposed Action. Although they are reasonably foreseeable actions that could follow from DOE's efforts, those activities are not part of the Proposed Action (see Section 1.4, *Proposed Action and Related Activities*). Further, the specifics of those activities are presently unknown and would be subject to U.S. Nuclear Regulatory Commission (NRC) licensing and analysis. Therefore, this EIS addresses those reasonably foreseeable activities to the extent possible, but a detailed analysis of the impacts of those activities, herein, would be speculative.

This "HALEU EIS" analyzes the range of options that could fulfill DOE's Proposed Action. Site-specific details (such as the location of enrichment) and whether activities would result in modifying existing facilities or constructing new facilities are not yet determined and will not be considered as a part of this EIS; the associated Record of Decision will not select specific facilities or locations. For this reason, to analyze a full range of impacts (i.e., to "bound" potential impacts), DOE has analyzed the potential impacts associated with (1) modifications to/expansions of **existing uranium fuel cycle facilities**, (2) construction

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[1] The CEQ has published A Citizen's Guide to NEPA *Having Your Voice Heard* (available at https://ceq.doe.gov/docs/get-involved/citizens-guide-to-nepa-2021.pdf). The guide provides an explanation of NEPA, how it is implemented, and how people outside the Federal Government can participate.

[2] HALEU is "uranium having an assay greater than 5.0 weight percent and less than 20.0 weight percent of the uranium-235 isotope" Section 2001 (d)(4) of the Energy Act of 2020 (42 U.S.C. 16281(d)(4)).

[3] Figure 1.0-1 shows transportation activities between every HALEU fuel cycle facility; however, some HALEU fuel cycle facilities may be co-located, eliminating the need to transport material between those co-located facilities.

and operation of new HALEU facilities at existing industrial facilities/sites (also known as **brownfield sites**), and (3) construction and operation at undeveloped sites (also known as **greenfield sites**). The impact analysis is based on existing NEPA analysis for fuel cycle facilities.[4] The modification, construction, and operation of fuel cycle facilities would be subject to NRC or Agreement State licensing and potentially other Federal and State permitting, including NEPA review.

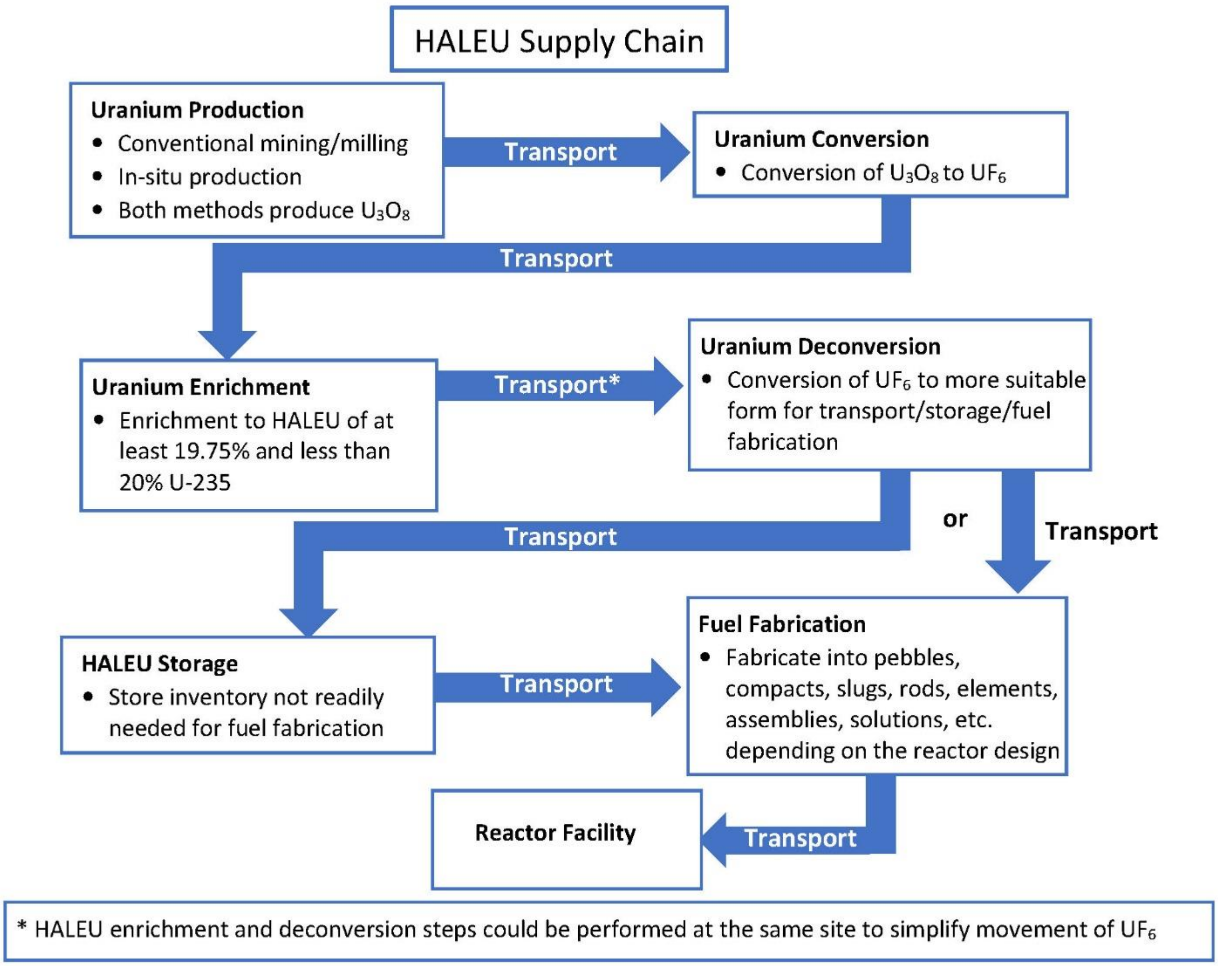

Figure 1.0-1. Components of the HALEU Supply Chain

As further discussed in Section 1.3, *DOE Requests for Proposals – HALEU Enrichment and Deconversion Services,* DOE has begun the procurement process with commercial vendors regarding HALEU procurement and enrichment and deconversion services. Site-specific details will only be available after proposals are received and evaluated in response to the relevant Request for Proposals (RFPs). If contracts are awarded thereunder, the awardee (Contractor) will be required to apply to and obtain licenses/permits from appropriate regulatory authorities (e.g., the NRC, other Federal agencies, or Agreement States) and these regulatory agencies will be required to comply with applicable NEPA

[4] Existing facilities that produce low-enriched uranium (LEU) and highly enriched uranium (HEU) are approved to operate under existing NRC licenses, U.S. Department of Interior permits, and/or applicable Federal, state, and local permits and approvals. NEPA or equivalent evaluations for these facilities were previously performed and considered under those licensing, permitting, and approval action decisions. Those NEPA evaluations—the majority of which are EISs and Environmental Assessments (EAs) prepared by the NRC—were identified for each of the HALEU fuel cycle activities and were used to characterize the potential environmental consequences associated with the Proposed Action.

requirements or state equivalents. At that time, DOE expects that site-specific environmental analysis would be conducted by the relevant regulatory agency.

1.0.1 What is HALEU?

Low-enriched uranium (LEU) is enriched to less than 20 percent (%) uranium-235 ("U-235")[5]—the main fissile isotope that produces energy during a chain reaction (NRC, 2009a). HALEU is ''uranium having an assay greater than 5.0 weight percent[6] and less than 20.0 weight percent of the uranium-235 isotope'' (Section 2001(d)(4) of the Energy Act of 2020 [42 U.S.C. 16281(d)(4)]). Under the Proposed Action, DOE seeks to acquire HALEU enriched to at least 19.75 and less than 20 weight percent U-235.

In the United States, HALEU is currently made, in limited quantities, by blending down highly enriched uranium (HEU) (enriched to 20% or greater) (DOE, 2020a), with natural uranium or lower enriched uranium (i.e., "downblending").[7]

1.0.2 Why Do We Need More HALEU?

The current U.S. commercial power reactor fuel cycle is based on LEU enriched to less than 5%, but many advanced reactor designs require HALEU (NEI, 2020; DOE, 2020b). Although some advanced reactor technologies are currently under development, there is no domestic commercial source of HALEU available to fuel them. The lack of such a source could impede both the demonstration of these technologies being developed and the development of future advanced reactor technologies. Using HALEU fuel allows advanced reactor designers to create smaller reactors that get more power with less fuel than the current fleet of reactors. HALEU will also allow developers to optimize their systems for longer life cores and other increased efficiencies (DOE, 2020a). A sufficient domestic commercial capability to produce HALEU through enrichment of natural uranium or LEU does not exist in the United States.

In addition, the Energy Act of 2020 directs DOE to establish and carry out, through the Office of Nuclear Energy, a program to support the availability of HALEU for civilian domestic research, development, demonstration, and commercial use, and to make such HALEU available to members of a DOE HALEU consortium by January 1, 2026 (Section 2001 of the Energy Act of 2020 (a)(1); (2)(H) [42 U.S.C. 16281(a)(1); (2)(H)]).[8] This EIS addresses DOE's Proposed Action as it relates to Section 2001(a)(2)(D)(v) of the Energy Act of 2020 for the acquisition of HALEU produced by a commercial entity using enrichment technology and making it available for commercial use or demonstration projects.

The Inflation Reduction Act (Section 50173) [Public Law 117-169] provided $700 million in support of various HALEU program activities directed in the Energy Act of 2020. From these funds, $500 million is being considered to enter into contracts for enrichment, deconversion, and storage of HALEU.

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5 Existing commercial light water reactors (LWRs) typically operate using LEU fuel enriched to 5% or less.

6 The terms "weight percent" and "percent" (when used in reference to enrichment) are synonymous and used interchangeably in this document.

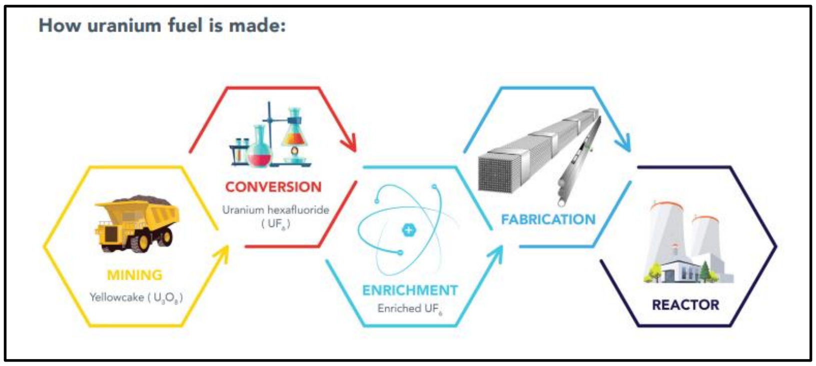
7 Idaho National Laboratory (INL) is working to produce up to 10 metric tons (MT) of HALEU from spent nuclear fuel (SNF) using electrochemical processing in the near term to support current testing and demonstration projects (DOE-ID, 2019).

8 DOE's activities to address Section 2001(a) of the Energy Act of 2020 are generally referred to as the HALEU Availability Program. The HALEU Availability Program includes several elements, such as conducting biennial surveys of industry stakeholders to estimate the amount of HALEU needed for domestic commercial use for the subsequent 5 years; establishing a consortium of entities involved in the nuclear fuel cycle to support the availability of HALEU (including by providing survey information and purchasing HALEU made available by the Secretary for commercial use); and acquiring or providing HALEU from a stockpile of uranium owned by the Department or, using enrichment technology to supply members of the consortium with HALEU for commercial use or demonstration projects. The focus of this EIS is DOE's Proposed Action, which addresses Section 2001(a)(2)(D)(v).

DOE estimates that by 2035 the domestic demand for HALEU could be 50 metric tons (MT) per year (MT/yr) and could increase to 500 MT/yr by 2050 (INL, 2021). Nuclear industry estimates provide a more aggressive timeline for the construction and operation of advanced reactors and indicate that government and/or commercial fuel fabricators will need to be able to generate more than 600 MT of HALEU in enrichments ranging from 10.9% to 19.75% annually for industry by 2035 (NEI, 2021). U.S. nuclear industry partners are concerned that a sufficient domestic commercial supply of HALEU will not be available in time to support the development, demonstration, and deployment plans for advanced nuclear reactors (ANRs) (NEI, 2020).

1.0.3 Where Do We Get Uranium for Reactor Fuel Now?

The primary ore mineral of uranium is uraninite or pitchblende (NRC, 2009a), though a range of other uranium minerals are found in particular ore deposits as described on the U.S. Energy Information Administration website[9] (EIA, 2020). After the uranium ore is mined,[10] it goes through a milling process that extracts uranium from the ore, producing uranium oxide (yellowcake) (primarily triuranium octoxide [U_3O_8] but containing other oxides. Although the original ore contains as little as 0.1% uranium, yellowcake, primarily consisting of U_3O_8, is usually more than 80% uranium. The U_3O_8 is then processed at conversion, enrichment, and fuel fabrication facilities, where reactor fuel is fabricated for use in commercial nuclear reactors (Figure 1.0-2).



Source: DOE (2020b)

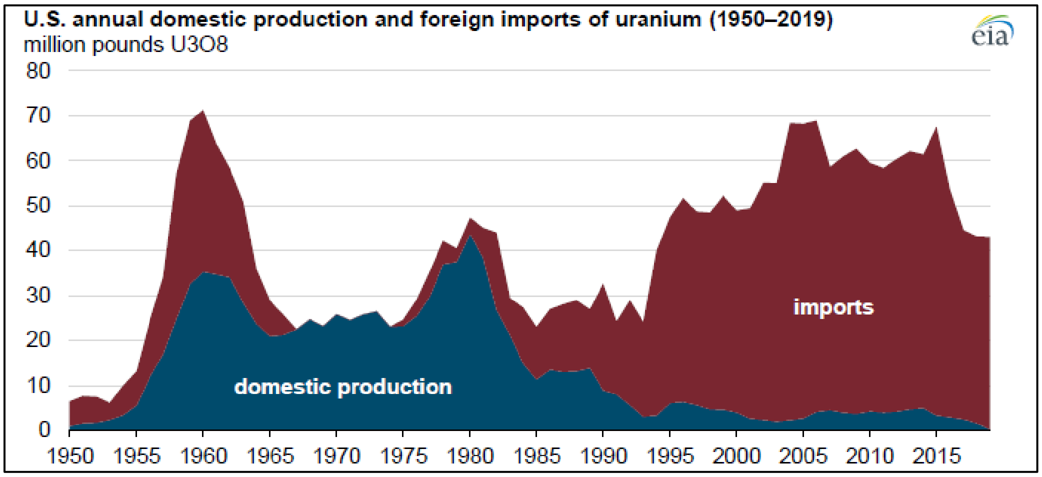
Figure 1.0-2. Uranium Fuel Production Process Overview

In the late 1940s and early 1950s, the United States introduced incentives and trade policies encouraging the growth of domestic uranium production. After these policies ended in the 1980s, domestic production began to decline. Other countries, such as Canada and Australia, have more accessible, high-quality uranium deposits, allowing them to produce U_3O_8 at a lower cost than the United States. As shown in Figure 1.0-3, since 1990, purchased imports of U_3O_8 have exceeded domestic U_3O_8 production each year. In 2019, U.S. commercial nuclear power reactor operators purchased a total of 48.3 million pounds of U_3O_8. Foreign imports of U_3O_8 supply the majority of fuel to U.S. commercial nuclear reactors, and 42.6 million pounds, or 88% of the total U_3O_8 purchased, was imported in 2019. The United States produced 174,000 pounds of U_3O_8 in 2019, 89% less than in 2018, and the lowest amount produced since

9 https://www.eia.gov/todayinenergy/detail.php?id=44416

10 As an alternative to surface and subsurface mining, the in-situ recovery (ISR) process can be used to recover uranium from low-grade ores or deeper deposits that are not economically recoverable by conventional mining and milling techniques. In the ISR process, a leaching agent, such as oxygen with sodium carbonate, is added to native groundwater and injected through wells into the subsurface ore body to mobilize the uranium. The leach solution containing the mobilized uranium is pumped from there to the surface processing plant, and then ion exchange separates the uranium from the solution. After additional purification and drying, the resultant product, a mixture of uranium oxides also known as "yellowcake," is placed in 55-gallon drums prior to shipment off-site for further processing.

the U.S. Energy Information Administration data series began in 1949. Domestic U_3O_8 production has declined since its peak of 43.7 million pounds in 1980.



Source: (EIA, 2020)

Figure 1.0-3. U.S. and Foreign Uranium Production

Canada, which has large, high-quality uranium reserves, has historically been the largest source of U.S. uranium imports. In 2019, Canada remained the largest source of imported uranium supplied to U.S. civilian nuclear power plants, followed by Kazakhstan, Australia, and Russia. Subsidies for uranium producers in Kazakhstan have led to increases in the country's uranium exports, including those to the United States.

1.0.4 How Will We Get What We Need?

There are limited options for the acquisition of HALEU. Currently, HALEU is only available (in limited quantities) domestically through downblending of DOE stockpiles of HEU and limited production at the American Centrifuge Plant (ACP), in Piketon, Ohio. American Centrifuge Operating, LLC, (ACO) a subsidiary of Centrus Energy Corp., began construction of a 16-centrifuge cascade in 2019 under contract with DOE. In November 2022, Centrus secured a follow-on contract to bring the cascade into operation and enrich uranium hexafluoride (UF_6) to produce HALEU. On November 7, 2023, ACO completed a major milestone by delivering 20 kilograms (kg) HALEU to DOE (Centrus Energy Corp, 2023a). The contract includes production of 900 kg in the first year with the ability to produce 900 kg per year in future option periods. The only source of foreign HALEU is from a state-owned Russian nuclear energy company. Future supplies of HALEU, from a domestic source, sufficient to meet the projected needs of the commercial nuclear power industry[11] would require the development of a U.S.-based HALEU fuel cycle economy. (Regalbuto M. C., 2020)

But as indicated by many commercial entities that responded to DOE's *Request for Information (RFI) Regarding Planning for Establishment of a Program to Support the Availability of High-Assay Low Enriched Uranium (HALEU) for Civilian Domestic Research, Development, Demonstration, and Commercial Use* (86 Federal Register [FR] 71055, December 2021) (referred to as the "RFI"), there is a potential timing/coordination issue with developing domestic commercial HALEU enrichment capability. Those interested in designing, building, and operating advanced reactor designs that use HALEU fuel are hesitant

[11] DOE estimates that by 2035 50 MT/yr of HALEU would be required to support commercial use, with the demand increasing to about 500 MT/yr by 2050 (INL, 2021).

to invest in the technology without a firm source of HALEU fuel. Likewise, those interested in providing HALEU fuel are hesitant to invest in facilities without a firm demand. As described in multiple responses to the RFI, this is a "chicken-and-egg" dilemma.

To address this issue, an initial public/private partnership, as proposed is intended to accelerate development of a sustainable commercial HALEU supply capability. If successful, this partnership could provide the incentive for the private sector to incrementally expand the capacity in a modular fashion as a sustainable market develops.

Capital costs for enrichment activities at various levels are key to the deployment of a HALEU supply chain. A factor in the capital costs is the physical security requirements for possession of that portion of HALEU enriched to above 10% U-235. About 90% of the separative work[12] required to enrich natural uranium from 0.711% to 19.75% U-235 is utilized in the 0.711% to 10% enrichment range. Enrichments above 5% and below 10% (often referred to as LEU+) can be attained in the same enrichment facilities used for enriching natural uranium up to 5% enrichment. This can be done in an NRC Category III facility.[13] Uranium enriched in U-235 at 10% but less than 20% must be conducted in an NRC Category II facility, which requires significant capital investments to license, build, secure, and operate. Deconversion, storage, and fuel fabrication of HALEU enriched to 10% or higher must also be conducted in an NRC Category II facility.

1.0.5 Background on Current DOE and Commercial HALEU Supply

1.0.5.1 DOE HALEU Supply

The potential near-term supply of HALEU will be from processing DOE materials at DOE facilities. These activities are estimated to produce HALEU as follows:

- Up to 10 MT of HALEU[14] produced from Experimental Breeder Reactor-II fuel at the Idaho National Laboratory (INL)
- Approximately to 2.5 MT of HALEU produced from existing HEU uranyl nitrate solution in storage at H-Canyon at the Savannah River Site
- Up to 2.4 MT of HALEU produced by BWX Technologies (BWXT)[15] using HEU from Y-12 National Security Complex

These DOE capabilities could supply up to a total of 14.9 MT of HALEU. There may be other DOE inventories that could provide some additional HALEU for advanced reactor developers, but this would not stimulate commercial development of a domestic HALEU production capability nor meet all near-term

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[12] Separative work is the work required to separate a stream of an element (feed material) into a product stream (enriched in one isotope of the element) and a waste stream (depleted in one isotope of the element). For uranium, the feed material is natural uranium, a U-235-enriched stream is the product. The waste stream consists of depleted uranium (DU), which has a higher content of uranium-238 (U-238) and lower content of U-235 than natural uranium. The standard unit of separative work is the separative work unit (SWU).

[13] The NRC classifies special nuclear materials (SNM) and the facilities that possess them into three categories based upon the materials' potential for use in nuclear weapons, or their "strategic significance." The NRC's physical security requirements differ by category, from least stringent for Category III facilities to most stringent for Category I facilities. NRC Category III Facility (low strategic significance) includes facilities containing uranium at enrichments of less than 10 weight percent U-235. NRC Category II Facility (moderate strategic significance) include facilities containing uranium at enrichments from 10 weight percent to less than 20 weight percent U-235. NRC Category I Facility (strategic SNM) include facilities containing uranium at enrichments equal to or greater than 20 weight percent U-235.

[14] 5 MT is to be provided to Oklo Inc. for use in the Aurora reactor.

[15] BWXT is NRC licensed.

HALEU needs; therefore, it is not analyzed in this EIS. Additional information on the decision to not include DOE downblending of HEU in the Proposed Action is provided in Section 2.4, *Alternatives Considered and Dismissed from Detailed Analysis*.

1.0.5.2 Potential Commercial HALEU Supply

There is currently no sufficient domestic commercial capability to produce HALEU. Technically, portions of the HALEU fuel cycle could use existing LEU fuel cycle facilities (uranium conversion facility, LEU enrichment facilities), however, DOE does not want the commercialization of the HALEU fuel cycle to negatively impact the existing baseline uranium production capacity currently supporting the U.S. domestic nuclear industry. Also, within the existing fuel cycle infrastructure, there are production gaps that would need to be filled. Enrichment of LEU to HALEU enrichment levels by a commercial entity is currently limited to the ACP, run by ACO a subsidiary of Centrus Energy Corp. ACO began construction of centrifuges in Piketon, Ohio, in 2019 under contract with DOE. On November 7, 2023, ACO marked a major milestone by delivering 20 kg of HALEU to DOE (Centrus Energy Corp, 2023a). ACP has a capacity of 900 kg per year, starting in 2024. BWXT in Lynchburg, Virginia, has demonstrated the capability to downblend HEU to produce HALEU. In and of themselves, these capabilities are insufficient to support establishment of a domestic commercial HALEU fuel cycle or to provide the amount of HALEU to be needed in the near future. Further, the only existing enrichment facility in the United States other than the facility in Piketon is the National Enrichment Facility (NEF) owned by the Urenco USA (UUSA), formerly "URENCO (LES)," facility in Eunice, New Mexico, which is an NRC Category III facility, licensed to possess LEU, and not an NRC Category II facility, licensed to possess HALEU. Figure 1.0-4 shows the potential U.S. HALEU fuel cycle (including those portions not specifically a part of the Proposed Action).

The first three steps in the commercial HALEU fuel cycle are the same as currently occurs in the LEU fuel cycle. This includes enrichment up to LEU (i.e., no more than 5%). Enrichments below 10% (LEU+)[16] could occur in an NRC Category III facility. Enrichments in the 10% to less than 20% range (HALEU) would need to be performed in an NRC Category II facility. The enrichment demonstration in Piketon, Ohio, is the only NRC-licensed Category II facility; Nuclear Fuel Services (NFS)/BWXT in Erwin, Tennessee, and BWXT in Lynchburg, Virginia, are the only NRC-licensed Category I facilities (able to possess HEU).

Increasing the concentration of uranium-235 is called **enrichment**, which is one of six activities in the HALEU fuel cycle associated with the Proposed Action.

The key commercial facilities[17] that could be part of the HALEU fuel cycle (and are considered in the range of the action alternative analyzed in this EIS) are described below:

Uranium Mining/Milling and In-Situ Recovery (ISR)[18] by United States and/or foreign suppliers:

- 0.1% uranium ore[19] mining/milling and production of U_3O_8 (1,000 MT ore to approximately 1 MT U_3O_8)

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[16] Some enrichment at levels above 5% but below 10% (often referred to as LEU+) would be for advanced fuels for LWRs. Production of LEU+ for LWRs is not within the scope of this analysis and would be separately conducted by NRC-licensed commercial facilities.

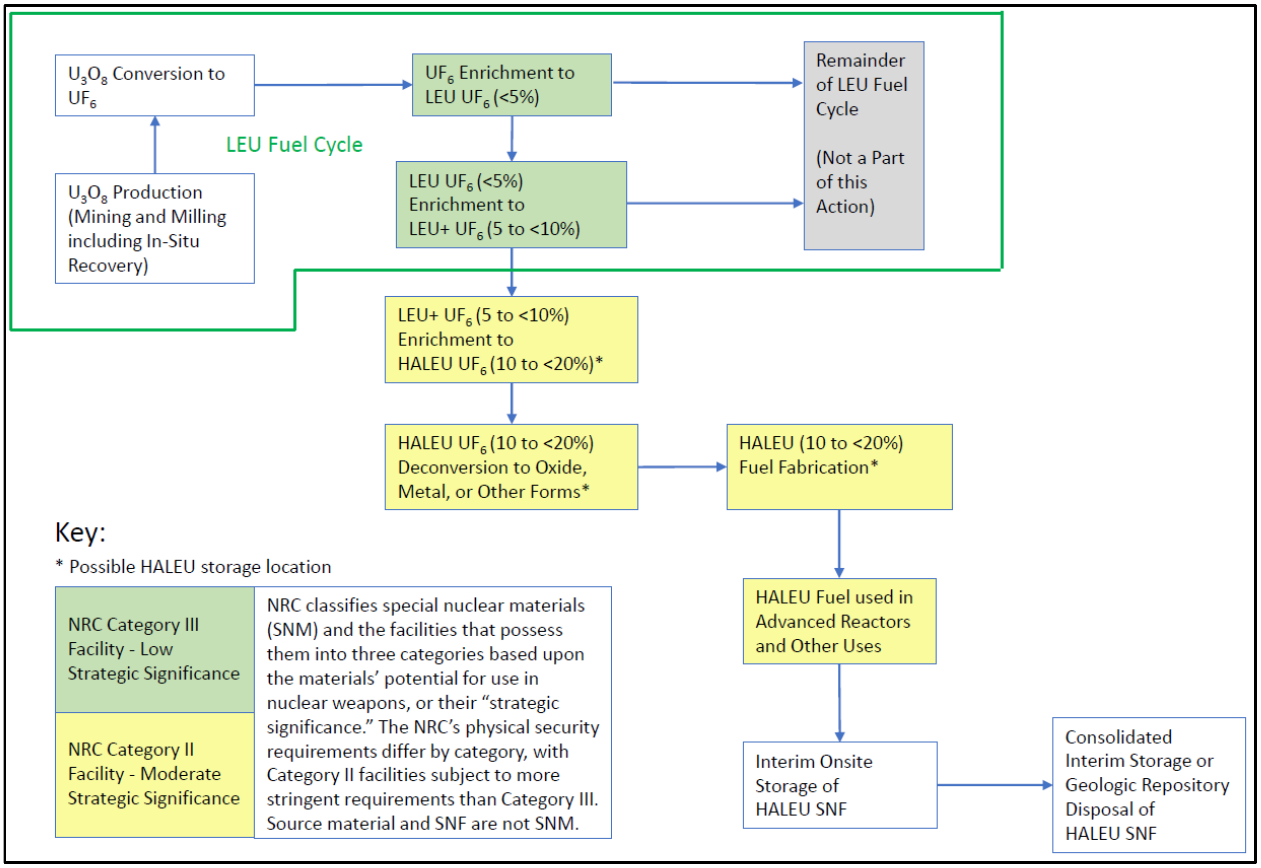
[17] Appendix B, *Facility NEPA Documentation*, describes the existing NEPA documentation for the facilities described in Section 2.1, *Proposed Action and Related Activities*. HALEU fuel cycle facilities could also be located at other industrial (brownfield) or undeveloped (greenfield) sites as evaluated in this HALEU EIS.

[18] Uranium mining in the United States is generally regulated by the Department of Interior – Bureau of Land Management and state agencies. Milling and ISR are regulated and licensed by the NRC and state agencies.

[19] Uranium ores vary from 0.02% to 15% uranium, a low-grade ore value of 0.1% uranium was assumed to be reasonable for analysis in the EIS.

- 0.1% uranium ore ISR and production of U_3O_8

As described in Section 1.0.3, *Where Do We Get Uranium for Reactor Fuel Now?*, while uranium mines and mills have been operated in the United States in the past, most uranium used in commercial nuclear power reactors is currently mined/extracted in foreign countries. The additional demand for uranium and a desire to reinvigorate the domestic market may require some domestic mines and ISR facilities to reopen.



Key: < = less than; HALEU = high-assay low-enriched uranium; LEU = low-enriched uranium; NRC = U.S. Nuclear Regulatory Commission; SNF = spent nuclear fuel; SNM = special nuclear materials; U_3O_8 = triuranium octoxide (uranium oxide) (yellowcake); UF_6 = uranium hexafluoride

Figure 1.0-4. Potential HALEU Fuel Cycle

DOE's *Request for Proposals for High-Assay Low-Enriched Uranium (HALEU) – Enrichment Acquisition* (the "Enrichment RFP") (DOE, 2024) identified existing mining capacity as preferred. While not required, it is anticipated that mines selected would have existing operational licenses. Having existing licenses would facilitate or shorten the startup period for the start or resumption of uranium mining activities.[20] DOE estimates that domestic mining limited to existing mines could supply all of the needed uranium ore to support the Proposed Action. However, as DOE stated in its Enrichment RFP (DOE, 2024), U.S.-sourced mines/mills are the preferred source of uranium, North American sources are the next preferred, and then allied or partner nations.

[20] Existing milling capacity is insufficient to meet the demands for the quantity of HALEU considered in the Proposed Action. Therefore, a combination of conventional mines/mill and ISR facilities could be used. The use of new mines, those without a current license, may also be considered.

Uranium Conversion could occur at the existing ConverDyn (formerly Honeywell) conversion facility in Metropolis, Illinois, or a new facility. Either facility would receive U_3O_8 from uranium mills and ISR facilities and produce UF_6.

- Yellowcake (80% U_3O_8) conversion to 0.711% UF_6 at the ConverDyn facility (1 MT yellowcake per 1 MT UF_6)
- New facility for yellowcake (80% U_3O_8) conversion to 0.711% UF_6 (1 MT yellowcake per 1 MT UF_6)

Uranium Enrichment

The production of HALEU requires the enrichment from natural uranium to HALEU of at least 19.75% to less than 20%. Enrichment could occur at multiple locations and facilities. Assuming two sites, the first site could enrich the uranium to up to 5% or less than 10%. This product would be transported to the second site for enrichment up to at least 19.75% and less than 20%. This discussion of enrichment addresses three enrichment levels, up to 5% (an enrichment currently being produced at one domestic site), between 5% and less than 10% (a capability that can be added to an existing facility without a change in NRC security classification), and up to at least 19.75% and less than 20% (at a site with additional security requirements).

Uranium Enrichment to no more than 5% could occur at existing and planned centrifuge facilities at UUSA, formerly "URENCO (LES)," in Eunice, New Mexico, and the facility in Piketon, Ohio, or at a new facility:

- Enrichment of natural uranium to LEU (no more than 5%) at existing or modified existing facilities (9.9 MT 0.711% natural uranium to approximately 1 MT 5% LEU)
- Enrichment of natural uranium to LEU (no more than 5%) at new facilities (9.9 MT 0.711% natural uranium to approximately 1 MT 5% LEU)

Uranium Enrichment from 5% to at least 19.75 and less than 20% could occur as an add-on at the existing LEU enrichment facility described above, although new facilities could be constructed. UUSA has submitted a license amendment application to the NRC to increase their enrichment limits to less than 10% enriched uranium utilizing an existing cascade hall at the NEF in Eunice, New Mexico (UUSA, 2023a). UUSA would need to further modify their license to enrich from 10% up to less than 20%.[21] UUSA has also submitted a Notice of Intent to submit license amendment requests to the NRC for construction of a new HALEU facility at the NEF location and to increase the license to allow production of up to 20% enriched uranium at that facility (UUSA, 2023b)**.**

In June 2021, the NRC issued a license to the ACO demonstration facility in Piketon, Ohio, to demonstrate HALEU production using 16 centrifuges (NRC, 2022a). The Piketon demonstration facility would need to amend its license to add new production capacity. ACO representatives have stated that they could reach production of 12 MT of HALEU in 4 years and add 12 MT production each year after (Herczeg, 2019; NRC, 2021a; NEI, 2022).

Potential enrichment activities for increasing enrichment from LEU to HALEU are summarized as follows:

- Enrichment of LEU (no more than 5%) to LEU+ (less than 10%) (approximately 2 MT 5% LEU to 1 MT 10% LEU+). This would represent a new capability, either at a new facility or as an expanded function of the existing UUSA NRC Category III LEU enrichment facility.

[21] Space has been allocated adjacent to existing cascade structures for the construction of an NRC Category II security-level cascade structure for this capability.

- Enrichment of the LEU+ (at less than 10%) to HALEU of at least 19.75 and less than 20%, (approximately 2 MT 10% LEU+ to 1 MT of HALEU of at least 19.75 and less than 20%) at an NRC Category II facility. It is possible, but not required, that this capability would be co-located with the NRC Category III LEU and/or LEU+ enrichment facilities.
  - Create capability to enrich to at least 19.75 and less than 20% HALEU at existing enrichment facilities:
    - The ACP in Piketon, Ohio, through a multi-step increase in capacity (expanded capability)
    - The UUSA facility in Eunice, New Mexico (expanded capability)
  - Create capability to enrich to at least 19.75 and less than 20% HALEU at a new facility (new facility and capability).

Each of the activities associated with the Proposed Action was evaluated carefully to understand various scenarios where a HALEU activity could be located, such as at an **existing** LEU fuel cycle facility, another developed industrial site (a **brownfield** site), or a previously undeveloped (**greenfield**) site, along with the possibility of co-located facilities conducting different activities.

HALEU (UF_6) Deconversion to uranium dioxide and other forms could be co-located at the HALEU enrichment facilities described above, co-located at the fuel fabrication facilities as is currently the case for LEU fuel or located independently at a separate site from either type of facility.

- Deconversion of HALEU in the form of UF_6 to uranium metal (1.5 MT UF_6 per 1 MT HALEU in metal form) and other forms (co-locate new capability at the HALEU uranium enrichment facility). The advantage of this option is that HALEU in the form of UF_6 would not need to be transported between enrichment and deconversion facilities.
- Deconversion of HALEU in the form of UF_6 to uranium metal (1.5 MT UF_6 per 1 MT HALEU in metal form) and other forms (co-locate new capability at HALEU fuel fabrication facilities). The advantage of this option is that deconversion would produce the exact form needed for the co-located fuel fabrication process.
- Deconversion of HALEU in the form of UF_6 to uranium metal (1.5 MT UF_6 per 1 MT HALEU in metal form) and other forms at independently sited facilities. The advantage of this option is that a single deconversion facility could support multiple enrichment sites and fuel fabrication sites.

HALEU Storage could be located at an enrichment, deconversion, or fuel fabrication facility or facilities.

- Storage of HALEU in the form of UF_6, oxide, and/or metal in a HALEU storage facility (new capability) at an enrichment, deconversion, or fuel fabrication facility or facilities, or at independently located facility or facilities with a capacity to store all HALEU produced as part of the Proposed Action.

The activities described above are the focus of two RFPs (DOE, 2024; DOE, 2023a) that seek commercial vendors for enrichment and deconversion services. To use the HALEU acquired under these RFPs, the HALEU would need to be fabricated into fuel.

HALEU Fuel Fabrication would be performed at NRC-licensed commercial facilities, which could include the following:

- Existing and proposed facilities (BWXT,[22] Lynchburg, Virginia; TRISO-X [a wholly owned subsidiary of X-energy, LLC], Oak Ridge, Tennessee)

[22] BWXT is an NRC Category I facility. Other fuel fabrication facilities would need to modify their licenses to become NRC Category II facilities.

- New fuel fabrication facilities possibly but not necessarily co-located at the existing or new enrichment facilities (Piketon, Ohio, and UUSA) and co-located new deconversion facilities or co-located with LEU fuel fabrication facilities

BWXT in Lynchburg, Virginia, is currently authorized to produce 0.4 MT of HALEU tri-structural isotropic (TRISO) fuel (demonstration scale) (SCO, 2022, pp. 4-61) but plans to develop a larger-scale TRISO fuel production line. TRISO-X plans to produce HALEU TRISO fuel at 8 MT/yr in 2025 expanding to 16 MT/yr by the early 2030s (X-energy, 2022), also in Oak Ridge. Global Nuclear Fuel – Americas (GNF-A) is in pre-application discussions with NRC about producing HALEU fuel for its Natrium™ reactor (GNF-A, 2021).

HALEU Use and Disposal – The fabricated fuel would be used to fuel ANRs. The reactors could include research and development, test, demonstration, and commercial power reactors. HALEU spent nuclear fuel (SNF) would be stored at the reactor site (or other user facility) until shipped to a consolidated interim storage facility or geologic repository for storage or disposal along with other SNF.

1.0.6 Current NEPA Analyses

NEPA documentation exists for many of the activities that would be associated with a HALEU fuel cycle, especially for the production of LEU (a necessary step in the enrichment process to produce HALEU). (For more details, see Appendix B, *Facility NEPA Documentation*, Section B.1, *Assessment of the NEPA Status of Potential HALEU Support Facilities*). Table 1.0-1 summarizes the NEPA coverage for facilities or types of facilities that might be among those considered for the HALEU fuel cycle. These documents represent the primary source of information for an assessment of HALEU activities at sites that support existing fuel fabrication activities.

Table 1.0-1. NEPA Status for Potential HALEU Fuel Cycle Facilities

Activity	*NEPA Status* [(a)]	*Additional NEPA* [(b)]
NRC-Licensed Facilities		
Generic NEPA coverage for advanced reactors	Partial Coverage	
Generic NEPA coverage for storage of HALEU SNF	Partial Coverage	
Generic NEPA coverage for uranium ISR mining	Full Coverage	
Uranium production – uranium recovery of U_3O_8 using ISR/recovery	Full Coverage	
ConverDyn conversion of U_3O_8 to 0.711% UF_6 (Metropolis, IL)	Full Coverage	
Centrus – HALEU enrichment demonstration (20 kg) (Piketon, OH)	Full Coverage	
Centrus – HALEU enrichment 0.9 MT/yr (9 MT total) (Piketon, OH)	Planned	NRC NEPA Documentation
Centrus – production-scale HALEU enrichment (Piketon, OH)	Proposed	NRC NEPA Documentation
GLE – production-scale HALEU enrichment (Wilmington, NC)	Proposed	NRC NEPA Documentation
UUSA – enrichment to < 5.5% (LEU) (Eunice, NM)	Full Coverage	
UUSA – enrichment from 5.5% to < 10% (LEU+) (Eunice, NM)	Planned	NRC NEPA Documentation
UUSA – production-scale HALEU enrichment (Eunice, NM)	Proposed	NRC NEPA Documentation
International Isotopes Fluorine Products, Inc. – depleted UF_6 deconversion and fluorine extraction (Hobbs, NM)	Full Coverage	

Table 1.0-1. NEPA Status for Potential HALEU Fuel Cycle Facilities

Activity	NEPA Status [(a)]	Additional NEPA [(b)]
NFS – HEU conversion at 1 to 2 MT/yr (10 MT) (Erwin, TN)	Full Coverage	
New dedicated HALEU deconversion facility	No Coverage	NRC NEPA Documentation
BWXT – demonstration-scale TRISO fuel fabrication (Lynchburg, VA)	Full Coverage	
BWXT – blending down HEU to HALEU at 1 to 2 MT/yr (10 MT) (Lynchburg, VA)	Full Coverage	
TRISO-X fuel fabrication (Oak Ridge, TN)	Planned	NRC NEPA Documentation
Framatome HALEU deconversion and fuel fabrication (Richland, WA)	No Coverage	NRC NEPA Documentation
GNF-A HALEU deconversion and fuel fabrication (Wilmington, NC)	No Coverage	NRC NEPA Documentation
Westinghouse HALEU deconversion and fuel fabrication (Columbia, SC)	No Coverage	NRC NEPA Documentation
HALEU storage facility at enrichment facility or deconversion facility	No Coverage	NRC NEPA Documentation
Interim storage partners – HALEU SNF storage (Andrews, TX)	Full Coverage	
Holtec International – HALEU SNF storage (Lea County, NM)	Full Coverage	
Transportation of HALEU as UF_6, oxide, metal, and fuel	Partial Coverage	Incorporated in NEPA documents
HALEU SNF Disposal in a Geologic Repository	No Coverage	DOE EIS

Key: BWXT = BWX Technologies, Inc.; DOE = U.S. Department of Energy; EA = Environmental Assessment; EBR-II = Experimental Breeder Reactor-II; EIS = Environmental Impact Statement; GLE = Global Laser Enrichment; GNF = Global Nuclear Fuel – Americas; HALEU = high-assay low-enriched uranium; HEU = highly enriched uranium; IL = Illinois; INL = Idaho National Laboratory; ISR = in-situ recovery; kg = kilograms; LEU+ = uranium enriched 5% less than10%; MT = metric tons; MT/yr = metric tons per year; NC = North Carolina; NEPA = National Environmental Policy Act; NFS = Nuclear Fuel Services; NM = New Mexico; NRC = U.S. Nuclear Regulatory Commission; OH = Ohio; SC = South Carolina; SNF = spent nuclear fuel; SRS = Savannah River Site; TN = Tennessee; TX = Texas; U_3O_8 = triuranium octoxide (yellowcake); UF_6 = uranium hexafluoride; UUSA = Urenco USA; VA = Virginia; WA = Washington

Notes:

[a] This column provides a broad assessment of the adequacy of the existing NEPA documentation to cover HALEU production activities. In some instances, documentation may be needed to demonstrate that the existing NEPA analysis is adequate to cover the HALEU activities.

[b] This column provides the most likely additional NEPA coverage that would be required to cover HALEU production activities if considered separately (on a project-specific basis). The EIS contains analyses at the level of detail commensurate with the level of information available at the time the EIS was prepared.

Full coverage = indicates the existing NEPA documentation covers substantially the same activities that would occur to accomplish a discrete portion of the Proposed Action. In some cases, documentation may be needed to demonstrate that the existing NEPA analysis is adequate to cover the HALEU activities.

Planned = indicates that NEPA documentation has not been prepared (or has yet to be completed), but an action has occurred to move toward the stated HALEU activity goal. For example, a license application could be in process or may have been submitted to the NRC.

Proposed = indicates that NEPA documentation has not been prepared, but there is a statement of a proposal to move toward a stated HALEU activity goal.

Partial Coverage = indicates the existing NEPA documentation covers some, but not all, of the same activities that would occur under the Proposed Action.

1.1 Purpose and Need for Agency Action

One of the aspects of a clean energy future is sustainment and expanded development of safe and affordable nuclear power. One key element of that goal is the availability of fuel to power advanced reactors. The Energy Act of 2020 directs the Department of Energy "to establish and carry . . . out a program to support the availability of HA-LEU for civilian domestic research, development, demonstration, and commercial use." DOE is committed to support the development and deployment of the HALEU fuel cycle and to acquire and provide HALEU as authorized by Congress in Section 2001 of the Energy Act of 2020. Further, Section 3131 of the recently enacted National Defense Authorization Act for Fiscal Year 2024 (Nuclear Fuel Security Act of 2023), among other things, seeks to expeditiously increase domestic production of HALEU to meet the needs of advanced nuclear reactor developers and the consortium established under Section 2001(a) of the Energy Act of 2020.

There is currently insufficient private incentive to invest in commercial HALEU production due to the current market base. There is also insufficient incentive to invest in commercial deployment of advanced reactors because the domestic HALEU fuel cycle does not exist. This concern is a consistent theme in the industry responses to DOE's RFI (see Section 1.0.4, *How Will We Get What We Need?*). These responders emphasized the importance of the HALEU consortium that is called for in the Energy Act of 2020 and that DOE established on December 7, 2022 (87 FR 75048). Responders also emphasized the opportunity for DOE to be an agent for stability (both in assuring HALEU availability and market price certainty) during the initial phase of HALEU fuel production.

DOE predicts that by the mid-2020s, approximately 22 MT of HALEU will be needed for initial core loadings to support advanced reactor demonstrations and DOE test and research reactors that were converted from HEU fuel with a high-fidelity HALEU (up to 19.75 weight percent U-235 enrichment), and for the next 10 years, will need between 8 and 12 MT of HALEU annually (Regalbuto M. C., 2022). DOE also predicts that commercial demand will increase to over 50 MT per year of HALEU by 2035 and over 500 MT of HALEU per year by 2050. (INL, 2021). Additionally, the Nuclear Energy Institute (NEI) surveyed its utility members that plan to utilize HALEU to identify their estimated annual commercial needs through 2035. This survey estimated industry requirements, driven by a more aggressive assessment of advanced reactor construction, could be as high as 600 MT of HALEU at between 10.9 and 19.75 weight percent enriched U-235 per year by 2035 (NEI, 2021)**.**

Table 1.1-1 shows the results of this 2021 survey.

Table 1.1-1. Nuclear Energy Institute Survey Results for Estimated HALEU Demand Through 2035

Year [(a)]	*Total MT/yr [(b)]*	*Cumulative MT*	*Year [(a)]*	*Total MT/yr [(b)]*	*Cumulative MT*	*Year [(a)]*	*Total MT/yr [(b)]*	*Cumulative MT*
2022	1.8	1.8	2027	78.7	204.1	2031	252.3	954.0
2023	7.7	9.5	2028	130.8	334.9	2032	375.3	1,392.2
2024	18.0	27.5	2029	151.7	486.6	2033	454.2	1,783.4
2025	25.8	53.3	2030	215.0	701.6	2034	527.1	2,310.5
2026	72.1	125.4				2035	613.8	2,924.3

Source: (NEI, 2021)

Key: % = percent; HALEU = high-assay low-enriched uranium; MT = metric tons; MT/yr = metric tons per year; NEI = Nuclear Energy Institute; U-235 = uranium-235

Notes:

[a] This represents the year the material is needed for fuel fabrication. Insertion in the reactor and reactor operations would occur in a later year.

[b] Material needs listed include enrichments between 10.9% and 19.75% U-235 and does not include utilities that are considering enrichments between 5% and 10%.

Both DOE and industry groups have recognized that DOE action is needed to facilitate the development of the necessary infrastructure, to support near-term research and demonstration needs, and to support the U.S. commercial nuclear industry (NEI, 2022; Regalbuto M. C., 2022). The NEI recognized that the main challenge to establishing a commercial HALEU-based reactor economy is the upfront capital investment required to establish the enrichment capability to produce quantities of HALEU suitable for fabrication into the fuel needed for the various types of advanced reactor designs (NEI, 2022).

1.2 DOE Notice of Intent and Opportunity for Comment

On June 5, 2023, the DOE Office of Nuclear Energy (DOE-NE) published a Notice of Intent (NOI) to prepare an EIS for DOE activities in support of commercial production of HALEU (88 FR 36573) (see Appendix C, *Federal Register Notices*). Publication of the NOI initiated a 45-day scoping period.

Notices of the scoping period and of the three virtual scoping meetings were published as press releases, email notifications, DOE-NE social media posts, and in newspaper outlets in states with historical ties to nuclear energy production (i.e., Arizona, Colorado, Idaho, Illinois, Nebraska, New Mexico, North Carolina, Ohio, South Dakota, Tennessee, Texas, Utah, Virginia, and Wyoming). A national notice was also distributed through *USA Today* to ensure maximum coverage.

DOE-NE hosted three consecutive virtual scoping meetings at 6:00 p.m. Eastern Time (ET), 8:00 p.m. ET, and 10:00 p.m. ET on June 21, 2023. The purpose of these meetings was both to allow the public to familiarize themselves with the Proposed Action, the EIS, and the NEPA process, as well as provide opportunities to submit comments on the scope of the Draft EIS. These meetings were an important component of DOE's continued efforts to provide stakeholders and the public with opportunities to participate in the NEPA process.

In addition to providing oral comments at the scoping meetings, interested parties were informed that they could provide written comments by email to: HALEU-EIS@nuclear.energy.gov or by U.S. Mail to: Mr. James Lovejoy, DOE EIS Document Manager, U.S. Department of Energy, Idaho Operations Office, 1955 Fremont Avenue, MS 1235, Idaho Falls, Idaho 83415.

During the scoping period, DOE received 11 oral comments and 32 comment documents from the previously listed submission methods. From these 43 comment submissions types, 282 comments were identified. DOE also received 1,675 comment documents, mostly identical, submitted through www.regulations.gov. From those 1,675 comment documents, 127 comments were identified. Fewer individual comments than comment documents were identified from the www.regulations.gov submissions because most of the comment documents included identical wording. DOE reviewed each comment document and grouped similar input to be treated as a single comment, concern, or issue.

The scoping comments impacted the Draft EIS in the following ways:

- Chapter 1, *Introduction and Purpose and Need*, includes a discussion on how project locations will be determined separately from this EIS and how this EIS cannot analyze site-specific locations.
- Chapter 3, *Affected Environment and Environmental Consequences*, includes a nonproliferation discussion.

DOE will offer opportunities for public review and comment, including public hearings, on this Draft HALEU EIS. Public involvement opportunities and public hearing information will be announced in newspapers in

DOE has engaged with the public and industry for several years regarding HALEU through DOE's 2021 *Request for Information*, a 45-day scoping period and virtual public scoping meetings for this EIS, and several other non-EIS-related efforts to provide information and receive comments from industry and the general public.

communities with historical ties to uranium fuel cycle activities and in other communications with stakeholders. Comments received during the public comment period will be evaluated in preparing the Final HALEU EIS. Comments received after the close of the public comment period will be considered to the extent practicable. DOE plans to publish the Final HALEU EIS in 2024. DOE will issue a Record of Decision no sooner than 30 days after the Notice of Availability of the Final HALEU EIS is published in the *Federal Register*.

1.3 DOE Requests for Proposals – HALEU Enrichment and Deconversion Services

On June 5, 2023, the DOE Idaho Operations Office published two Draft RFPs for comment: (1) HALEU enrichment capability in the United States (DOE, 2023b) and (2) U.S. capabilities in HALEU deconversion to oxide, metal, or other forms (DOE, 2023c). DOE solicited comments from industry regarding DOE's proposal to acquire, through procurement from commercial sources, HALEU UF_6 enriched to a minimum of 19.75 and less than 20 weight percent U-235 as soon as possible to secure a more robust, longer-term HALEU production capability. DOE also solicited comments from industry regarding DOE's proposal to acquire domestic HALEU deconversion services for HALEU and storage until future fuel fabrication. DOE received comments on the Draft RFPs in July 2023 and published the *Request for Proposals for the High-Assay Low-Enriched Uranium (HALEU) – Deconversion Acquisition* (the "Deconversion RFP") in November 2023 (DOE, 2023a) and the Enrichment RFP in January 2024 (DOE, 2024).

Under the Enrichment RFP, which identifies a 10-year period of performance, enrichment may be performed in one or more steps and locations per awardee. Enrichment of uranium up to less than 5% in the U-235 isotope may be performed either within the continental United States or in an allied or partner nation. All enrichment to greater-than-or-equal-to 5% and less than 20% must be performed in the continental United States, and HALEU (in the form of UF_6) storage must occur at a physical location within the continental United States.[23] For purposes of this EIS, the analysis assumes that DOE may enter into multiple enrichment agreements as a result of the enrichment services solicited in the Enrichment RFP.[24]

While the Enrichment RFP no longer includes the exact parameters that were extrapolated from the Draft Enrichment RFP (e.g., 145 MT of HALEU per procurement, 6 years of facility operations), DOE considers the assumption of 6 years of facility operations reasonable and applicable for the purposes of analysis in this EIS due to the estimated timeline for the design, licensing, and readiness activities required prior to the start of enrichment operations. The Enrichment RFP no longer specifies a total amount of material as the award(s) will be for an Indefinite Delivery/Indefinite Quantity contract; however, DOE estimates that a maximum of 290 MT HALEU will be needed to establish a temporary domestic demand for HALEU to stimulate a diverse, domestic commercial supply that would ultimately lead to a competitive HALEU market.

The product of HALEU enrichment is uranium enriched to between 19.75% and less than 20% U-235 in the form of UF_6. The enriched UF_6 must be deconverted to other forms, like oxide or metal, before it can be fabricated into HALEU fuel or put to other use. The Deconversion RFP (DOE, 2023a) was issued in November 2023. Under the Deconversion RFP, DOE solicited proposals from industry regarding DOE's

23 Acquisition of UF_6 would be the responsibility of the commercial entity. Uranium and conversion services, while preferably sourced from U.S. mines and conversion facilities, could be sourced from foreign sources.

24 As clarified during the scoping meetings, DOE envisions the possibility of multiple awards that could total up to 290 MT of HALEU.

desire to acquire domestic HALEU deconversion services for HALEU UF_6 and HALEU storage until future fuel fabrication.

The Deconversion RFP (DOE, 2023a) seeks to acquire deconversion and related services to convert the acquired, enriched UF_6 to forms such as metal and oxide, and identifies a potential 10-year duration for deconversion activities. Before facility operation could begin, facility design and preparation/submittal of applications for permits and licenses must be performed, including environmental report production, and regulatory review and approval.

A 6-year period was used to estimate the deconversion operations assumed in this EIS. The Deconversion RFP stated that all deconversion and related subsequent storage activities must occur at a physical location within the continental United States.

Table 1.3-1 provides the options that may be considered by a potential bidder.

Table 1.3-1. Activities Identified in the Request for Proposals

Process	*Location Preference*	*New Capacity Consideration*
Mining/Milling	U.S. preferred, North America next preferred, allied or partner nations next preferred	Existing capacity preferred
Conversion	U.S. preferred, North America next preferred, allied or partner nations next preferred	New or restored capacity preferred
Enrichment (Natural up to < 5%)	Continental U.S. preferred, allied or partner nations next preferred	New capacity preferred
Enrichment (> 5% up to < 20%)	Continental U.S. only	No preference
Deconversion/Storage	Continental U.S. only	New

This information provides the basis for the quantity of HALEU and the duration of facility operations evaluated in this EIS.

Due to the parallel nature of the development of this EIS and the DOE acquisition efforts for HALEU enrichment and deconversion, no specific sites have yet been identified for evaluation in this EIS. Therefore, this EIS uses existing or proposed fuel cycle facilities and their prior NEPA documents as the basis for evaluating representative impacts for the potential fuel cycle facilities. The scope of the Draft EIS is based on the services sought in the Enrichment RFP (DOE, 2024) and Deconversion RFP (DOE, 2023a) and related activities. This scope is expected to be bounding to capture a range of variables that may result in potential impacts; however, if incoming proposals suggest changes outside of the scope of this Draft EIS, DOE will address such changes in the Final EIS or in a supplemental NEPA review, as applicable.

1.4 Proposed Action and Related Activities

The Proposed Action is to acquire, through procurement from commercial sources, HALEU enriched to at least 19.75 and less than 20 weight percent U-235 over a 10-year period of performance, and to facilitate the establishment of commercial HALEU fuel production. The Proposed Action addresses Section 2001(a)(2)(D)(v) of the Energy Act of 2020 for the acquisition of HALEU produced by a commercial entity using enrichment technology and making it available for commercial use or demonstration projects.

Given the variety of HALEU applications, the initial capability is intended to be flexible and able to accommodate the following:

- Enrichments of U-235 to greater than 5 and less than 20 weight percent
- Production of up to 290 MT of HALEU
- Modular HALEU fuel cycle facility design concepts to accommodate future growth
- Deconversion of UF_6 to forms suitable for production of a variety of uranium fuels, to include oxides and metal

This EIS will address the following activities facilitating the commercialization of HALEU fuel production and acquisition of up to 290 MT[25] of HALEU:

- Extraction and recovery of uranium ore (from domestic and/or foreign sources)
- Conversion of the uranium ore into UF_6
- Enrichment (possibly in up to three steps)
  - Enrichment to LEU to no more than 5 weight percent U-235
  - Enrichment to HALEU greater than 5 and less than 10 weight percent U-235
  - Enrichment to HALEU from 10 to less than 20 weight percent U-235 in an NRC Category II facility
- Deconversion of the UF_6 to uranium oxide, metal, and potentially other forms in an NRC Category II facility
- Storage in an NRC Category II facility
- DOE acquisition of HALEU
- Transportation of uranium/HALEU between facilities

In addition to the activities above, there are several reasonably foreseeable activities that could result from implementation of the Proposed Action. They include the following:

- Fuel fabrication for a variety of fuel types in an NRC Category II facility
- Reactor (demonstration and test, power, isotope production) operation
- Spent fuel storage and disposition

While not specifically a part of the Proposed Action, the impacts from these reasonably foreseeable activities are acknowledged and addressed to the extent practicable in this EIS. Many of the specifics associated with these activities are subject to factors beyond the scope of the Proposed Action. The fuel requirements for advanced reactors would be dependent not only upon which reactor designs are ultimately licensed and operated but also to what extent the commercial operation of advanced reactors is successful. This in turn impacts both the type and number of fuel fabrication facilities needed and the ultimate disposal of HALEU spent nuclear fuel. Therefore, a detailed assessment of the impacts of these activities would be speculative and is not included in the EIS.

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[25] As discussed in Section 1.3, *DOE Requests for Proposals – HALEU Enrichment and Deconversions Services,* this EIS assumes a 6-year period of HALEU production resulting in 290 MT of HALEU total across multiple awards (i.e., rounding to approximately 50 MT of HALEU per year).

1.5 Decisions to be Supported

Briefly, this EIS provides information to support a decision regarding whether to:

(1) Facilitate the establishment of commercial HALEU fuel production capability.

(2) Acquire (through procurement of enrichment and deconversion services) from commercial sources, up to 290 MT of HALEU enriched to at least 19.75 and less than 20 weight percent U-235 over a 10-year period of performance.

While this EIS will provide information that could be used to identify impacts from the construction and operation of HALEU fuel cycle facilities, the selection of specific locations and facilities will not be a part of the Record of Decision for this EIS. The decisions to be supported are whether or not to acquire HALEU from commercial sources and to facilitate commercial HALEU fuel production capability.

Chapter 2

PROPOSED ACTION AND ALTERNATIVES TO SUPPORT HALEU PRODUCTION AND UTILIZATION

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2 PROPOSED ACTION AND ALTERNATIVES TO SUPPORT HALEU PRODUCTION AND UTILIZATION

2.1 Proposed Action and Related Activities

The Proposed Action is to acquire, through procurement from commercial sources, HALEU enriched to at least 19.75 and less than 20 weight percent[26] U-235 over a 10-year period of performance, and to facilitate the establishment of commercial HALEU fuel production. The Proposed Action addresses Section 2001(a)(2)(D)(v) of the Energy Act of 2020 for the acquisition of HALEU produced by a commercial entity using enrichment technology and making it available for commercial use or demonstration projects.

Given the variety of HALEU applications, the initial capability is intended to be flexible and able to accommodate the following:

- Enrichments of U-235 to greater than 5 and less than 20 weight percent
- Production of up to 290 MT of HALEU
- Modular HALEU fuel cycle facility design concepts to accommodate future growth
- Deconversion of UF_6 to forms suitable for production of a variety of uranium fuels, to include oxides and metal

HALEU can exist in many forms. Those considered in this EIS are triuranium octoxide (U_3O_8) uranium hexafluoride (UF_6), uranium metal, and uranium dioxide (UO_2). When addressing the amount of HALEU considered under the Proposed Action, unless specifically identified as existing in another form, the quantities are those of HALEU in metallic form (i.e., 50 MT of HALEU and 290 MT of HALEU refers to MT of HALEU in metallic form).

This EIS will address the following activities facilitating the commercialization of HALEU fuel production and acquisition of up to 290 MT of HALEU:[27]

- Extraction and recovery of uranium ore (from a combination of domestic and foreign ISR or conventional mining and milling sources)
- Uranium conversion from U_3O_8 to UF_6 for input to enrichment facilities
- Enrichment (possibly in up to three steps)
    - enrichment to LEU to no more than 5 weight percent U-235
    - enrichment to HALEU greater than 5 and less than 10 weight percent U-235
    - enrichment to HALEU from 10 to less than 20 weight percent U-235 in an NRC Category II facility
- HALEU deconversion from UF_6 to uranium oxide, metal, and other forms in an NRC Category II facility
- Storage in an NRC Category II facility or facilities
- DOE acquisition of HALEU
- Transportation of uranium/HALEU between facilities

[26] The terms "weight percent" and "percent" (when used in reference to enrichment) are synonymous and used interchangeably in this document.

[27] As discussed in Section 1.3, *DOE Requests for Proposals – HALEU Enrichment and Deconversion Services*, this EIS assumes a 6-year period of HALEU production resulting in 290 MT of HALEU total across multiple awards (i.e., rounding to approximately 50 MT of HALEU per year).

In addition to the activities above, there are several reasonably foreseeable activities that could result from implementation of the Proposed Action. They include:

- Fuel fabrication for a variety of fuel types in an NRC Category II facility
- HALEU-fueled reactor (demonstration and test, power, isotope production) operations
- Spent fuel storage and disposition

The following subsections provide additional information about the activities associated with the Proposed Action and the reasonably foreseeable post-Proposed Actions. Section 2.1.1, *Uranium Mining and Milling*, through Section 2.1.6, *HALEU Transportation,* address the fuel cycle activities required to stimulate the HALEU fuel cycle, which encompass efforts to generate quantities of HALEU and to facilitate commercial investment in the activities associated with HALEU production. Section 2.1.7, *Related Post-Proposed Action Activities,* addresses those post-Proposed Action activities that complete the HALEU fuel cycle (HALEU fuel fabrication, advanced reactor operations, and HALEU spent fuel disposition). While these activities are not specifically a part of the Proposed Action, the impacts from these reasonably foreseeable actions are acknowledged and addressed to the extent practicable in this EIS. Many of the specifics associated with these activities are unknown. For example, the fuel requirements for advanced reactors would be dependent not only upon which reactor designs are ultimately licensed and operated, but also to what extent the commercial operation of advanced reactors is successful. This in turn impacts both the type and number of fuel fabrication facilities needed and the ultimate disposal of HALEU fuel. A detailed assessment of the impacts of these potential future activities would be speculative and is not included in this EIS.

2.1.1 Uranium Mining and Milling

The production of 50 MT of HALEU[28] as a metal per year would require mining operations to produce about 2,500 MT of U_3O_8 (commonly referred to as yellowcake) either through conventional mining and milling or through ISR. If conventional mining techniques are used, this would require the mining of about 2.6 million MT of uranium-bearing ores with a uranium content of 0.1%. To encourage the use of a domestic supply of uranium for the HALEU fuel cycle, DOE has identified domestically sourced uranium from existing capacity as the preferred option for acquiring uranium (yellowcake). However, uranium could be imported,[29] as most supplies of uranium currently are.

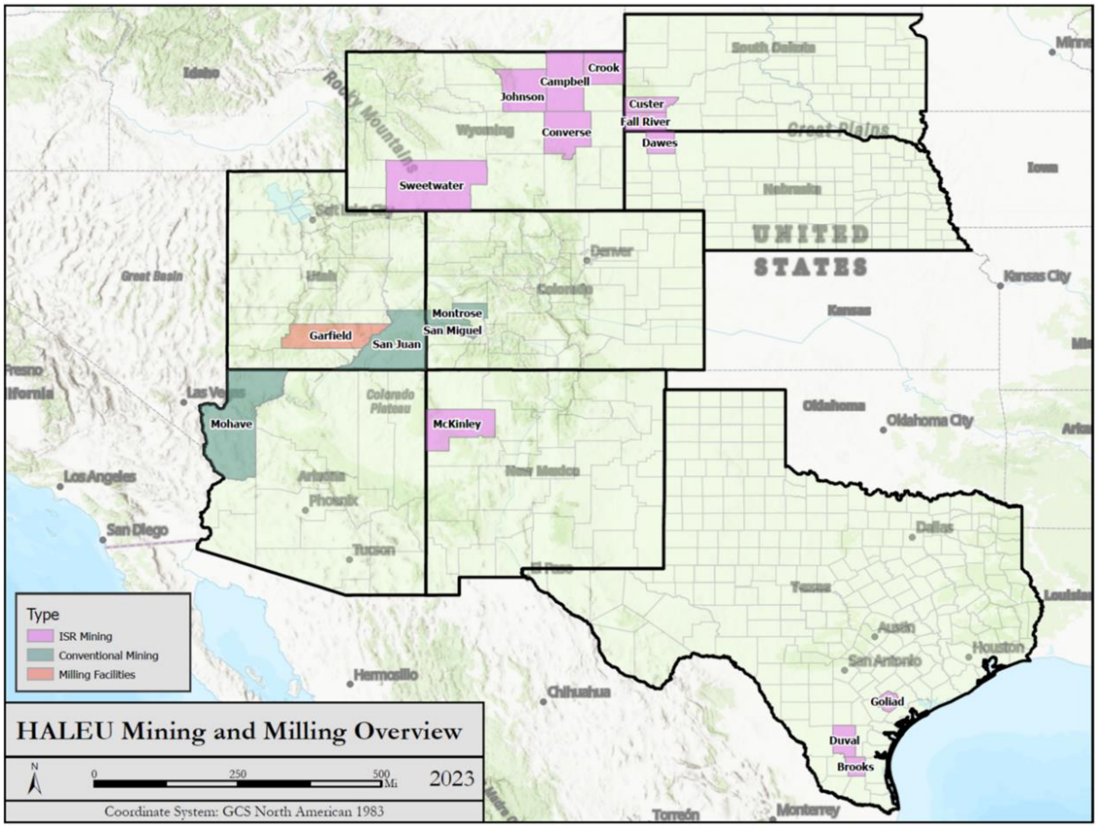
U.S. uranium mines are primarily located in a region from the Texas Gulf Coast to the U.S. West Coast and the Canadian border. Historically, the majority of mining activity was in Colorado, New Mexico, Arizona, Utah, and Wyoming (Figure 2.1-1). Currently, very little uranium is mined in the United States; about 8 MT were mined in 2020, down from 227 MT in 2018 (Nuclear Energy Agency and International Atomic Energy Agency, 2023, p. 75 Table 1.17).

To encourage the use of a domestic supply of uranium in support of the commercialization of the HALEU fuel cycle, the DOE's Enrichment RFP identified domestic supplies of uranium as the preferred source, and North American supplies as the next preferred source, although other foreign sources (allied or partner nations) could be utilized (DOE, 2024). The Enrichment RFP also identified existing mining capacity as preferred. Having existing licenses would facilitate or shorten the startup period for the start or resumption of uranium mining activities. However, this EIS does not assume that only existing mines

[28] Based on multiple enrichment contract awards for up to 290 MT of HALEU and assuming concurrent 6-year production periods for the enrichment facilities.

[29] Preferably from a North American source.

would be utilized to meet the Proposed Action. New mines (i.e., mines not currently licensed) were also considered as an option for a domestic supply of uranium.



Key: GCS = geographic coordinate system; HALEU = high-assay low-enriched uranium; ISR = in-situ recovery

Figure 2.1-1. Uranium Mines in the United States

In the United States, portions of the uranium mining and recovery process are regulated by different agencies. As described on the NRC website,[30] the regulatory responsibility depends on the extraction method that the given facility uses (NRC, 2023a). Specifically, conventional mining (where uranium ore is removed from deep underground shafts or shallow open pits) is regulated by the U.S. Department of the Interior, Office of Surface Mining, and the individual states where the mines are located. By contrast, the NRC regulates ISR (formerly known as in-situ leaching), where a solution is pumped underground into the in-situ uranium-bearing ore before being pumped to the surface for processing to concentrate and extract the uranium.

The distinction between these regulatory responsibilities is that the NRC becomes involved in uranium recovery operations when the ore is processed and chemically altered. This happens either in a uranium mill (the next step in processing ore from a conventional mine) or during ISR. For that reason, the NRC regulates ISR facilities (as stated above), as well as uranium mills. Currently, the NRC regulates uranium recovery operations in New Mexico and Nebraska. However, the NRC does not directly regulate the uranium recovery operations in Wyoming, Texas, Colorado, and Utah, as they are NRC Agreement States, meaning that they have entered into agreements with the NRC to exercise regulatory authority over this type of material, which provides for the discontinuation of the regulatory authority of the NRC.

30 https://www.nrc.gov/materials/uranium-recovery.htm

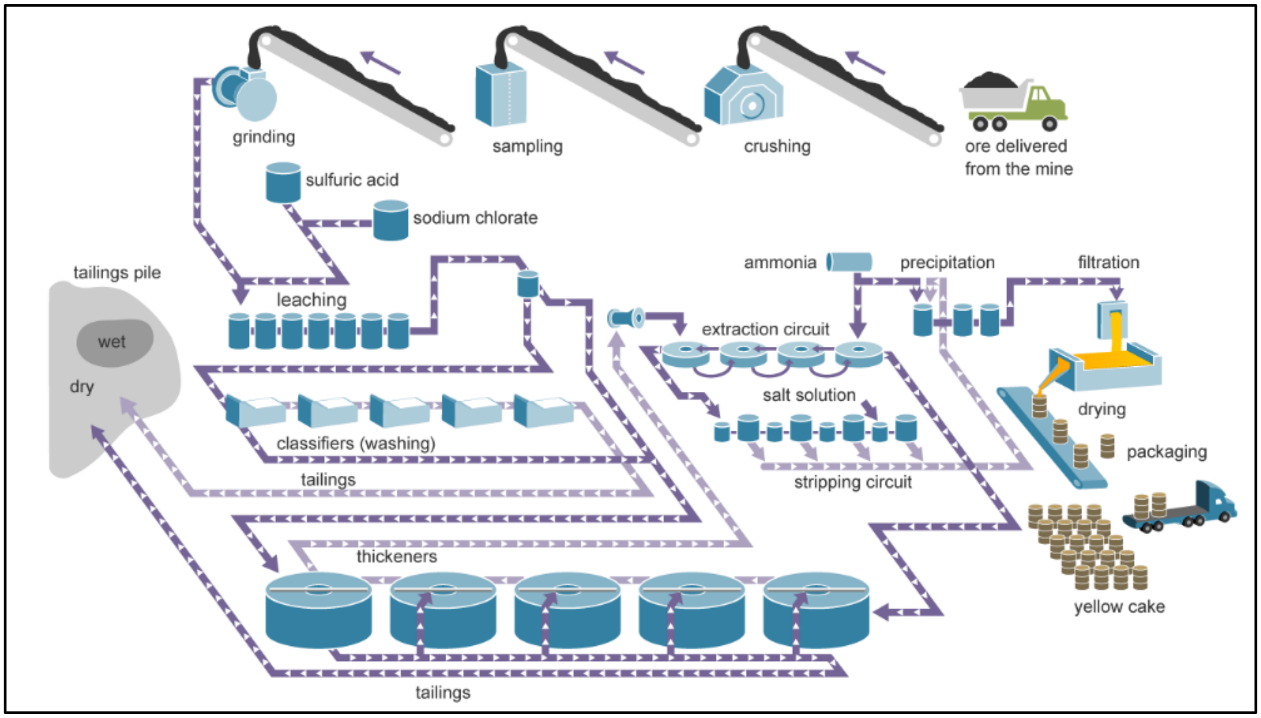
The majority of the uranium milling processing facilities receive coarse uranium-bearing ore or ore slurries excavated by conventional underground or above-ground mining techniques. Crushed uranium-bearing ore or slurry is hauled to a nearby, often co-located, mill where it is crushed and undergoes a chemical process to remove the uranium. The uranium is concentrated to produce a material called "yellowcake."

Milling to produce yellowcake from excavated ore is generally composed of the following operations (see also Figure 2.1-2). The process descriptions are from *Uranium Mining and Milling* (Lawrence Livermore National Laboratory, 2018).

- **Ore preparation** is blending and grinding of ore. Coarse ores are pulverized in a series of crushing and grinding stages, often with the addition of water to produce a slurry.
- **Extraction** is accomplished by dissolving the uranium ore to produce a leach slurry through the addition of lixiviants and oxidants in a series of mechanical- or air-agitated vessels. Sulfuric acid leaching is most common, whereas alkaline leaching is utilized for acid-consuming carbonate ores. Common oxidants include sodium chlorate, manganese dioxide, hydrogen peroxide, and ferric sulfate.
- **Solid/liquid separation** of uranium-bearing solutions from solid ore residues produce a clarified leach liquor or dilute pulps via decantation, filtration, and/or sand-slime separation.
- **Purification** of solutions from the solid-liquid separation selectively extracts uranium from impurities. Both solvent extraction and ion exchange are utilized by large production facilities.
- **Precipitation** of uranium from solution, where uranium is recovered from solution through precipitation, most commonly by the addition of ammonia to produce a wet concentrate of ammonium diuranate or precipitate uranium peroxide by the addition of hydrogen peroxide.
- **Drying** removes moisture and volatiles, and results in calcination, or oxidation of ore concentrate. Wet uranium concentrate is washed to remove residues and dried in a series of thickeners, filters, spray driers, and/or centrifuges. The dried uranium concentrate is heated in furnaces to form oxides of uranium, most commonly U_3O_8. The resulting powder is packaged in drums for shipment to a conversion facility.

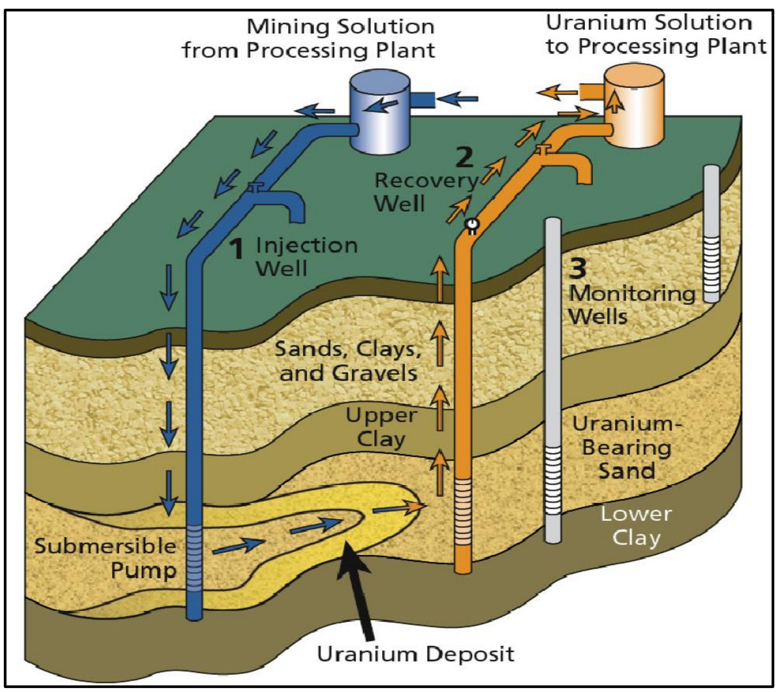
A commercial ISR facility consists of both an underground and a surface infrastructure (see Figure 2.1-3). The underground infrastructure includes injection and production wells drilled to the uranium mineralization zone, monitoring wells drilled to the surrounding ore body aquifer and to the adjacent overlying and underlying aquifers, and perhaps deep injection wells to dispose of liquid wastes (NRC, 2009a).

ISR facilities also include a surface infrastructure that supports uranium processing. The surface facilities can include a central uranium processing facility, header houses to control flow to and from the well fields, satellite facilities that house ion-exchange columns and reverse osmosis equipment for groundwater restoration, and ancillary buildings that house administrative and support personnel. Surface impoundments such as solar evaporation ponds may be constructed to manage liquid effluents from the central processing plant and the groundwater restoration circuit. The surface extent of a full-scale (i.e., commercial) ISR facility encompasses about 2,500 to 16,000 acres and includes a central processing facility and supporting surface infrastructure for one or more well fields (sometimes called "mine units"). However, the total amount of land disturbed by such infrastructure and ongoing activities at any one time is much smaller, and only a small portion around surface facilities is fenced to limit access. Well fields typically are not enclosed by fencing (NRC, 2009a).



Source: EIA (2022)

Figure 2.1-2. Uranium Mill Process



Source: NRC (2011)

Figure 2.1-3. An In-Situ Recovery Operation

Above-ground structures include the well heads (well head covers would be approximately 3 feet high and 2 feet in diameter). Groupings of wells would be connected to a well house building, which in turn would be connected to the main processing facility, all by piping laid relatively close to the ground. The largest structure associated with the processing facility would be typically about 30 feet tall. The entire processing facility would cover an area of about an acre (NRC, 2010).

Although specific operations will vary depending on the individual operator and site-specific characteristics, the ISR uranium recovery process generally involves two primary operations: (1) injection of barren lixiviant to mobilize uranium in underground aquifers and (2) extracting and processing the pregnant lixiviant in surface facilities to recover the uranium and prepare it for shipment.

During ISR, mining chemicals[31] are added to groundwater to produce a leaching solution or lixiviant. Through injection wells, this solution is injected into the production zone to dissolve uranium from the underground formation and subsequently remove uranium from the deposit. This process also removes additional ores (such as arsenic, selenium, vanadium, iron, manganese, and radium), which must be removed from the solution during the recovery process (NRC, 2010).

The leaching solution in the production zone becomes progressively enriched in uranium and the other metals that are typically associated with uranium in nature until the solution is extracted from the mine through production wells. These metals and other constituents such as chloride, which is introduced by the ion-exchange resin system, are removed or precipitated from the groundwater during aquifer restoration after uranium recovery is completed (NRC, 2010).

Key aspects of uranium processing include:

- **Purification** – Uranium ores are purified using a combination of ion exchange and elution.
- **Ion exchange** – The leaching solution from the production wells enters the ion-exchange columns containing ion-exchange resin (small negatively charged particles of polymer or plastic). Resin beds selectively adsorb the uranium in the the ion-exchange columns. The primary reaction is the exchange of the uranium carbonate complexes for chloride. The ion columns with uranium-saturated beds are removed from service and transferred to a processing facility (NRC, 2010).
- **Elution** – Within the processing facility, the resins are washed in an elution circuit where the uranium is washed (eluted) from the resin. A concentrated brine solution is used to wash the uranium-saturated resins. The resins, now with the uranium removed, are recycled for further use in the ion-exchange columns (NRC, 2010).
- **Precipitation, drying, and packaging** – In the precipitation and drying circuit, the solution from the elution process is typically acidified using hydrochloric or sulfuric acid and hydrogen peroxide is added to precipitate the uranium as uranyl peroxide. Caustic soda or ammonia is also normally added after this stage to neutralize the acid remaining in the eluate. The now uranium barren eluant is typically recycled. Water left over from these processes may be reused in the eluant circuit. After the precipitation process, the resulting slurry is sent to a thickener where it is settled, washed, filtered, and dewatered. For on-site processing, the slurry is next dried. Older ISR facilities used yellowcake dryers, either multihearth dryers or vacuum dryers.[32] Newer ISR facilities usually use vacuum yellowcake dryers. In a vacuum dryer, the heating system is isolated from the yellowcake so no radioactive materials are entrained in the heating system or its exhaust.

[31] Such as sodium carbonate/bicarbonate, ammonia, sulfuric acid, gaseous oxygen, and hydrogen peroxide.

[32] Alternatively, this thickened slurry may be transported off-site to a uranium processing plant to produce yellowcake. Any organic contaminants in the yellowcake (e.g., grease from bearings) will be completely burned and will exit the system with the dryer off-gas. Any uranium remaining in the off-gas is scrubbed before discharge to the atmosphere. As a result, the stack discharge normally contains only water vapor and quantities of uranium fines that are managed to be below regulatory limits.

Moisture in the yellowcake is the only source of vapor. The dried product (yellowcake) is removed from the bottom of the dryer and packaged in drums for eventual shipping off-site to a conversion facility (NRC, 2010).

2.1.2 Conversion of U_3O_8 to UF_6

The production of 50 MT of HALEU[33] per year would require the conversion of about 2,500 MT of U_3O_8 into about 3,100 MT of UF_6.

Under the Proposed Action, conversion could occur at any existing conversion facility or at a new facility. The Enrichment RFP (DOE, 2024) states that conducting conversion services in the United States is preferred, with North American locations being next preferred and foreign locations in allied or partner nations also allowed. There is one NRC-licensed conversion facility in the United States: the Honeywell International Metropolis Works Uranium Conversion Facility (the Metropolis Works Plant or "Metropolis facility") near Metropolis, Illinois. In April 2023, the plant resumed operations after over 5 years in a ready-idle mode (i.e., not operating but easily restarted).[34] The Metropolis facility has the licensed capacity to produce up to 15,000 MT of UF_6. The requirements for HALEU commercialization would be about 20% of the plant's capacity.

The Metropolis facility site is about 1,000 acres and borders the Ohio River, just northeast of the city limits of Metropolis, Illinois. Of the 1,000 acres, the processing facility is contained within a 59-acre fenced restricted area. The developed portion of the Metropolis facility site (Figure 2.1-4) contains the primary process buildings: the Feed Materials Building (FMB) and associated pads, potassium hydroxide muds building, wet processing/sodium removal building, and the sampling plant, and about a dozen support facilities (NRC, 2019, pp. 2-1).

Source: NRC (2019, pp. 3-32)

Figure 2.1-4. Developed Portion of the Metropolis Works Plant Site

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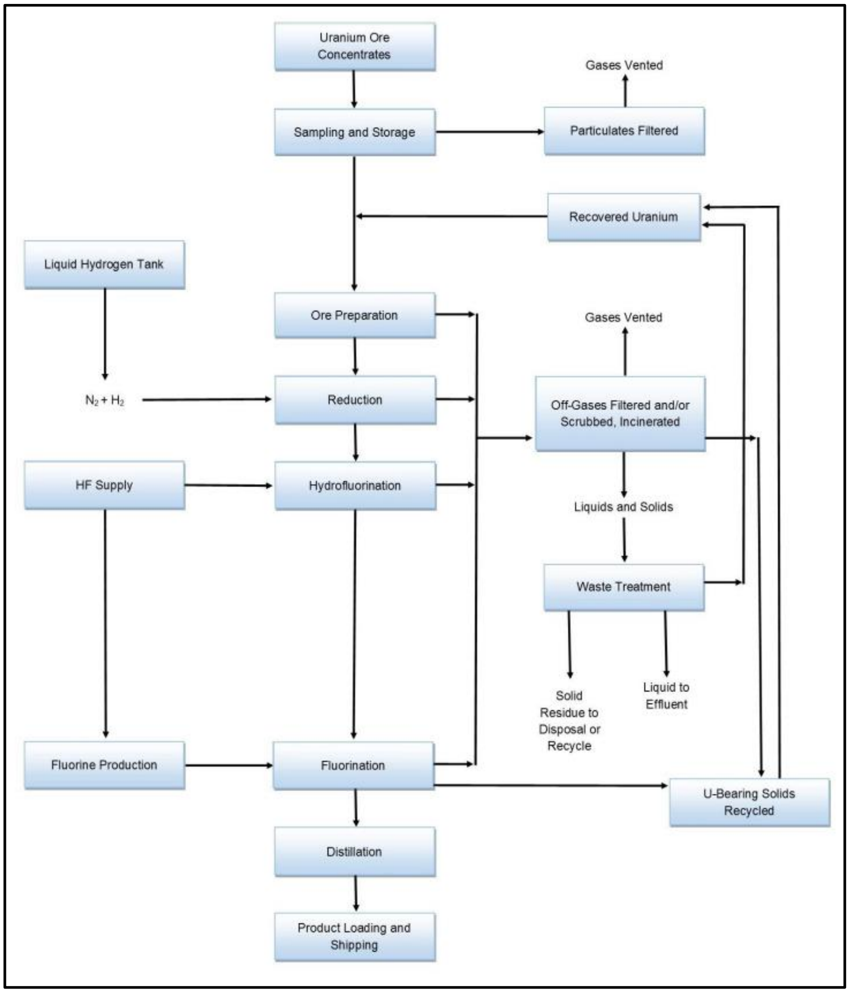
33 As previously discussed, this EIS assumes a 10-year period of performance and a 6-year period of HALEU production resulting in 290 MT of HALEU total across multiple awards (i.e., rounding to approximately 50 MT of HALEU per year).

34 In early 2023, DOE awarded ConverDyn (the marketing arm for the Metropolis Works Plant) a $14 million award for conversion services supporting the domestic uranium reserve. This award was made by the National Nuclear Security Administration (NNSA) and is separate from the actions being pursued under DOE's Proposed Action (this EIS) to facilitate the establishment of commercial HALEU fuel production.

The developed portion of the Metropolis facility has the appearance of a typical industrial complex. The area includes industrial/warehouse type buildings. Most of the buildings are low, with the FMB being the tallest, at six stories. Several of the structures have exhaust stacks with pollution control equipment. In addition to the buildings, the area includes open-air storage areas, settling ponds, and parking lots. The protected area is enclosed in a double chain-link fence (NRC, 2019, pp. 3-31).

The conversion process used at the Metropolis facility is shown in Figure 2.1-5.



Source: NRC (2019, pp. 2-4)

Figure 2.1-5. Uranium Conversion Process

There are five major steps to the conversion process. The following information is from the NRC's *Environmental Assessment for the Proposed Renewal of Source Material License SUB-526 Metropolis Works Uranium Conversion Facility (Massac County, IL. ML19273A012)* (NRC, 2019, pp. 2-5).

- **Uranium oxide ore storage, sampling, and preparation** – Uranium oxide ore concentrates, often referred to as "yellowcake," are shipped to the conversion facility via truck in 55-gallon drums and stored on asphalt pads. At the sampling plant, a representative sample from each drum is collected to determine the general composition of the ore and to characterize impurities in the ore sampling building. Feed material may require treatment with sulfuric acid if it contains high levels of sodium or potassium. Treated uranium feed is filtered from the rinse solution and transferred to the ore preparation system. Ore with an acceptable purity level is heated in a furnace, crushed, and sized to produce uniform solid particles. The filtered rinse solution is pumped to uranium settling ponds and some particulates are released to the atmosphere. The preparation building air is released to the atmosphere after being filtered at an efficiency greater than 95%. Solid waste filter bags are produced in this operation. The contaminated liquid stream produced in drum washing is routed to a uranium settling pond.

- **Reduction** – The initial step in the conversion process is reduction of yellowcake to solid uranium oxide, which is accomplished by contacting feed yellowcake with hydrogen gas (from an 18,000-gallon cryogenic storage tank) in a fluidized bed reactor in the FMB. Reduction off-gases consist of hydrogen sulfide, hydrogen, nitrogen, and metallic sulfides. These are processed through a gas-fired incinerator to burn off the excess hydrogen, convert hydrogen sulfide and other sulfides, and produce carbon dioxide. Particulates are removed through a sintered metal filter. The stream is processed through a gas-fired incinerator to produce carbon dioxide, which then exits the incinerator stack.

- **Hydrofluorination** – In the FMB, solid uranium oxide is converted to solid uranium tetrafluoride (UF_4) by contacting the uranium oxide with gaseous hydrogen fluoride in two series-arranged fluidized bed reactors. The hot reactor off-gas is filtered and scrubbed with water and potassium hydroxide solution before being released to the atmosphere. The spent scrubber liquid is processed for neutralization and recovery of fluorine as calcium fluoride.

- **Fluorination** – The final chemical reaction in the conversion process is fluorination of solid UF_4 in the FMB using fluorine gas to generate gaseous and then liquid UF_6. The gaseous fluorine is produced by decomposition of hydrogen fluoride in a fluidized bed at elevated temperatures located in a building near the FMB. The fluidized bed contains calcium fluoride material. The bed material, which gradually becomes too fine and contaminated with uranium is continuously removed and fresh bed material is continuously added. The uranium contaminated bed material is continuously removed along with residual uranium deposits from the process. The reactor effluent gas stream containing the UF_6 product is passed through two filters in series and three cold traps in series. The UF_6 is condensed in the cold traps to create liquefied crude UF_6 that is transferred to the distillation area. Gases exiting the cold traps are scrubbed with potassium hydroxide solution. Potassium fluoride mud is removed from the scrubber solution, washed, and recycled to the uranium recovery system. The spent scrubber solution is transferred to the environmental protection facility for neutralization, recovery of potassium hydroxide, and recovery of fluorine as calcium fluoride. Filtered and scrubbed off-gases (primarily hydrogen fluoride) are released to the atmosphere.

- **Distillation and Packaging** – In the FMB, impurities are removed from the liquefied crude UF_6 in two series-arranged distillation columns. The bottoms from the first column are fed to the second column, and the purified UF_6 product that meets or exceeds ASTM C787, *Standard Specification for Uranium Hexafluoride for Enrichment*, purity requirements is collected in the overheads. Gaseous effluents from the distillation process are fed back to the fluorination system and treated with the fluorination off-gas. The purified product UF_6 vapor is condensed and transferred as liquid to cylinders for shipment. On occasion, filled cylinders are heated in a steam chest for vaporization and sampling. The filled cylinders are moved to cooling and storage areas.

2.1.3 Uranium Enrichment to HALEU

The production of 50 MT of HALEU[35] per year would require the enrichment of about 3,100 MT[36] of UF_6 comprised of natural uranium into about 75 MT UF_6 enriched to 19.75% HALEU and would generate approximately 2,900 MT of depleted UF_6 (DUF_6).[37] The Enrichment RFP (DOE, 2024) allows enrichment up to less than 5% at locations within the United States and in foreign (allied or partner) nations but requires that enrichment to 5% or above occur in the United States. The RFP allows that the enrichment services could be provided in two steps at separate locations. Several options are available to support the domestic commercial production of HALEU enriched to at least 19.75% and less than 20%:

- Construction of new enrichment facilities capable of using natural uranium as feed and producing 19.75% HALEU
- Modification of existing enrichment facilities that currently produce LEU
- Use of existing enrichment facilities to produce LEU (of up to less than 10% U-235) and augmentation of the existing facilities with new facilities to enrich the LEU to HALEU

There are two means of enrichment considered. The more technologically mature is gas centrifuge enrichment, and the other is laser enrichment. Gas centrifuge enrichment is the current process by which commercial enrichment is being performed in the United States. A centrifuge consists of a large rotating cylinder (rotor) and piping to feed UF_6 gas into the centrifuge and then withdraw enriched and depleted UF_6 gas streams. The rotor spins at a high rate of speed inside a protective casing, which maintains a vacuum around the rotor. The centrifugal force produced by the spinning rotor creates radial separation, in which the heavier uranium-238 (U-238) hexafluoride molecules concentrate near the rotor wall and the lighter U-235 hexafluoride molecules collect closer to the axis of the rotor (USEC, 2004a). In addition to the radial separation of isotopes, separation along the vertical axis (axial) is also induced in response to a thermal gradient along the length of the rotor. The hotter gas stream rises, while the relatively cooler gas stream flows downward.

Figure 2.1-6 shows the components of a gas centrifuge, including the flow of UF_6 gas. The combination of radial and axial separation results in a relatively large assay change between the top and bottom of the centrifuge. Enriched UF_6 is extracted by a scoop at the top of the centrifuge while depleted material is removed from a scoop at the bottom.

A single centrifuge, while more efficient than older enrichment technologies, cannot enrich natural uranium to HALEU (or even to current commercial light water reactor [LWR] enrichments of less than 5%) and cannot process the volume of material needed to enrich signifiant quantities of uranium. Therefore, the centrifuges are combined in both series and parallel in what is called a cascade. The cascade allows for processing more uranium and allows for the extraction of uranium enriched to different levels at any point during the enrichment process.

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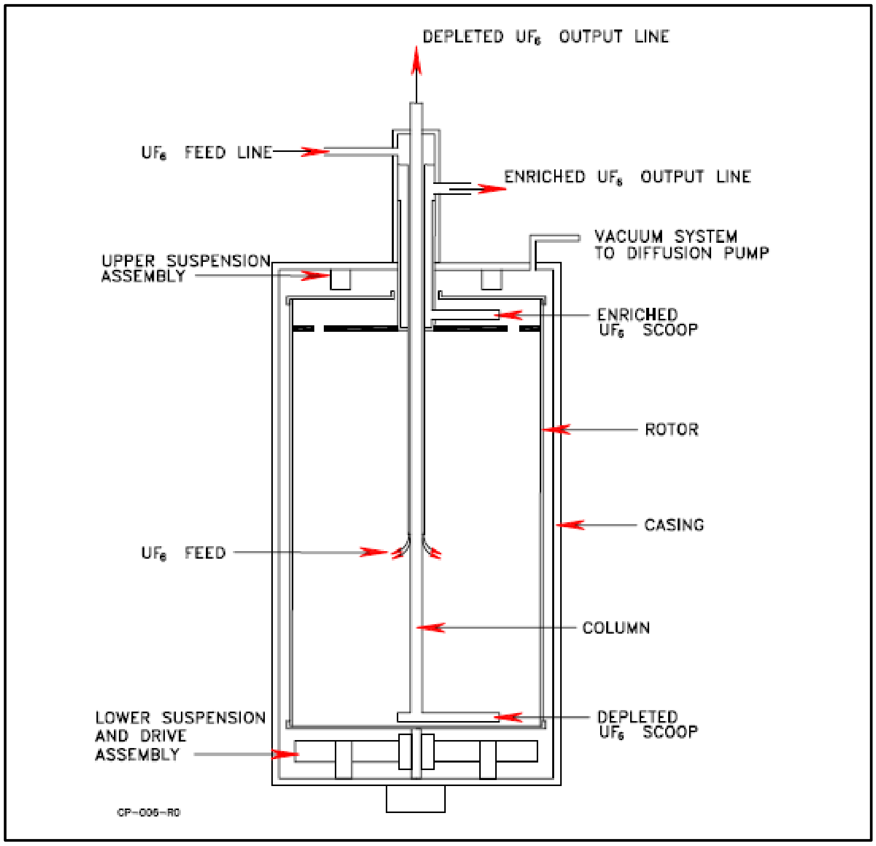
[35] As previously discussed, this EIS assumes a 6-year period of HALEU production resulting in 290 MT of HALEU total across multiple awards (i.e., rounding to approximately 50 MT of HALEU per year).

[36] Assuming the enrichment is performed at a single enrichment facility. If enrichment is performed in two steps (up to about 5% the first step and then up to 19.75%, the required feed material (natural uranium UF_6) could be approximately 10% higher.

[37] Depleted uranium (DU) consists of uranium with less than the naturally occurring percentage of the U-235 isotope, which is less than 0.7% U-235.



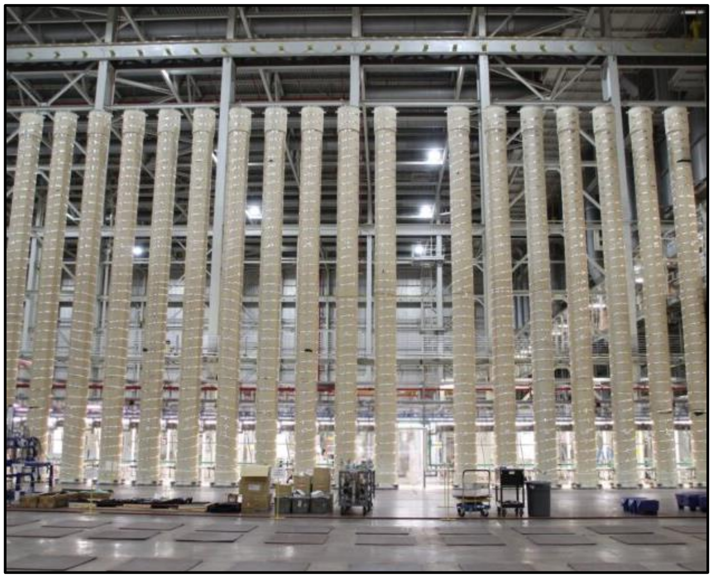
Source: USEC (2004a)

Figure 2.1-6. Uranium Centrifuge Enrichment

Three enrichment facilities are described here: the ACP located in Piketon, Ohio, the UUSA facility located near Eunice, New Mexico, and the Global Laser Enrichment (GLE) facility that would have been located near Wilmington, North Carolina. These descriptions are provided to support the analysis for impacts from the enrichment of up to 50 MT/yr of uranium[38] to 19.75% but less than 20% HALEU, but are not intended to limit future DOE options for enrichment actions to these three facilities. Uranium enrichment to LEU (3% to less than 5%) is currently occurring at UUSA with LEU+ (uranium enriched to between 5% and less than 10%) enrichment planned. DOE currently has a contract with ACO for a 16-centrifuge HALEU demonstration cascade at the Piketon, Ohio, Centrus facility (capacity of 0.9 MT/yr of HALEU) (Figure 2.1-7).[39] The demonstration cascade and supporting equipment was installed and on November 7, 2023, Centrus announced the first delivery of HALEU to DOE (Centrus Energy Corp, 2023a). Separately, General Electric (GE)-Hitachi had planned a laser enrichment facility for its complex in Wilmington, North Carolina. A license was granted by the NRC in 2009, but the facility was not constructed and this license has been terminated. Although the location of enrichment is not limited to existing facilities/locations, together these three facilities represent the range of possible options, under the Proposed Action, from converting an existing facility to building a completely new facility.

[38] 50 MT per year is the production rate assumed for the analysis of Proposed Action production total of 290 MT of HALEU.

[39] NEPA documentation for the demonstration effort has been prepared (NRC, 2021e). The demonstration effort is not a part of the Proposed Action.



Source: Centrus Energy Corp (2023b)

Figure 2.1-7. Centrus Centrifuge Demonstration Cascade

The UUSA facility is located about 5 miles east of Eunice, New Mexico, on 543 acres of land. It is currently licensed to enrich uranium to 5% in U-235. Construction of the facility disturbed about 200 acres of the site. The completed facility structures occupy about 180 acres of this fenced site (Figure 2.1-8), including the following:

- Uranium Byproduct Cylinder Storage Pad
- Centrifuge Assembly Building
- Cascade Halls
- Cylinder Receipt and Dispatch Building
- Blending and Liquid Sampling Area
- Technical Services Building
- Administration Building
- Visitor Center
- Security Building
- Central Utilities Building

As originally constructed, there were six Cascade Halls, each of which housed eight cascades. Cascade Halls are the largest of the facility structures. They are metal-framed buildings with metal siding. In addition to the centrifuge cascades, feed and withdrawal systems are located in the Cascade Halls. The entire facility was initially capable of a maximum output of almost 3.3 million separative work units (SWUs),[40] but expansion in 2015 increased capacity to 4.8 million SWUs, with a planned increase to 10 million SWUs (in addition to the increased capability to enrich up to 10%).

Other smaller structures house activities that are needed to support cascade operation, including administrative activities, control systems, an emergency power system, sampling capabilites, and so on.

[40] The SWU is a measure of the work required to separate isotopes of uranium during an enrichment process. Approximately 42.5 SWUs are required to enrich 40.5 kg of natural uranium to 1 kg of 19.75% HALEU.

Source: Fletcher (2020)

Figure 2.1-8. Urenco USA (UUSA) National Enrichment Facility, New Mexico

On the north side of the site, storage pads for UF_6 cylinders would occupy a maximum of 23 acres. This includes storage for feed material, product material, and depleted uranium (DU) tails. Storage cylinders would be stacked two high on the pads.

The Centrus ACP is located on the DOE Reservation in Piketon, Ohio, that was formerly the site of the Portsmouth Gaseous Diffusion Plant. The reservation is located about 18 miles north of Portsmouth, Ohio, east of the Scioto River. The reservation consists of about 3,700 acres, and existing facilities are located within a 1,200-acre fenced perimeter.

Newly constructed facilities for the Centrus ACP would be located on about 200 acres within this fenced perimeter. Some of the former gaseous diffusion plant facilities would also be used by Centrus for centrifuge enrichment (USEC, 2004b). The developed portion of the Centrus ACP has the appearance of a typical industrial complex. The largest of the structures to be used are the two former processing facilities, both about 416 feet by 730 feet with an 87-foot-tall bay (containing the gas centrifuge cascades). These structures provide a 3.5 million SWU capacity. If the Centrus ACP expands to a 7 million SWU capacity, two additional processing buildings would be constructed on the ACP site. Additional feed and withdrawal facilities contain the equipment and operations to feed the UF_6 that the Centrus ACP receives from the Metropolis facility and withdraw the HALEU product and DU tails, respectively. The Centrus ACP also has utilized multiple support facilities; most are existing buildings used during the gaseous diffusion plant operation. Shipping and receiving, waste handling, facility control, and maintenance are among the support facilities required for plant operation. All of these structures are smaller, and in most cases significantly smaller, than the process buildings (USEC, 2004b, pp. 1-3). Any future operation of Centrus ACP would make use of existing and new cylinder storage yards, totaling about 1.6 million square feet, for the temporary storage of feed material, product material, and tails (USEC, 2004a, pp. 2-6).

The proposed GLE facility[41] (a first-of-a-kind facility for the United States) would have been located on the GE Wilmington, North Carolina, site of the existing GNF-A and the GE Aircraft Engines/Services Components Operation manufacturing facilities. The site consists of about 1,620 acres, of which the GLE facility would have occupied about 100 acres. The proposed facility was to have had a capacity of 6 million SWUs per year (NRC, 2012a, pp. 2-1).

[41] The NRC license application for the GLE laser enrichment facility was terminated in January of 2021.

The largest of the proposed facilities would be the operations building, it would house the laser equipment and any necessary support equipment. All major activities (feed receipt, enrichment, product and tails withdrawal, sampling, waste management) would occur within the operations building. Estimates for the size of the building indicate it would be about 120 by 600 and up to 160 feet tall (NRC, 2012a, pp. 4-7). There would be three cylinder yards (one each for feed, tails, and product) totaling about 650,000 square feet (15 acres), with the cylinder pad for tails accounting for about two-thirds of this area (NRC, 2012a, pp. 2-7). Additionally, the facility would require new facility buildings and supporting infrastructure that would include administrative buildings, waste storage buildings, an electrical substation, backup diesel generators, potable and process water systems (including a 130-foot water tower), a holding pond for cylinder storage pad stormwater, a stormwater wet detention basin, parking areas, and roads (NRC, 2012a, pp. 2-7).

The four major processing steps involved in enriching the natural UF_6 at the proposed GLE facility would have been (1) UF_6 feed and vaporization, (2) cascade/gas handling, (3) product withdrawal, and (4) tails withdrawal. With the exception of the cascade/gas handling process (laser separation), the processing steps are similar to those associated with the gas centrifuge enrichment process. During the first step, the feed material (natural enrichment UF_6) is first vaporized and then resolidified to remove impurities. During the second step, the solid UF_6 is revaporized and exposed to laser-emitted light and separated into two streams (one enriched in U-235 and one depleted in U-235). Properly tuned (specific frequency/wavelength) laser-emitted light is selectively absorbed by U-235 and not U-238. The absorbed energy ionizes (removes an electron from) the U-235, allowing it to be separated from the non-ionized U-238. The laser selectively adds enough energy to ionize or remove an electron from U-235 atoms. As with centrifuge enrichment, a single laser does not enrich the uranium to product levels (both LEU and HALEU) in a single step and the lasers are arranged in cascades to generate the desired enrichment at production level quantities. The process results in the output of enriched uranium and DU, which are collected at the product and tails withdrawal stations, respectively (NRC, 2012a, pp. 2-8).

2.1.4 HALEU Deconversion Facility

The production of 50 MT of HALEU[42] per year would require the conversion of about 75 MT of HALEU as UF_6 into a form suitable for fabrication into reactor fuel. This could be 50 MT of uranium metal, 57 MT of uranium dioxide (i.e., UO_2), or an equivalent amount in another chemical form.[43] The deconversion facilities need not be of the same size (capacity) as the enrichment facilities. DOE may choose to enter into multiple deconversion contracts under the Proposed Action. As discussed in Section 2.1.7.1*, HALEU Fuel Fabrication Facilities*, advanced reactor designs may utilize HALEU in different forms. UO_2 is the form currently used by commercial LWRs and may be used in some advanced reactors. TRISO fuel, a uranium/oxide/carbide fuel, is being considered for, among others, many liquid metal reactors. Molten salt reactors (MSRs) use fuel in the form of a molten fluoride or chloride salt.

Deconversion of the UF_6 HALEU into a form suitable for storage or to be provided to fuel fabricators could include conversion into any of the forms identified above, including uranium metal. All of these processes

[42] As previously discussed, this EIS assumes a 6-year period of HALEU production resulting in 290 MT of HALEU total across multiple awards (i.e., rounding to approximately 50 MT of HALEU per year).

[43] It is possible that not all of the UF_6 HALEU would be processed through the deconversion facility. Some may be sent directly to fuel fabricators for conversion into their preferred form. The values used here represent the maximum throughput for the deconversion facility to support DOE estimates of 50 MT of HALEU per year and 290 MT for the 6-year period of HALEU production. It is anticipated that multiple facilities would be used to deconvert the full amount of HALEU addressed in the Proposed Action.

are chemical conversions. Although deconversion into either a uranium metal or UO_2 has been assumed for this EIS, the form of HALEU to be stored or provided to fuel fabricators is not ripe for a decision.

Deconversion is currently performed at several fuel fabrication facilities. In the LEU fuel cycle, LEU in the form of UF_6 is shipped directly to the LEU fuel manufacturers. But because existing deconversion facilities are designed for LEU, not HALEU, these facilities would not be amenable to HALEU deconversion. The commercial fuel fabrication facilities routinely start with cylinders of UF_6 and convert the UF_6 to oxide for blending and fabrication into LEU fuel pellets. Existing cylinders of depleted UF_6 are also currently being converted to oxide at the DOE Portsmouth and Paducah sites. The process for conversion of cylinders of HALEU in the form of UF_6 to an oxide form would be similar to those used for LEU and DU.

Since there is no deconversion facility capable of handling at least 19.75% HALEU in the United States, facilities would need to be constructed or existing facilities modified. Under the Proposed Action, possible locations could include one that is co-located with the enrichment facility, co-located with a fuel fabrication facility, or independently located at a greenfield site (i.e., a previously undeveloped site) or on a site with other nuclear facilities. The facility would have to be an NRC Category II facility, with security features meeting NRC requirements for the possession of uranium enriched to between 10% and less than 20%. Security could be provided for the facility itself or for the site where the facility is located (e.g., at a site with appropriate existing security).

A proposed deconversion facility for DU that would have been located in Lea County, New Mexico (14 miles west of Hobbs), is representative of the type of facility that could be used for deconversion of the UF_6 HALEU. This facility would be typical of industrial chemical facilities. The facility site would be about 640 acres and the facility itself would occupy about 40 acres of the site and be surrounded by a security fence. Structures within the security fence would include process, administration, and laboratory buildings; a maintenance shop; security facilities; utilities; cylinder storage pads (occupying a little over an acre); storage tanks; and warehouses. Because this facility would have used a two-step process, there would have been multiple processing buildings for UF_6 conversion, UF_4 (i.e., uranium tetrafluoride) conversion, and fluorine extraction. In total, the facility would consist of about 10 major buildings. The tallest structure on the site would be the meteorological tower (about 30 feet) and the tallest building, excluding stacks, would be about 70 feet tall. Building exhaust stacks would be under 100 feet tall. (NRC, 2012b, pp. 2-6)

The Lea County facility would have utilized a two-step deconversion process, producing UF_4 as an interim step, and then converting the UF_4 to UO_2. The HALEU-enriched UF_6 would be received at the deconversion facility in cylinders specifically designed for the transport of HALEU. The first step of the deconversion process would vaporize the feed material in an autoclave. The vaporized material would be reacted with hydrogen in a separate vessel to produce the UF_4. In the second step, the UF_4 would be combined with either silicon dioxide or boron oxide in a furnace. This reaction would result in the production of the UO_2. Additional byproducts of this process include hydrogen fluoride (or, in its aqueous form, hydrofluoric acid), silicon tetrafluoride, and boron trifluoride (NRC, 2012b, pp. 2-2).

Other methods to deconvert UF_6 include a method that directly converts UF_6 to UO_2 in a one-step dry conversion process. The HALEU-enriched UF_6 would be received at the deconversion facility in cylinders specifically designed for the transport of HALEU. The dry chemical conversion process would convert the UF_6 feed into the solid uranium oxide in a dry conversion facility. In the dry conversion process, the solid UF_6 is heated and the resultant gas is reacted directly with a hydrogen-nitrogen-steam atmosphere in a fluidized bed to form UO_2 powder. A rotary calciner removes residual fluoride from the UO_2 powder. Off-gas from the hydrolysis reactor and calciner is filtered to remove particulates and passed through a condenser where hydrogen fluoride and water are recovered as a liquid stream. The off-gas is exhausted through high-efficiency particulate absolute filters to the atmosphere.

Uranium metal can be produced in a two-step process. In the first step, the UF_6 would be placed in an autoclave enclosed in a containment to vaporize the feed. The UF_6 vapors would be transferred to a reaction vessel where it would react with hydrogen to produce solid UF_4 (and anhydrous fluorine). The solid UF_4 would be transferred to another process line (possibly in another facility). Here, the UF_4 is readily reduced to uranium metal by reacting with either high-purity magnesium or calcium metal at an elevated temperature. Presses are sometimes used to compact the uranium mixtures prior to reduction (NRC, 2009b, p. 5).

The resulting products would then be packaged in HALEU-certified containers for storage at the HALEU storage facility and stored by the awardee(s) until there is a need to ship it to the fuel fabricator.

2.1.5 HALEU Storage

The Proposed Action includes storage in a facility (or facilities) to store the full amount to be acquired by DOE under the Proposed Action. Therefore, storage facilities sufficient to meet the maximum amount under the Proposed Action would require a storage capacity of up to 290 MT of HALEU enriched to at least 19.75% and less than 20% U-235. The most likely forms for the HALEU to be stored would be following enrichment and in the form of UF_6[44] (total quantity of material of 440 MT), or following deconversion UO_2 (340 MT), or uranium metal (290 MT). No specific location for the storage facilities is proposed. They could be co-located with an enrichment facility or a deconversion facility, which may be co-located with an enrichment facility or a fuel fabrication facility or independently located. A storage facility could reside within an existing building if co-located. However, as a conservative approach, the Proposed Action analysis assumes the construction and operation of a new HALEU storage facility at one of these locations.

The notional new storage facility is conservatively based on the assumption that the facility would store the material that requires the most space, which is UO_2. The project annual and total storage demands for UO_2 are 56 and 340 MT, respectively.[45] The ES-3100 package was chosen as a surrogate package design for storing UO_2 as it satisfies the safety standards needed for HALEU (NRC, 2021b). Based on the capacity and size of these containers (INL, 2019), the preliminary dimensions of the storage facility are about 12,100 square feet with a height of 25 feet. The building walls would likely have pre-cast concrete panels topped with metal exterior siding and roof. The floor would be solid reinforced concrete. The facility also would likely include an associated approach pad constructed of reinforced concrete with a dimension of 40 feet by 30 feet.

The design would be required to meet NRC criteria for the storage of HALEU (such as seismic capability, tornado protection, etc.) and would include the necessary environmental controls to protect staff and the environment. The storage facility would be an NRC Category II facility, with security features meeting NRC requirements for the possession of uranium enriched to between 10% and less than 20%.

Operations at the storage facility would be limited to (1) receipt and shipment of HALEU containers by truck, (2) handling of HALEU containers with industrial equipment such as forklifts, and (3) monitoring and

[44] Commercial entities providing enrichment services are required to propose the capability to store UF_6 per the DOE's Enrichment RFP. Those providing deconversion services are required to propose the capability to store the deconverted product per the Deconversion RFP (DOE, 2023a).

[45] Multiple storage facilities may be required. Parameters are for one storage facility based on the capability to store half of the HALEU procured under the Proposed Action, up to 145 MT of HALEU.

inspection of stored HALEU containers. Security could be provided for the facility itself or by existing security of the site location.

2.1.6 HALEU Transportation

The Proposed Action consists of activities that could be performed at many different facilities across the United States. Although some of the facilities for multiple steps in the fuel cycle could be co-located,[46] no specific facilities have been identified under the Proposed Action, and therefore, transportation of the radioactive materials used in the HALEU fuel cycle could involve the transportation of materials between up to seven sites. The EIS assumes, for analytical and bounding purposes, the following potential transportation scenarios:

- Up to 15 million MT (2.6 million MT annually) of uranium ore from conventional mines to milling facilities
- Up to 14,000 MT (2,500 MT annually) of yellowcake from either mills, ISR facilities, or foreign sources to the Metropolis or new conversion facility[47]
- Up to 18,000 MT (3,100 MT annually) of UF_6 from the Metropolis facility, new conversion facility, or foreign sources to LEU enrichment facilities
- Up to 1,800 MT (310 MT annually) of 5% LEU from LEU enrichment facilities to HALEU enrichment facilities
- Up to 440 MT (75 MT annually) of enriched UF_6 from the HALEU enrichment facilities to the deconversion/storage facility (or facilities)
- Up to 330 MT (56 MT annually) of deconverted HALEU, in the form of UO_2, from the deconversion/storage facilities to fuel fabrication facilities

Transportation of the first three items listed above involve the transport of natural uranium, containing 0.711% U-235. Transportation of these materials would be carried out in the same manner as that currently done in support of the LEU fuel cycle, by truck using type A packaging. This type of packaging must withstand the conditions of normal transportation without the loss or dispersal of the radioactive contents. DOE is engaged with the commercial sector to develop transportation and storage casks specifically designed and certified for HALEU. That effort is not a part of the Proposed Action.

2.1.7 Related Post-Proposed Action Activities

It is reasonable to assume that the HALEU acquired under the Proposed Action would ultimately be used, although exactly where and by whom cannot be determined at this time. The steps associated with the use of the HALEU would be fabrication into fuel at a fuel fabrication facility (either a new facility or modified existing facility), use in a HALEU-fueled advanced reactor, and storage and disposal of the SNF. Although these are reasonably foreseeable actions resulting from implementation of the Proposed Action, many of the specifics are unknown Therefore, a detailed analysis of the impacts of these activities would be speculative. These activities are discussed to the extent possible in the following sections.

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[46] For example, enrichment, deconversion, and storage facilities could all be co-located. Co-location would reduce the amount of material transported between sites.

[47] The analysis of the Proposed Action assumes that the natural uranium would be domestically mined. The Enrichment RFP (DOE, 2024) identifies domestically source uranium as the preferred option.

2.1.7.1 HALEU Fuel Fabrication Facilities

Fuel fabrication is the last step in the process of turning natural uranium into nuclear fuel. Nuclear reactor fuel is specifically designed for particular types of reactors. While all present U.S. commercial reactors use oxide fuel, research and development efforts are aimed at the production of other fuel types that could be used in advanced reactors.

Fuel fabrication facilities would convert the acquired HALEU into fuel for ANRs. Advanced reactors have been proposed that utilize several different fuels designs, requiring fuels to be manufactured in different shapes/forms and chemical compositions. Advanced reactors could require forms such as pebbles, rods, or particles and varying chemical compositions, such as metallic, molten salt, TRISO particle fuel (uranium/oxygen/carbon fuel kernel), uranium nitride, and advanced ceramic (oxide, carbide) fuel. Given that each of the nuclear fuels are fabricated using techniques specific to the fuel shape and composition, it is unlikely that the same fuel fabrication facility would produce multiple fuel types.

Facilities could be sited anywhere in the United States as long as that facility meets NRC siting requirements. Because of their participation in the uranium fuel cycle, current fuel fabricators and possibly the fuel fabrication sites are likely candidates for new HALEU fuel fabrication facilities. Other likely candidates include the reactor vendors themselves, possibly building new facilities that would produce fuel specifically designed for their advanced reactor designs.

Current fuel fabrication sites and potential reactor vendor affiliated candidate sites include, but are not limited to the following:

- The NFS facility in Erwin, Tennessee, and the BWXT facility in Lynchburg, Virginia (both NRC Category I facilities). The BWXT facility is the only facility currently capable of fabricating HALEU fuel using production-scale equipment and is authorized to produce demonstration-scale quantities of fuel (0.4 MT of HALEU TRISO fuel)[48] (SCO, 2022, pp. 4-61). BWXT has plans to develop a larger-scale TRISO fuel production line.
- The currently operating LEU facilities (all NRC Category III facilities) that would require modification/or new fabrication capabilities):
  - The Framatome fuel fabrication facility in Richland, Washington
  - The GNF-A fuel fabrication facility in Wilmington, North Carolina
  - The Westinghouse Electric Company fuel fabrication facility in Columbia, South Carolina
- Reactor vendors expressing interest in HALEU fuel fabrication:
  - X-energy in Oak Ridge, Tennessee, plans to produce HALEU TRISO fuel at 8 MT/yr in 2025, expanding to 16 MT/yr by the early 2030s (X-energy, 2022).
  - GNF-A and Terra Power are in pre-application discussions with the NRC about producing HALEU fuel for the Natrium™ reactor.
  - Ultra Safe Nuclear Corporation plans to produce TRISO fuel at its Pilot Fuel Manufacturing facility in Oak Ridge, Tennessee.

2.1.7.2 HALEU-Fueled Reactors

The expected consequence of a viable commercial HALEU production capability would include the construction and operation of multiple ANRs fueled with HALEU fuel. The reactors could include research and development, test, demonstration, and commercial power reactors. Determining the numbers,

[48] This facility has produced HALEU by downblending HEU with depleted or natural uranium.

locations, and exact types of facilities would be speculative at this time.

Multiple technologies are under development that vary with respect to the fuel form used, neutron moderators employed, cooling processes, and other factors. Examples include small modular reactors, which generate between 20 and 300 megawatts electric (MWe), microreactors that generate less than 20 MWe, and larger reactors generating more than 300 MWe.

New HALEU-fueled commercial and research reactors would require NRC licenses and the required NRC NEPA documentation. A brief description of potential types of advanced reactors is provided below (McDowell & Goodman, 2021), with some projects that are at various stages of the NRC licensing process:

- High-temperature gas-cooled reactors (HTGRs) refer to graphite-moderated, typically helium-cooled systems that use TRISO fuel. The particles are packed into a graphite matrix to form either spherical or cylindrical fuel elements. The pebble bed version of the HTGR uses spherical billiard ball-sized fuel elements that flow continuously through the reactor. The prismatic version of the HTGR uses the cylindrical fuel compacts in hexagonal blocks in a fixed geometry. X-energy is in the pre-application stage for its Xe-100 80 MWe HTGR.
- Fluoride salt-cooled high-temperature reactors refer to a hybrid design that uses pebble fuel elements (like pebble bed HTGRs) and a fluoride salt coolant (like salt-cooled MSRs). Some fixed-fuel fluoride salt-cooled high-temperature reactors designs (like prismatic HTGRs) have been proposed, but none is currently under commercial consideration.
- MSRs come in several varieties. Some designs use molten fluoride salt, while others use chloride salts as the coolant. Some designs have stationary fuel rods or plates, while others have moving fuel pebbles or fissile material dissolved within the flowing coolant. In addition, some MSRs use a fast neutron spectrum, while others use a thermal spectrum. Abilene Christian University's NEXT Lab submitted an application for construction of its 1 megawatt thermal research reactor, and Kairos Power LLC is engaged in pre-application activities for its fluoride salt-cooled high-temperature pebble bed reactor that would use TRISO fuel.
- Liquid metal-cooled reactors are an advanced type of nuclear reactor in which the primary coolant is a liquid metal. Liquid metal-cooled reactors are classified based on the liquid metal coolant used, such as sodium, lead-bismuth eutectic alloy, and lead-bismuth. TerraPower is engaged in pre-application activities for the Natrium™ reactor (a HALEU-fueled, 345 MWe sodium-cooled reactor).
- Heat pipe reactors typically consist of a solid block core with the fuel in holes inside the solid block. Heat pipes are built into the block in a lattice configuration and remove the heat from the block as the liquid in the heat pipe is vaporized. Oklo Inc. submitted a licensing project plan to the NRC in late 2022[49] for their Aurora microreactor, a 1.5 MWe heat pipe reactor that would use metallic HALEU fuel.
- Integral pressurized water reactors are an advancement upon historical pressurized water reactor designs that use coolant and fuels similar to existing LWRs, but that have the primary coolant circuit components placed within the reactor pressure vessel, thereby eliminating the need for primary circuit pipework with the intention of enhancing safety and reliability.

[49] A previous license application had been denied by the NRC for lack of information.

2.1.7.3 HALEU Spent Nuclear Fuel Storage and Disposition

Interim HALEU SNF storage at the reactor sites is possible. The ultimate disposition of SNF is dependent upon the licensing (no facility is currently in the licensing process) of a permanent repository.

HALEU spent fuel storage at the reactor site can utilize spent fuel pools (fuel assemblies stored under water in structures integrated with the reactor building) or dry cask storage. Currently, most LWR SNF is stored on-site in spent fuel storage pools. Storage sites that are away from the reactor site may also be an option for temporary storage of SNF. Such facilities could be very similar to the at-reactor dry cask storage facilities, only larger. Both above-ground (storage casks located on concrete pads) and below-ground-level systems (casks stored in pits accessible from a storage pad) are used. These facilities could be used to store SNF from a single reactor or in the case of a consolidated storage facility for multiple reactors at a single location.

Ultimately, SNF is to be disposed at a permanent repository. In a geologic repository, the SNF would be irretrievably stored underground in sealed tunnels. A geological repository uses engineered barrier systems and a portion of the site's natural geology, hydrology, and geochemical systems to isolate the SNF from the environment for long periods of time. While there have been efforts to design and build a geologic repository, the United States does not have an NRC-licensed permanent repository.

2.2 No Action Alternative

The No Action Alternative is the status quo, where no sufficient domestic commercial fuel supply of HALEU is available and DOE would not implement the Proposed Action. Development of a domestic commercial supply of HALEU would be left to industry or industry would remain reliant on foreign supplies of HALEU.

Without DOE funding, the development of a domestic HALEU production capacity and acquisition of up to 290 MT of HALEU for use in reactors would be uncertain and speculative. Potential scenarios could range from (1) no significant HALEU production ever materializing, with most reactor designs and reactors continuing to rely on LEU and LEU+-based fuel that can be produced in existing facilities and other forms of energy production (e.g., fossil fuels, wind, solar, etc.), to (2) significant HALEU production eventually developing as a result of commercial and/or foreign investment.

Under the No Action Alternative, where no significant HALEU production ever materializes, existing electrical generation capacity and associated fuel sources would continue to operate. DOE would not undertake the Proposed Action or address the activities in Section 2001(a)(2)(D)(v) of the 2020 Energy Act. Traditional electricity generation sources, including LWRs, hydropower, solar, wind- and fossil-fueled plants, would continue to be relied on to supply our nation's energy demand and energy security.

Under the No Action Alternative, where HALEU production eventually develops as a result of commercial and/or foreign investment, existing electrical generation capacity and associated fuel sources would continue to operate. The timeframe for this organic development of a HALEU fuel cycle economy and subsequent replacement of existing fuel sources would be uncertain.

2.3 Reasonable Alternatives

There are no reasonable alternatives that would fulfill the purpose and need for agency action other than the Proposed Action. As discussed in Section 1.1, *Purpose and Need for Agency Action*, both DOE and industry groups have recognized that DOE action is needed to facilitate the development of the infrastructure that would support the availability of HALEU fuel to support both near-term research and demonstration needs and to support the U.S. commercial nuclear industry. Further, both DOE and the NEI recognized that the main challenge to establishing a commercial HALEU-based reactor economy is the upfront capital investment.

2.4 Alternatives Considered and Dismissed from Detailed Analysis

DOE identified the following alternative, which was considered for evaluation but ultimately dismissed from detailed study in this HALEU EIS, as discussed below.

2.4.1 Use of DOE Stockpiles

As discussed in Section 1.0.5, *Background on Current DOE and Commercial HALEU Supply*, DOE has limited capability to produce HALEU by downblending existing surplus stockpiles of HEU. This has been done in limited quantities, sometimes using commercial facilities.[50] (These facilities are operated for purposes other than downblending HEU to HALEU. Downblending can be performed by temporarily repurposing existing facility capabilities.) By one estimate, DOE could produce a total of nearly 15 MT of HALEU using this method. In addition to being insufficient to meet the Proposed Action (the acquisition of 290 MT of HALEU) and as explained in Section 1.1, *Purpose and Need for Agency Action*, this amount would not meet the needs of 8 to 12 MT/yr in the 2020s or the 50 MT/yr predicted to be needed by 2035.

Downblending HEU to produce HALEU also would not encourage the development of the commercial capability needed to foster a HALEU fuel cycle, the stated purpose and need for the Proposed Action. Once available DOE stockpiles of HEU are depleted, there would be no available source of HEU to feed the downblending process. It is unrealistic to assume that commercial vendors, looking to engage in a HALEU fuel cycle, would pursue construction and operation of downblending facilities that would operate for a limited time. Thus, the use of DOE stockpiles of HEU to produce HALEU would provide limited and, at most, short-term supplies of HALEU, which would not support commercialization.

The Energy Act of 2020 aims to stimulate HALEU supply to support the development, demonstration, and deployment of advanced reactors in a manner that establishes a diversity of supply and healthy market forces for the future and identifies commercial enrichment as a means of acquiring HALEU in a manner consistent with Section 2001(a)(2)(D)(v). Downblending of DOE stockpiles of HEU, a different production approach to producing HALEU, does not meet the purpose and need since it does not encourage the development of a commercial enrichment capability. Therefore, use of DOE stockpiles of HEU for the Proposed Action was not analyzed in this HALEU EIS.

2.5 Preferred Alternative

The Preferred Alternative is the Proposed Action, to acquire, through procurement from commercial sources, HALEU enriched to at least 19.75 and less than 20 weight percent U-235 over a 10-year period of performance, and to facilitate the establishment of commercial HALEU fuel production. The No Action Alternative would not implement the Proposed Action, leaving industry reliant on foreign supplies of HALEU and domestic commercial supply at a status quo, and would be contrary to Congressional direction under Section 2001 of the Energy Act of 2020.

[50] These activities are addressed by separate existing or pending NEPA documentation.

2.6 Summary of Environmental Consequences of the Proposed Action and No Action Alternatives

This section summarizes the potential environmental consequences associated with the activities in support of commercial production of HALEU. Environmental consequences for the HALEU fuel cycle activities are derived from the potential environmental consequences developed in previous NEPA documentation mainly for LEU fuel cycle facilities. This EIS summarizes and incorporates by reference the findings contained in previously issued NEPA evaluation documents.[51] (See Appendix A, *Environmental Consequences Supporting Information*, for activity-specific lists of NEPA documentation used to estimate impacts from each activity associated with the Proposed Action and post-Proposed Action activities.) That information was used to estimate impacts for the Proposed Action.

In the Record of Decision for this EIS, DOE expects to make a decision on whether to move forward with the Proposed Action. The Record of Decision will not select specific locations or facilities. For this reason, and to bound impacts, DOE has analyzed construction and operation of new HALEU facilities at existing uranium fuel cycle facilities (through either modification of existing facilities or construction of new facilities), other previously developed industrial (brownfield) sites, and at undeveloped (greenfield) sites.

Analytical Approach: Existing LEU facilities are approved to operate under existing NRC licenses, U.S. Department of Interior permits, and/or applicable Federal, state, and local permits and approvals. NEPA or equivalent evaluations for these facilities were previously performed and considered under those licensing, permitting, and approval action decisions. Those NEPA evaluations—the majority of which are EISs and EAs prepared by the NRC—were identified for each of the HALEU fuel cycle activities and were used to characterize the potential impacts associated with the Proposed Action.

The environmental consequences in previously issued NEPA evaluations were used in the following manner to address (1) the potential use of **existing** uranium fuel cycle facilities (modified or expanded for HALEU activities), (2) construction and operation of new HALEU facilities at existing industrial sites (**brownfield** sites), and (3) the construction and operation of new HALEU facilities at an undeveloped site (**greenfield** site). This approach was designed to cover the range of potential environmental consequences given the uncertainty regarding the facilities and locations that might be used to produce HALEU.

1. ***Existing facilities*** – LEU fuel cycle facilities perform the same activities (i.e., uranium mining and milling, and uranium conversion) or very similar activities (e.g., enrichment, deconversion, and storage) that HALEU fuel cycle facilities would be expected to perform. Evaluation of individual LEU fuel cycle facilities' existing NEPA documents indicated that the required capacities of a HALEU facility, for the Proposed Action, would be less than those corresponding LEU fuel cycle facilities that have been previously evaluated (Leidos, 2023). It is logical to infer that the potential environmental consequences of constructing and operating HALEU-related facilities would be similar to or less impactful than those existing LEU facilities. Therefore, the potential environmental consequences of construction and operation of a HALEU-

[51] Use of the available NEPA documentation for licensed fuel cycle facilities in no way is intended to indicate a preference for the use of these facilities in commercializing the HALEU fuel cycle. They provide information on the kind and significance of impacts that could be incurred through the use of an existing or new facility.

This EIS adopts the NRC impact assessment categories from most of the NEPA documents that were used as the basis for the impact analysis:

- **SMALL –** The environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
- **MODERATE** – The environmental effects are sufficient to alter noticeably, but not destabilize, important attributes of the resource.
- **LARGE** – The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

related facility were developed for this HALEU EIS from the environmental impacts analyses presented in the LEU facilities' existing NEPA documents. The resulting determination of potential impacts associated with existing sites is presented in Chapter 3, *Affected Environment and Environmental Consequences*. (Further details regarding the bases for that extrapolation are provided in Appendix A, *Environmental Consequences Supporting Information*, which includes lists of specific NEPA documents and respective impact indicators [acreages, gallons per day of operational water use, etc.] that were evaluated for each respective activity and resource.)

2. ***Brownfield sites*** – Applying similar logic, the estimated potential environmental consequences for constructing and operating a new HALEU facility on an existing industrial site (a brownfield site) were extrapolated based on the potential environmental consequences associated with construction and operation of fuel cycle facilities as presented in existing NEPA documentation. Subject matter experts for the respective resources leveraged their education, working knowledge, experience, and professional judgement to extrapolate the potential environmental consequences associated with the Proposed Action and post-Proposed Action activities using respective impact indicators, analyses, and impact assessment ratings for existing facilities in previous NEPA analysis. The resulting determination of potential impacts associated with brownfield sites is presented in Chapter 3, *Affected Environment and Environmental Consequences*.
3. ***Greenfield sites*** – As with the brownfield site evaluation, subject matter experts applied information from previous NEPA analysis for the construction and operation of existing facilities to estimate the relative difference in potential impacts of building a new facility on a site that had not been previously developed versus a brownfield or existing site. The resulting determination of potential impacts associated with greenfield sites is also presented in Chapter 3, *Affected Environment and Environmental Consequences*.

For a discussion regarding use of potentially multiple facilities for a given activity, see Section 3.8, *Potential Multiple Facilities and Simultaneous Activities*.

This Section 2.6 summarizes the potential impacts of the Proposed Action as defined in Section 2.1, *Proposed Action and Related Activities*, and for the No Action Alternative as defined in Section 2.2, *No Action Alternative*.

2.6.1 Proposed Action

The Proposed Action assumes that multiple HALEU fuel cycle activities, including mining and milling, uranium conversion and enrichment, and HALEU deconversion and storage, would occur at multiple locations with transportation of radiological material between the locations. Related HALEU fuel cycle activities (i.e., HALEU fuel fabrication, HALEU use in advanced reactors, and spent fuel storage and disposition) would also occur at multiple locations.

In general, constructing and operating modified or new HALEU fuel cycle facilities at **existing facilities** results in estimated potential environmental consequences that range from mostly SMALL to MODERATE. Most MODERATE consequences are associated with construction activities and not the HALEU operations or production-related processes.

Overall, constructing and operating new HALEU fuel cycle facilities at previously developed industrial sites (**brownfield sites**) or previously undeveloped locations (**greenfield sites**) also could result in estimated potential environmental consequences that range from SMALL to MODERATE. The MODERATE consequences are generally associated with the uncertainties of the specific characteristics (particularly the presence of ecological and historic and cultural resources) of the site relative to construction and not the HALEU operations or production-related processes. Construction activities are usually transient in nature and mitigations would be expected to be incorporated, as appropriate, to minimize potential consequences, as part of the required regulatory licensing, permitting, and associated NEPA or equivalent evaluation processes. Therefore, potential environmental consequences would likely range from SMALL to MODERATE, and LARGE potential environmental consequences are not anticipated after mitigation.

Table 2.6-1 summarizes the potential impacts of the Proposed Action for each activity.[52] The table provides impact assessments for siting of HALEU fuel cycle facilities at existing facilities, brownfield sites, and greenfield sites. In general, siting HALEU facilities at existing uranium fuel cycle sites[53] results in the lowest impact assessments. They are developed sites, with much of the infrastructure, operational controls, and other elements needed to support HALEU operations already in place. For HALEU fuel cycle facilities at developed industrial sites (i.e., brownfield sites) that are not part of the existing fuel cycle, the information in the table addresses only those resource areas that may have higher impact assessments than would be expected at the uranium fuel cycle facility sites (e.g., if traffic is assessed as having SMALL impacts for existing fuel cycle facilities and that assessment would not change for a brownfield site, then traffic is not discussed under the brownfield column). For siting new HALEU fuel cycle facilities at undeveloped (greenfield) sites, the table addresses only those resource areas that may have higher impact assessments than would be expected at the developed sites. When impacts across types of sites are identical, the entries have been combined into a single entry across multiple columns.

Most MODERATE consequences are associated with construction activities and LARGE consequences are associated with the ***uncertainties of the specific characteristics of the site*** and are related to construction and *not* the operations or HALEU production-related processes. Construction activities are usually transient in nature, and mitigations regarding construction and facility siting could be incorporated, as appropriate, as part of the regulatory licensing, permitting, and associated NEPA or equivalent evaluation processes.

Impacts information on each of the 16 resources analyzed under the Proposed Action plus transportation and post-Proposed Action activities (fuel fabrication, reactor operations, and spent nuclear fuel management) is presented in the text following the table as well as Chapter 3, *Affected Environment and Environmental Consequences*, and/or Appendix A, *Environmental Consequences Supporting Information*.

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[52] Impacts for all activities are those associated with the production and use of 290 MT of HALEU.

[53] Sites include LEU fuel cycle facility sites and fuel fabrication sites used to produce HALEU from HEU.

Table 2.6-1. Summary of Impacts

Activity	***Located at Existing Uranium Fuel Cycle Facility***	***Located at Other Non-Uranium Fuel Cycle Facility Industrial Site***	***Located on Previously Undisturbed Land***
All HALEU Activities	Overall, the potential environmental consequences are SMALL for most resource areas for most HALEU activities. Exceptions tend to be related to site-specific conditions and transient construction impacts and not to HALEU facility operations.	Overall, the potential environmental consequences are generally SMALL to MODERATE for resource areas and the MODERATE impacts are generally associated with construction, which are transient in nature and not could be expected to be identified as appropriate to minimize impacts.	Overall, the potential environmental consequences are generally SMALL to MODERATE for resource areas and the MODERATE impacts are generally associated with construction, which are transient in nature, and related to site-specific uncertainties, not operations. Mitigations would be expected to be identified as appropriate to minimize impacts and would likely limit impacts to MODERATE.
Uranium Mining and Milling [a]	Impacts to some resource areas are SMALL, but larger (MODERATE to LARGE) impacts for resource areas at specific mines are possible. Due to the rural settings of most mines, development and operations have the potential for SMALL to MODERATE impacts on traffic. Development of mines also has the potential for SMALL to MODERATE impacts on ecological resources, and historic and cultural resources and SMALL to MODERATE (existing facilities) or LARGE (industrial or undisturbed sites) impacts on socioeconomics, though with proper management these impacts may be mitigated. The impacts to some resource areas differ depending upon the mine type. In-situ recovery facilities have potentially SMALL to MODERATE impacts to land use, visual resources, noise, and accidents and SMALL to LARGE impacts on water use. Conventional mines show the potential for up to MODERATE impacts for geology and soils. One proposed conventional mine also shows potential for disproportionate and adverse effects on communities. These impacts would be expected to be SMALL to MODERATE. The MODERATE and LARGE potential environmental consequences are generally associated with site-specific conditions and temporary land-disturbing activities. Mitigation measures are expected to be identified as appropriate to minimize impacts and would likely reduce LARGE impacts to MODERATE.		
Uranium Conversion [a]	Overall, the potential environmental consequences are SMALL for all resource areas.	Additional MODERATE impacts may also be seen in the resource area of socioeconomics because of construction. Impacts would be predominately associated with construction activities and should be amenable to mitigation.	Additional MODERATE impacts may also be seen in the areas of ecological resources and historic and cultural resources. Impacts would be predominately associated with construction activities and should be amenable to mitigation.

Table 2.6-1. Summary of Impacts

Activity	*Located at Existing Uranium Fuel Cycle Facility*	*Located at Other Non-Uranium Fuel Cycle Facility Industrial Site*	*Located on Previously Undisturbed Land*
Uranium Enrichment	For an existing site or other industrial site, impacts are generally SMALL for most resources. Impacts to ecological resources, water resources and impacts driven in part by the local population have the potential for MODERATE (traffic and environmental justice) to LARGE (socioeconomics) impacts, particularly on regions with smaller populations.		At a greenfield site, MODERATE impacts may also occur to historic and cultural resources, infrastructure, and noise. Impacts would be predominately associated with construction activities and should be amenable to mitigation.
HALEU Deconversion	Overall, the potential environmental consequences are SMALL for all resource areas except socioeconomics which may have MODERATE impacts if the in-migration of workers is larger than expected (fewer local workers employed).		MODERATE impacts may also be seen as a result of construction in the areas of ecological resources and historic and cultural resources. Impacts would be predominately associated with construction activities and should be amenable to mitigation.
HALEU Storage	Construction and operation of a HALEU storage facility would disturb approximately 1 acre, there would be no routine emissions of hazardous or radioactive materials, and the facility would be operated by only a few employees; therefore, the impacts of construction and operation of such a facility would likely be SMALL for all resource areas regardless of the location.		Due to site-specific conditions at a greenfield site, there could be potentially MODERATE impacts to ecological resources and historic and cultural resources. Impacts would be predominately associated with construction activities and should be amenable to mitigation.
Transportation [(b)]	The radiological impacts from low levels of radiation emitted during incident-free transportation and from the accidental release of radioactive materials and the nonradiological impacts from accident fatalities resulting from the physical forces of the accident are SMALL for all transportation activities between HALEU fuel cycle facilities.		
HALEU Fuel Fabrication Facility	Overall, the potential environmental consequences are SMALL for land use, air quality, ecological resources, infrastructure, noise, waste management, and public and occupational health – normal operations. SMALL to MODERATE impacts were identified for visual resources, geology and soils, water resources, historic and cultural resources, public and occupational health – accidents, traffic, socioeconomics, and environmental justice. All but public and occupational health – accidents and are related to construction and site-specific		Potentially MODERATE impacts to ecological resources could result from construction at a greenfield site. Mitigative actions would be expected to be identified during site-specific environmental analyses.

Table 2.6-1. Summary of Impacts

<table>
<tr><th>Activity</th><th>Located at
Existing Uranium Fuel Cycle Facility</th><th>Located at
Other Non-Uranium Fuel Cycle Facility Industrial Site</th><th>Located on
Previously Undisturbed Land</th></tr>
<tr><td></td><td colspan="2">conditions but not fuel fabrication facility operations. Mitigative actions would be expected to be identified during site-specific environmental analyses.</td><td></td></tr>
<tr><td>HALEU Use in Reactors</td><td colspan="3">Impacts for use of HALEU in advanced reactors was evaluated for a generic site. Therefore, no distinctions are made between impacts for the three site categories applied to the Proposed Action activities. The NRC in its evaluation of the impacts of advanced reactor construction and operation (NRC, 2021c) deferred impact assessments for some resource areas to site-specific analysis. The NRC identified the impacts as undetermined due to the site-specific nature of these impacts that could not be assessed generically. Impacts in the resource areas of water resources, ecological resources, historic and cultural resources, and public and operational health – accidents were given this designation. The analysis of environmental justice impacts was also deferred to a site-specific analysis.</td></tr>
<tr><td>HALEU SNF Storage and Disposition</td><td colspan="3">At-reactor storage of HALEU SNF would have SMALL impacts for most resource areas. Because the reactor sites are unknown, there is the potential for MODERATE impacts from nonradioactive waste management and LARGE impacts on ecological resources (special status species and habitat) and historic and cultural resources. The HALEU SNF generated by activities related to the Proposed Action would not substantially add to the overall impacts of managing the nation’s inventory of SNF.</td></tr>
</table>

Key: HALEU = high-assay low-enriched uranium; NRC = U.S. Nuclear Regulatory Commission; SNF = spent nuclear fuel

Notes:

[a] Impacts are assessed based on all uranium being mined in the United States. Use of foreign-mined uranium ore or uranium hexafluoride (as allowed in the Enrichment RFP) would reduce domestic impacts proportionally to the amount of foreign material used.

[b] The transportation impacts identified in this table relate to human health impacts. Other impacts are addressed elsewhere (emissions are part of the air quality assessment for the other activities and climate change [greenhouse gas emissions] in the cumulative impacts assessment, Chapter 4, *Cumulative Effects*).

Sixteen resources are considered in this EIS:

- land use
- visual and scenic resources
- geology and soils
- water resources
- air quality
- ecological resources
- historic and cultural resources
- infrastructure
- noise
- waste management
- public and occupational health – normal operations
- public and occupational health – facility accidents
- traffic
- socioeconomics
- environmental justice
- human health – transportation

The following sections address the impacts by resource area considering the impacts of using an existing facility, construction and operation of facilities at a previously disturbed site (a brownfield site), or construction and operation of facilities at a greenfield site. These summaries address impacts relative to the Proposed Action as a whole. Individual activities are only identified when they are the reason for an impact assessment of MODERATE or LARGE. Additional information, including impacts by resource area per individual activity, can be found in Chapter 3, *Affected Environment and Environmental Consequences,* and/or Appendix A, *Environmental Consequences Supporting Information*.

2.6.1.1 Land Use

Construction of HALEU fuel cycle facilities at existing uranium fuel cycle facilities have the potential to impact 2,600 acres to 26,600 total acres. Other than mines, most individual facilities result in the disturbance of no more than a couple hundred acres. Some ISR mines could impact over a thousand acres during construction of well heads (but not all at one time, as wells are placed into and removed from service on a staggered schedule). Construction and operation would likely occur on previously disturbed land and be compatible with land use plans and zoning. Construction and operation impacts for the individual HALEU activities located at **existing fuel cycle facility** locations are estimated to be SMALL with total impacts estimated to be SMALL. However, decommissioning of ISR sites could have SMALL to MODERATE impacts related to land use due to the amount of activity and larger land area impacted compared to operation and aquifer restoration. The size of the facility is relatively independent of whether the HALEU facility would be located at an existing fuel cycle facility, an undeveloped site, or a greenfield site. The amount of land used (either temporarily disturbed or used for operation) should be relatively consistent regardless of whether the facility is located at an existing fuel cycle facility, **brownfield site**, or **greenfield site**. Impacts at all three types of sites are expected to be SMALL to MODERATE.

2.6.1.2 Visual and Scenic Resources

Construction and operation of HALEU fuel cycle facilities at existing uranium fuel cycle facilities would occur on sites of poor visual quality (Bureau of Land Management Class III or IV) and introduce visible structures to the landscape, such as drill rigs, buildings, and stacks, with the tallest substantial structures ranging from 25 feet to 160 feet. Areas of construction and operation would occur within a developed portion of the site typically surrounded by an undeveloped controlled access area providing a buffer between activities and the public. The impacts of construction and operations at **existing fuel cycle facility** sites are estimated to be SMALL, with possible MODERATE impacts at some ISR facilities and fuel fabrication facilities. Other **brownfield sites** would be expected to have similar visual characteristics as the fuel cycle facilities. Therefore, the impacts of construction and operation at these sites would be expected to be similar to the impacts of construction and operation of the facilities at existing fuel cycle sites: SMALL to MODERATE for most facilities. Although construction and operation of fuel cycle facilities at **greenfield sites** would be expected to change the visual nature of the site, the relatively small size of facilities, both in terms of footprint and height, plus the probable inclusion of controlled access areas to act as buffer zones, would not be expected to elevate the impacts beyond MODERATE.

2.6.1.3 Geology and Soils

As described in Section 2.6.1.1, *Land Use*, construction of HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** have the potential to impact 2,600 acres to 26,600 total acres. Other than mines, most individual facilities result in the disturbance of no more than a couple hundred acres. Some ISR mines could impact over a thousand acres during construction of well heads (but not all at one time, as wells are placed into and removed from service on a staggered schedule). Construction and operation of most facilities would likely occur on previously disturbed land and not result in large excavations or require large amounts of fill. Impacts for the individual HALEU activities are estimated to be SMALL to MODERATE with total impacts estimated to be SMALL to MODERATE. MODERATE impacts are related to excavation of large quantities of soil and rock during conventional mining (an impact unaffected by whether the mine is currently licensed or new), the potential to disturb contaminated soils, and the potential for soil erosion. The construction and operation at other **brownfield sites** would be expected to similarly affect previously disturbed areas. At **greenfield sites**, while quantitatively the quantities of soil and geologic material used or disturbed during mining could be larger, the small amounts required should not elevate impacts beyond MODERATE.

2.6.1.4 Water Resources

Construction of HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** would generally produce SMALL short-term (lasting months or a few years) impacts on water resources. Individual fuel cycle facilities could use from almost no water (minimal amount for HALEU storage) to up to a couple of million gallons per day (ISR mines potentially could require the most). Depending upon the number of sites, this could result in the use of millions of gallons of water per day for the Proposed Action. Impacts of the individual HALEU activities are estimated to range from SMALL to LARGE with total site impacts estimated to be SMALL to LARGE. LARGE impacts would occur only in the event of a leak or spill of lixiviant at an ISR mine, if the affected groundwater table is located close to the ground surface, is an important source of water for local domestic or agricultural uses or is hydraulically connected to other important aquifers. This possibility would be minimized through frequent monitoring of the pipeline system to quickly detect and prevent potential leaks or spills. MODERATE impacts were estimated for the UUSA enrichment facility due to limited groundwater resources available for withdrawal in the region, and both the Columbia Fuel Fabrication Facility (FFF) and GNF-A FFF sites due to the potential to disturb existing groundwater contamination. Use of best management practices (BMPs) to control and limit discharge contamination should be adequate to limit impacts. The site-specific conditions that elevated impacts to MODERATE or LARGE could be found at both **brownfield** and **greenfield sites**. Therefore, the impacts of construction and operation at other industrial sites or previously undeveloped sites would be expected to be similar.

2.6.1.5 Air Quality

Air quality impacts from construction of HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** would occur from combustive emissions due to fossil-fuel powered construction equipment and trucks and fugitive dust emissions from the operation of equipment on exposed soils. Impacts generally would be SMALL, except for the potential for fugitive dust to contribute to an exceedance of a particulate ambient air quality standard, which could result in MODERATE impacts. Implementation of standard fugitive dust control measures would be expected to mitigate fugitive dust impacts to SMALL. Air quality impacts from the operation of HALEU fuel cycle facilities mainly would occur from natural gas-fired boilers and heaters, nonradiological and radiological particulates from material processes, and the transport of materials by trucks. Adherence to facility air permit conditions for the control of both nonradiological and radiological emissions would be expected to ensure that air quality impacts from operations would be SMALL. Air quality permits would be required for the control of both nonradiological and radiological emissions applicable to any site chosen; the quantities of emissions would not change from site to site. Construction quantities could vary slightly, but the expected level of activity at brownfield and greenfield sites for the construction effort is not greatly different from that at an existing fuel cycle facility. Air quality impacts from construction and operation at other industrial (**brownfield sites**) or undeveloped (**greenfield**) sites would be expected to be similar.

2.6.1.6 Ecological Resources

Construction and operation of HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** would generally produce SMALL to MODERATE impacts (most impacted areas are already disturbed lands) on ecological resources at individual sites, although impacts at mining and milling facilities could be SMALL to MODERATE, depending upon the resources disturbed and the mitigation and minimization efforts employed. Total impacts are estimated to be SMALL to MODERATE. The impacts of construction and operation at **brownfield sites** or at **greenfield sites** would be expected to be similar to those associated with construction and operation of the facilities at existing fuel cycle sites: SMALL for most facilities. However, the potential exists for larger impacts for activities associated with the development of a greenfield site due to the unknown nature of the ecological conditions at a greenfield site. Proper site characterization and planning that takes into consideration the sensitive ecological resources in the area of the proposed facility can be used to reduce potential impacts. The magnitude of impact would depend on the size of a new facility or extension to an existing facility and the amount of land disturbance. Inventory of threatened or endangered species would be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing/avoiding adverse impacts—SMALL to MODERATE—depending on site-specific habitat and presence of threatened or endangered species.

2.6.1.7 Historic and Cultural Resources

Construction of HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** would generally produce SMALL to MODERATE (from mining and milling and fuel fabrication facility construction only) impacts on historic and cultural resources. Operation of all HALEU fuel cycle facilities would be expected to produce SMALL impacts. Total impacts are estimated to be SMALL to MODERATE at **brownfield** or **greenfield sites**, even though there is a greater potential for impacts on undiscovered historic and cultural resources. Impacts to historic and cultural resources could be mitigated through measures such as license conditions. The impacts of construction and operation at other industrial sites or previously undeveloped sites would be expected to be similar.

2.6.1.8 Infrastructure

Infrastructure impacts from the construction and operation of HALEU fuel cycle facilities at existing uranium fuel cycle facilities would occur from the potential need for new infrastructure, the demand on existing infrastructure, and the capacity of local utility providers. The intensity and magnitude of the infrastructure impact would depend on the availability and capacity of existing service networks. Existing infrastructure serving the existing fuel cycle facilities currently have excess capacity and can handle the additional anticipated demand. As such, infrastructure impacts would be SMALL during construction and operation of HALEU facilities at **existing fuel cycle facilities**. Operation of facilities would have similar infrastructure demands regardless of where the facility would be located; fuel, electricity, and water demands are relatively unaffected by location. There would most likely be existing infrastructure at a **brownfield site**. Additional demands on the infrastructure would be an incremental increase in demands and not significantly change potential impacts. Construction and operation of HALEU facilities at an undisturbed site would generate similar increases in infrastructure demand; however, the existing infrastructure may need more modifications than that required at a developed site. Access roads may need to be built, and electrical and water systems improvements (including building connections to existing infrastructure) may be more extensive than would be expected at a developed site. Additionally, the utility needs of the new HALEU facility, may adversely affect utility service to existing customers. However, the infrastructure demands for any one of the HALEU fuel cycle facilities are relatively small (contributing to the SMALL impact for HALEU facilities sited at existing fuel cycle facility locations). Considering the unknowns and the uncertainties associated with locating the HALEU fuel cycle facilities at a greenfield site, the potential impacts could be SMALL to MODERATE for uranium enrichment facilities at a **greenfield site** depending on the extent of utility infrastructure, particularly power supply systems, construction required.

2.6.1.9 Noise

Noise impacts from construction of HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** would generally result in SMALL to MODERATE, short-term (lasting months or a few years) impacts to nearby receptors, and therefore SMALL to MODERATE impacts. Operational impacts of the individual HALEU activities are estimated to range from SMALL to MODERATE. MODERATE impacts are related to traffic noise along existing roads to ISR facilities near small communities and construction of new roads. Noise impacts from construction and operation at other **brownfield sites** would be expected to be similar since the area around a developed industrial site would be expected to have similar characteristics (e.g., other noise-generating activities) to that of a fuel cycle facility site. At a **greenfield site**, the physical characteristics of a new fuel cycle facility would tend to limit impacts. The facilities are relatively small and do not generate excessively loud noises, and the noise-generating activities would occur within a small area most likely surrounded by a controlled access area. This would create a distance between the sound generation and any sound receptors (e.g., people, animals). Construction would be of limited duration and the impact transitory in nature. Noise impacts from construction and operation would be expected to range from SMALL to MODERATE.

2.6.1.10 Waste Management

Waste generated at **existing facilities** or new facilities at **brownfield** or **greenfield** sites would have SMALL impacts, both for individual HALEU fuel cycle activities and across all activities. There are no wastes with unique or problematic characteristics. All wastes have a path to disposal. Waste quantities generated represent small fractions of the commercial facilities' capacities. Separately, see the subsection entitled *HALEU Spent Nuclear Fuel Storage and Disposition* in Section 2.6.1.17, *Post-Proposed Action Activities*, for a summary of the impacts of HALEU SNF management.

2.6.1.11 Public and Occupational Health – Normal Operations

Construction of HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** would generally result in SMALL, short-term (lasting months or a few years) impacts from occupational accidents and worker doses. There would be little or no dose to the public from construction activities and therefore SMALL impacts. Based on the analysis of public and occupational health at existing fuel cycle facilities, an average worker dose from operation of the HALEU fuel cycle facilities can be expected to range from 29 millirem (mrem) per year to 1,200 mrem per year. Doses to the maximally exposed individual from operation of the HALEU fuel cycle facilities can be expected to range from 2.1×10^{-5} to 31.7 mrem per year, while total population doses would range from 4.9 person-roentgen equivalent man (rem) per year to 470 person-rem per year, with 0 (0.003 to 0.3) latent cancer fatalities (LCFs) likely. Impacts are estimated to be SMALL for the individual HALEU activities with total impacts also estimated to be SMALL. Any new fuel cycle facility would have to meet regulatory requirements for both public and operational health impacts.

The facility can be expected to have a sufficient controlled area that would be large enough to limit impacts to anyone at the site boundary. Construction at either a **brownfield site** or a **greenfield site** should not expose workers to man-made radiological hazards, so construction health impacts are limited to the same occupational hazards from any construction. Therefore, the impacts of construction and operation at other industrial sites or previously undeveloped sites would be expected to be similar to those for construction and operation at existing uranium fuel sites.

2.6.1.12 Public and Occupational Health – Facility Accidents

Accidents during construction of the HALEU fuel cycle facilities are standard industrial hazards. Impacts to workers from radiological accidents at HALEU fuel cycle facilities range from less than 10 rem to fatality resulting from an inadvertent nuclear criticality (only the involved worker/workers would be at risk for a fatality). Based on the analyses for accidents at **existing fuel cycle facilities**, impacts to the population range from less than 0.11 rem to 0.97 rem for the maximally exposed individual, and 12,000 person-rem for the off-site public with a potential 7 LCFs. Without consideration of items relied on for safety (IROFS), impacts to workers from chemical accidents range from no adverse impacts to potentially fatal impacts when exposed to hydrogen fluoride at 58,500 milligrams per cubic meter [mg/m^3] and uranium at 6,250 mg/m^3. Without IROFS, impacts to the public range from high on the basis of uranium exposure to intermediate for hydrogen fluoride exposure. With IROFS, the radiological and chemical impacts from accidents at HALEU fuel cycle facilities are expected to be SMALL to MODERATE for workers and the public. The impacts of construction and operation are driven by the types of activities performed at the fuel cycle facility and not the location of the facility. The facility can be expected to have a sufficient controlled area that would be large enough to limit impacts to anyone at the site boundary. Therefore, the impacts of accidents at other **brownfield sites** or **greenfield sites** would be expected to be similar.

2.6.1.13 Traffic

Traffic impacts from the construction and operation of HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** would occur from new daily vehicle trips on local roadways near the facilities. New vehicle trips would be generated from commuting workers and trucks transporting equipment, materials, supplies, and wastes. The additional traffic volumes on local roadways leading up to the facilities would add to existing traffic volumes and could result in increased roadway congestion, delays, and safety hazards, especially during peak commuting hours, and could decrease the operating capacity of the roadways. The intensity and magnitude of the traffic impact would depend on the level of capacity that the roadways are currently operating under. Because the majority of key roadways near the existing fuel cycle facilities currently have excess capacity (i.e., within the daily design capacity volume), and can handle the additional traffic volumes, traffic impacts would range from SMALL to MODERATE during construction and operation of HALEU facilities, as long as baseline traffic conditions do not increase substantially from current volumes. The MODERATE impacts are associated with substantial increases in traffic on rural roads near uranium mines, and increases in traffic near the enrichment and fuel fabrication facilities. Construction and operation of HALEU facilities at a **brownfield site** or at a **greenfield site** would also generate similar increases in traffic volumes and be expected to result in similar levels of impact.

2.6.1.14 Socioeconomics

Construction of all HALEU fuel cycle facilities at **existing uranium fuel cycle facilities** could employ a combined workforce ranging between 7,000 to 10,700 workers. Most individual facilities would require a construction workforce of a couple of hundred, although enrichment facility construction could require on the order of 1,000 workers. Construction impacts would be short term (lasting months or a few years). Operation of all HALEU fuel cycle facilities would employ a combined workforce ranging between 5,900 to 16,100 workers. Individual sites would require at most a couple of hundred workers. Construction and operation impacts of the individual HALEU activities are estimated to range from SMALL to MODERATE to LARGE (uranium enrichment facilities only), with combined impacts from all activities estimated to be SMALL to MODERATE. The degree of impact (e.g., on housing and public services) would be dependent on the size of the workforce, how many workers would in-migrate into the region of influence (ROI) (and bring their families), and where they choose to reside as well as their distribution within the ROI. Smaller impacts would be expected if the majority, or all, of the new hires are local (no change in population), and greater impacts (LARGE) would be expected if a large percentage of workers in-migrate to the area with their families and concentrate in the host county or a local community (or communities) with a small population. The impacts of construction and operation at **brownfield sites** or **greenfield sites** would be expected to be similar. Some socioeconomic impacts would be generally beneficial. The creation of new jobs, increased income, spending and tax revenues would similarly result in SMALL to MODERATE beneficial impacts, depending on how they were distributed through the local and regional economies.

2.6.1.15 Environmental Justice

Construction and operation of all HALEU activities at **existing uranium fuel cycle facilities** would not be expected to cause disproportionate and adverse effects to surrounding communities with environmental justice concerns. This means the ROI at existing sites either did not have minority or low-income populations or, if present, those populations did not meet or exceed 50% of the geographic population. In addition, this could mean the percentage of minority or low-income populations was not meaningfully greater than the state percentage of minority or low-income populations. Construction and operation at other **brownfield** or **greenfield sites** would require site-specific analysis to determine whether disproportionate and adverse impacts would be expected. In the absence of a site-specific analysis, resource area impacts for each activity were used to determine the degree of impact on communities with environmental justice concerns, should they exist in future project locations. Impacts were generally assessed as having no disproportionate and adverse effects, but some locations associated with mining, enrichment, and ANR activities could have disproportionate and adverse impacts (potentially MODERATE).

2.6.1.16 Human Health – Transportation

Both radiological and nonradiological transportation impacts would result from shipment of radioactive material (e.g., natural uranium and HALEU products) and wastes. Radiological impacts are those associated with the effects from low levels of radiation emitted during incident-free transportation and from the accidental release of radioactive materials. Nonradiological impacts are independent of the nature of the cargo being transported and expressed as traffic accident fatalities resulting only from the physical forces that accidents could impart to humans. Consistent with 10 CFR 51, the impacts of transporting radioactive materials for the Proposed Action in this HALEU EIS would be SMALL regardless of the location of facilities at **existing fuel cycle facilities**, **brownfield sites**, or **greenfield sites**.

2.6.1.17 Post-Proposed Action Activities

Fuel Fabrication

Fuel fabrication for the 290 MT of HALEU produced under the Proposed Action was assumed to be performed at multiple locations. Based on NEPA documentation for existing or planned fuel fabrication facilities, impacts at each facility are expected to be mostly SMALL, but as identified in Section 3.7.1, *HALEU Fuel Fabrication Facilities*, could be SMALL to MODERATE (visual and scenic resources, geology and soils, water resources, historic and cultural resources, public and occupational health – accidents, traffic, socioeconomics). Ecological resource impacts could be SMALL for **existing facilities and developed sites** to MODERATE for **greenfield sites**. The variation in impacts is due to potential differences in sites and in most cases are expected to be avoidable or amenable to mitigative actions.

Reactor Operations

For HALEU made available to members of the consortium described in Chapter 1, *Introduction and Purpose and Need*, identifying the specific reactors in which it may be used would be highly speculative. For purposes of this HALEU EIS, NRC's *Draft Generic Environmental Impact Statement for Advanced Nuclear Reactors (ANRs)* (NUREG-2249) (the "ANR GEIS") (NRC, 2021c) was examined for information on potential impacts from operation of reactors that might use HALEU fuel. The impacts information in the ANR GEIS was used to develop potential impacts associated with the use of HALEU fuel and summarized in Section 3.7.2, *HALEU-Fueled Reactors*. Generically, impacts of reactor operations have been identified as mostly SMALL, but for those areas for which the GEIS could not make that determination, site-specific analysis for each proposed commercial reactor would be required. While not stated in the ANR GEIS, the implication is that without appropriate mitigation or control, these impacts (water resources, ecological resources, historic and cultural resources, and public and occupational health – both normal operations and accidents) could be MODERATE to LARGE.

The impact of future reactor operations on the emissions of greenhouse gases (GHGs) is discussed in Section 2.7.1.3, *Global Cumulative Effects*.

HALEU Spent Nuclear Fuel Storage and Disposition

As described in Section 2.1.7.3, *HALEU Spent Nuclear Fuel Storage and Disposition*, HALEU SNF on-site storage is assumed to occur at the reactor generating the SNF. Off-site storage and disposition is assumed to occur at the future facilities that would be used for consolidated storage and disposition of the much larger quantity of existing commercial power reactor SNF. As discussed in Section 3.7.3.1, *Storage of Spent Nuclear Fuel at the Reactor*, at-reactor storage of SNF would have SMALL impacts for most resource areas, but there is the potential for MODERATE to LARGE impacts on special status species and habitat, historic and cultural resources, and from nonradioactive waste management. See Section 3.7.3.1 for more information.

The Proposed Action activities would generate about 290 MT of HALEU SNF. This is 0.4% of the 86,584 MT of heavy metal SNF in inventory in the United States in 2021 (DOE, 2021, p. 2). Therefore, the HALEU SNF generated by the activities related to the Proposed Action would not substantially add to the overall impacts of managing the nation's inventory of SNF.

2.6.1.18 Effects Associated with Use of Foreign Fuel Cycle Facilities

The Enrichment RFP allows for the use of foreign-mined yellowcake, UF_6 produced at a foreign conversion facility, and uranium enriched to less than 5% in U-235 produced at a foreign enrichment facility. The degree to which domestic environmental impacts of the Proposed Action would be reduced by use of these foreign capabilities depends upon the extent to which material is supplied from foreign sources. A complete reliance on foreign yellowcake (eliminating the use of domestic mining and milling capabilities) would eliminate domestic environmental impacts associated with these activities. Similarly, a complete reliance on foreign UF_6 (eliminating both domestic mining and milling and domestic conversion) would eliminate domestic environmental impacts associated with these activities. Finally, the reliance on foreign UF_6 enriched to less than 5% would also reduce, but not eliminate, the impacts from domestic enrichment activities.

The use of foreign capabilities also affects the impacts from transporting material between facilities. The transportation analysis considered the use of foreign conversion capabilities and concluded that there was little difference in domestic impacts between transporting UF_6 from the Metropolis facility or foreign conversion facilities to the enrichment facilities. While not specifically analyzed, impacts from the shipment of enriched UF_6 from foreign suppliers should not adversely affect transportation impacts. Impacts of shipping UF_6 from one domestic enrichment facility to another is evaluated in this EIS. While specific transportation routes would differ, these differences (e.g., route distance) should not significantly affect impacts. The number of shipments and the containers used to ship the UF_6 should be the same for shipments from foreign sources versus between domestic enrichment facilities. Additionally, use of foreign UF_6 would reduce or eliminate domestic transportation impacts from the shipment of yellowcake to a conversion facility.

A partial use of foreign capabilities would have a commensurate reduction in domestic impacts. The more yellowcake imported results in fewer domestic mines and lower capacity demands on domestic milling operations. The impacts from conversion are not as noticeable since a single conversion facility could convert yellowcake into a sufficient amount of UF_6 to support the Proposed Action. If only some of the yellowcake were to be imported, many of the impacts from operation of a U.S. conversion facility would not be different (e.g., impacts to resources such as land use, geology and soils, ecological resources, and historic and cultural resources). Others may be reduced commensurate with the amount of material imported. The most notable reduction in domestic impacts from using foreign sources of uranium would be the reduction of the domestic impacts of mining uranium. Impacts associated with mining can range from SMALL to LARGE and impacts in each resource area are very dependent upon the type of mine (conventional mine and mill or ISR facility), the number of mines, and the location of the mines (site-specific differences are largely responsible for the large range of impacts associated with mining activities). Similarly, using foreign sources of UF_6 would reduce the domestic impact of mining, uranium conversion, and enrichment (if enriched uranium is produced in foreign nations). Use of foreign sources of UF_6 could result in a reduction of the impacts associated with conversion, which are SMALL when using an existing facility, with some potential MODERATE impacts associated with construction and operation of a new facility.

2.6.2 No Action Alternative

Under the No Action Alternative, DOE would not address the activities in Section 2001(a)(2)(D)(v) of the 2020 Energy Act. DOE would not acquire, through procurement from commercial sources, up to 290 MT of HALEU nor facilitate the establishment of commercial HALEU fuel production. Without the implementation of the Proposed Action, the future availability of HALEU would be uncertain and speculative. Potential scenarios could range from (1) no significant HALEU production ever materializing, with most reactor designs and reactors continuing to rely on LEU and LEU+-based fuel that can be produced in existing facilities and other forms of energy production (e.g., fossil fuels, wind, solar, etc.), to (2) significant HALEU production eventually developing as a result of commercial and/or foreign investment unaided by DOE.

Under the scenario where no significant HALEU production materializes, there would be no immediate change to the status quo. Existing electrical generation capacity would continue to operate. Traditional electricity generation sources, including LWRs, hydroelectric, solar, wind and fossil-fueled plants, would continue to be relied on to supply our nation's energy demand and energy security.

This could have adverse impacts on meeting GHG reduction goals.[54] The full-lifecycle GHG emissions of coal and natural gas-power generation sources are substantially higher than for nuclear power. For instance, coal generates 820 grams (g) of carbon dioxide equivalent (CO_2e) per kilowatt-hour (g CO_2e/kWh) of

[54] The White House National Climate Task Force has leadership responsibility to implement President Biden's climate change goals including up to a 52% reduction in GHG emissions by 2030 and reaching 100% clean (carbon-free) electricity by 2035.

electricity, while natural gas produces 490 g CO_2e/kWh. Even hydroelectric and solar produce lifecycle emissions at 24 g CO_2e/kWh and 41 g CO_2e/kWh, respectively. In contrast, nuclear power produces 12 g CO_2e/kWh (Schlömer et al., 2014). Therefore, using coal or natural gas (and even hydroelectric and solar) to generate electricity would result in higher GHG emissions. Those higher GHG emissions from non-nuclear power could contribute to a greater rate of climate change.

If significant HALEU production and use were to eventually develop as a result of commercial and/or foreign investment unaided by DOE, the impacts of that production could be similar to the impacts evaluated in this EIS for a similar level of HALEU production and use.

2.7 Summary and Comparison of Cumulative Effects

NEPA established the CEQ to oversee Federal environmental impact regulations. The Council on Environmental Quality defines cumulative effects as "effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.1(g)(3)). This section summarizes the more detailed cumulative impacts analyses presented in Chapter 4, *Cumulative Effects*.

Cumulative effects are typically evaluated by combining the effects of a proposed action with the effects of other past, present, and reasonably foreseeable actions[55] in the ROI.[56] These other actions include on-site and off-site projects conducted by Federal, state, and local governments, the private sector, or individuals, that are within the ROIs of a proposed action.

The HALEU activities described in Chapter 2, *Proposed Action and Alternatives to Support HALEU Production and Utilization*, Section 2.1, *Proposed Action and Related Activities*, are likely to be geographically separated and have different ROIs. Therefore, the impacts at one location would not generally be cumulative with the impacts at another location.

Many of the activities evaluated in this HALEU EIS have existing NEPA documentation for LEU operations that are either directly applicable or similar to the potential HALEU fuel cycle activity. Most, but not all, of those NEPA documents contain cumulative impacts analyses for the specific facilities and locations (see the activity-specific sections of Appendix A, *Environmental Consequences Supporting Information,* as well as Appendix B, *Facility NEPA Documentation*). Generally, these assessments mirrored the impacts associated with the activity being analyzed in the document. Resource areas with SMALL impacts from the proposed activity tended to have SMALL cumulative impacts. Similarly, resource areas with MODERATE or LARGE impacts did as well. However, while generally true, it is not possible to extrapolate that analysis to sites where no cumulative effects analysis has been performed. Because of the large number of activities and potential facilities evaluated in this HALEU EIS and the uncertainty of the numbers and locations of facilities, a cumulative effects analysis for most activities under the Proposed Action in this HALEU EIS would be speculative and not amenable to detailed analysis at this time. DOE expects that new or modified HALEU production facilities that would be licensed and subject to additional NEPA or equivalent state evaluation would include consideration of cumulative impacts by the NRC, an Agreement State, or other Federal agencies.

[55] Reasonably foreseeable, as defined in 40 CFR 1508.1(aa), "means sufficiently likely to occur such that a person of ordinary prudence would take it into account in reaching a decision."

[56] The ROI is the geographic area over which past, present, and reasonably foreseeable future actions could contribute to cumulative impacts and is dependent on the type of resource analyzed.

2.7.1 Nationwide and Global Commons Effects

There are some effects that are relatively independent of the location of the facilities needed to implement the Proposed Action and the associated activities. SNF would be created by the use of up to 290 MT of HALEU in reactor fuel. This fuel would contribute to the existing SNF inventory from operating commercial LWRs. GHG generation is a function of the materials used (principally the burning of fossil fuels) and not where the materials are used. Transportation impacts (GHGs emitted) are dependent upon the quantity of material being shipped and the distances this material is shipped. The location of facilities does impact the miles traveled, which impacts the quantity of GHGs generated. However, the same assumptions used in the transportation health impact analysis would provide a conservative estimate of GHG generation. The generation of ozone-depleting materials is a function of the types of activities and materials used, not location. The following sections discuss these impacts.[57] Additionally, ozone depletion and GHG generation have impacts that are global in nature and not limited to a facility's local ROI.

2.7.1.1 Cumulative Effects of HALEU Spent Nuclear Fuel Storage and Disposition

As described in Section 2.1.7.3, *HALEU Spent Nuclear Fuel Storage and Disposition,* HALEU SNF on-site storage is assumed to occur at the reactor that generates the SNF. Off-site storage and disposition is assumed to occur at the facilities used for consolidated storage and disposition of the much larger quantity of existing commercial power-reactor SNF. The total HALEU SNF generated by the Proposed Action would contain 290 MT of HALEU. This is 0.4% of the 86,584 MT of heavy metal SNF inventory in the United States in 2021 (DOE, 2021, p. 2). Therefore, the HALEU SNF generated over multiple years of reactor operation would not substantially contribute to cumulative impacts of managing the nation's inventory of SNF.

2.7.1.2 Cumulative Effects of Transportation

As described in Section 2.1.6, *HALEU Transportation*, HALEU activities would require the transportation of radioactive materials between the facilities associated with HALEU production. The impacts of transportation of these materials are presented in Section 3.6, *Transportation*. Cumulative transportation impacts are described in more detail in Section 4.2, *Nationwide Radioactive Materials Transportation*.

The assessment of cumulative transportation effects of transportation throughout the United States addressed the potential radiation exposure to transportation workers and the general population. Cumulative radiological impacts from transportation are estimated using the dose to the workers and general population because dose can be directly related to LCFs using a cancer risk coefficient.

The total number of LCFs (among the workers and the general population) estimated to result from all radioactive material transportation over the period between 1943 and 2090 is about 523, or an average of about 4 LCFs per year, from exposures of about 6,000 person-rem per year[58] (DOE, 2022). Over the 6 years of plant operations associated with the Proposed Action, over 3.5 million people are projected to die from cancer, based on National Center for Health Statistics data. The annual number of cancer deaths in the United States in 2019 was about 599,600 (CDC, 2021). The total worker and public dose from transportation activities associated with the Proposed Action would be about 100 person-rem with an expected LCF of 0.06 for the entire duration of the effort. The transportation-related LCFs would be indistinguishable from the natural fluctuation in the total annual death rate from cancer.

[57] For GHG impacts, no comparison is made between the GHG generated by the Proposed Action plus associated activities and annual U.S. or global GHG emissions. As with most projects, due to the size of annual global and U.S. GHG emissions, such a comparison does not provide any significant insight.

[58] Total LCFs are calculated assuming 0.0006 LCFs per person-rem of exposure (DOE, 2003).

2.7.1.3 Global Cumulative Effects

Ozone Depletion

Construction and operation activities associated with the Proposed Action and related activities are expected to be accomplished using materials and equipment that would be compliant with applicable ozone-depleting substances (ODSs) laws and regulations. The activities are not expected to use substantial quantities of ODSs, as regulated under 40 CFR 82, *Protection of Stratospheric Ozone*. Emissions of ODSs would be very small and would represent a negligible contribution to the destruction of Earth's protective ozone layer.

Greenhouse Gases and Climate Change

Recent scientific evidence indicates a correlation between increasing global temperatures over the past century and the worldwide proliferation of GHGs emitted by mankind. Climate change associated with this global warming is predicted to produce negative environmental, economic, and social consequences across the globe (USGCRP, 2018; IPCC, 2023).

Observed changes due to global warming include rising temperatures, shrinking glaciers and sea ice, thawing permafrost, sea level rise, a lengthened growing season, increases in droughts and severe weather, and shifts in plant and animal ranges. Predictions of long-term environmental impacts due to increased atmospheric GHGs include an increasing rate of sea level rise, changing weather patterns (e.g., increases in severity of storms and droughts), reductions in winter snowpacks, changes in local and regional ecosystems (with potential losses of species), and increases in mortality due to excessive heat and air pollution (USGCRP, 2018; IPCC, 2023).

The direct environmental effect of GHG emissions is an increase in global temperatures, which indirectly causes numerous environmental and social effects. Therefore, the ROI and potential effects of GHG emissions from the Proposed Action and related activities are by nature global and cumulative.

It is unknown at this time where the various Proposed Action activities would take place across the United States. Therefore, to provide a bounding analysis of potential GHG emissions, low- and high-emission scenarios were developed for the cumulative Proposed Action activities and the related post-Proposed Action activity of fuel fabrication and reactor operations. Emissions from the Proposed Action (construction and operations of facilities and inter-site transportation) and related activities would occur over a period of up to 10 years (except up to 60 years for advanced reactors operations with the use of HALEU fuel) and could add between 774,000 to 2.91 million MT of CO_2e to global GHG emissions.

Offsetting the CO_2e emissions from the Proposed Action and related activities would be the expected reduction of CO_2e emissions if the power produced were from reactors fueled by the up to 290 MT of HALEU instead of power produced by existing electrical power generation sources within regions across the United States. The total electrical power that could be generated by advanced reactors with the use of HALEU fuel produced under the Proposed Action is estimated to be roughly 50 gigawatt-years (electricity), or 438,000,000 megawatt-hours (MW-h). Total CO_2e emitted from the generation of roughly 438,000,000 MW-h by existing electrical power generation sources could range from a low of 48.2 million MT to a high of 328.5 million MT, depending upon the mix of current generation capabilities assumed. These estimates reveal that electrical power generated by HALEU-fueled ANRs would result in between 47.4 million and 326 million MT lower CO_2e emissions, compared to power generated from the combination of existing non-nuclear sources.

The social cost of GHG (SC-GHG) is the monetary value (in U.S. dollars) of the net harm to society associated with adding GHG emissions to the atmosphere (IWG, 2021). In principle, it includes the value of all climate change impacts, including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The estimated SC-GHG for the Proposed Action and associated activities would range from $13 million to $485 million. Offsetting this cost could be the SC-GHG savings associated with using the HALEU from the Proposed Action in reactors.

2.7.2 Effects of Climate Change on the Proposed Action Activities

Change in resilience is the effect of climate change on a proposed project. There are anticipated future climate change and environmental impacts for regions of the United States that encompass the potential locations of proposed activities (USGCRP, 2018). Current operations at facilities that could be used in support of the Proposed Action generally have adapted to their changing climates. However, exacerbation of these conditions in the future could impede proposed activities during extreme events.

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Chapter 3

Affected Environment and Environmental Consequences

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3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.0 Introduction

In accordance with the CEQ NEPA regulations (40 CFR 1500–1508), Chapter 3 of this HALEU EIS describes the affected environment and potential environmental consequences associated with the Proposed Action as defined in Section 2.1, *Proposed Action and Related Activities* (see Section 3.1, *Uranium Mining and Milling*, through Section 3.6, *Transportation*). This chapter also presents the environmental consequences of related post-Proposed Action activities (Section 3.7) and potential multiple facilities and simultaneous activities (Section 3.8). Additionally, Chapter 3 includes discussions of nonproliferation and terrorism concerns (Section 3.9), the No Action Alternative (Section 3.10), and potential mitigation measures (Section 3.11).

As previously discussed, the selection of specific locations and facilities will not be a part of the Record of Decision for this EIS, so affected environment discussions, which are usually site specific, are not broken out as separate sections in this chapter. Instead, relevant affected environment information and potential environmental consequences are presented together in sections dedicated to the respective resource areas under each Proposed Action activity.

To determine the potential environmental consequences without knowing which exact locations and facilities would be chosen or developed, DOE considered a range of potential locations in this analysis, including **existing uranium fuel cycle facilities** and potential new facilities on previously developed industrial sites (**brownfield sites**) or previously undeveloped sites (**greenfield sites**).

> Regardless of the type of site ultimately chosen for HALEU facilities, a site-specific NEPA evaluation (or its state equivalent) would be completed by the NRC, an Agreement State, and/or other Federal agency (e.g., Bureau of Land Management) before a new HALEU fuel cycle facility could be constructed or operated.

As discussed in Chapter 2, Section 2.1.1, *Uranium Mining and Milling*, through Section 2.1.7, *Related Post-Proposed Action Activities*, HALEU fuel cycle facilities could be located at **existing uranium fuel cycle facilities**, either via existing capacity or via modification/expansion. In many instances, relevant NEPA documents already exist for LEU fuel cycle facilities, and the analysis in those NEPA documents was utilized to evaluate the potential environmental consequences of locating similar HALEU fuel cycle facilities at various existing fuel cycle facilities. New HALEU fuel cycle facilities could also be located at previously developed industrial sites (also known as **brownfield sites**) or at undeveloped sites (also known as **greenfield sites**).

Because the specific locations of the Proposed Action HALEU facilities cannot be determined at this time, existing NEPA documents for uranium facilities[59] were analyzed to extrapolate what potential environmental consequences could occur during the construction and operation of HALEU facilities. In

[59] Existing facilities that produce uranium are approved to operate under existing NRC licenses, U.S. Department of Interior permits, and/or applicable Federal, state, and local permits and approvals. NEPA or equivalent evaluations for these facilities were previously performed and considered under those licensing, permitting, and approval action decisions. Those NEPA evaluations—the majority of which are EISs and EAs prepared by the NRC—were identified for each of the HALEU fuel cycle activities and were used to characterize the potential environmental consequences associated with the Proposed Action.

some cases, the NEPA documents covered the construction and operation of a totally new facility, which provided insight into what the potential environmental consequences associated with locating at a brownfield or greenfield site might be.

When referring to the degree of environmental impact, this EIS uses the same impacts assessment rating terminology from the existing NEPA evaluations to the extent possible. For reference, the NRC generally defines environmental consequences as:

- SMALL: The environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
- MODERATE: The environmental effects are sufficient to alter noticeably, but not destabilize, important attributes of the resource.
- LARGE: The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

Therefore, DOE has generally adopted the NRC's environmental consequences definitions for this EIS, with a few exceptions for NEPA evaluations that were prepared by other agencies. Another commonly used impact assessment term is "No Significant Impact." An impact that is not significant does not equate to "no impact" but is typically regarded as SMALL.

An exception to the NRC's environmental consequence terminology is DOE's inclusion of new environmental justice impact terminology as required by Executive Order 14008 and amended by Executive Order 14096. These Executive Orders update the definition of environmental justice, the methodology for determining disproportionate and adverse impacts, as well as the language used to describe impacts on communities with environmental justice concerns. Therefore, to ensure the analysis in this EIS meets the most current environmental justice policies, DOE used existing NEPA documents to determine a project's ROI and conducted an analysis based on the most recent Executive Order requirements. The terminology to describe environmental justice impacts in this EIS is "disproportionate and adverse" as opposed to the preceding description, "disproportionately high and adverse." Any other exceptions are noted where applicable.

3.0.1 Assumptions

Additional assumptions for estimating impacts at **existing facilities**, **brownfield sites**, and **greenfield sites** are described in this section.

DOE assumes that NRC regulations for siting, construction, and operation of new uranium fuel cycle facilities, and other applicable regulations for siting, construction, and operation of other industrial facilities, would be followed regardless of the site. The siting regulations would likely result in avoidance of earthquake and land subsidence prone locations, and locations with substantial wetlands or floodplains. In addition, construction and operations at all sites are assumed to be conducted in compliance with applicable regulations including regulations for building construction, worker and public health and safety, air and water effluents, and waste management. These regulations would help to limit environmental impacts regardless of location.

Operational activities at any of the HALEU fuel cycle facilities would generally not be affected by the location of the facility. Impacts associated with facility operations would result from the processes needed to perform the activity (i.e., uranium conversion, enrichment, etc.), not where the activity is being performed. Resource requirements for facility operation are largely independent of site. The availability of those resources may vary from site to site, but that variability is not generally the major driver of environmental consequences. Therefore, operation impacts generally would be similar regardless of the siting scenario (i.e., similar impacts would occur at existing facilities, brownfield sites, and greenfield sites). Exceptions are described in the sections below.

Activity-specific assumptions are discussed in the introductory text for each activity in Section 3.1, *Uranium Mining and Milling*, through Section 3.7, *Related Post-Proposed Action Activities*. Additional general assumptions are outlined below.

Existing Facilities/Sites: Section 2.1, *Proposed Action and Related Activities*, describes existing commercial uranium fuel cycle facilities (existing facilities) that could be used for uranium mining and milling, and uranium conversion activities, or modified for uranium enrichment and uranium deconversion activities for the Proposed Action. Other existing commercial uranium fuel cycle facilities could be used (e.g., SNF storage) or modified (e.g., reactor fuel fabrication facilities) for the post-Proposed Action activities. Existing NEPA documents for these fuel cycle facilities were used to develop the impacts for construction and operation of HALEU fuel cycle facilities at existing sites.

DOE conservatively assumed that the HALEU fuel cycle facilities would require a full complement of support facilities and structures. However, if a HALEU fuel cycle facility was constructed at an existing uranium fuel cycle facility or industrial site with existing site infrastructure, many of the support facilities (e.g., office buildings, warehouses, parking facilities) and much of the infrastructure (e.g., security, utilities, and waste management facilities) would likely be used to support the new HALEU fuel cycle facility along with existing activities. Therefore, analyzing construction and operation of a new HALEU fuel cycle facility would likely overestimate (bound) the impacts of locating this facility at an existing site or industrial site.

Other Industrial (Brownfield)[60] Sites: For most resource areas, the impacts of construction at brownfield sites are likely to be similar to construction at existing facilities. This is based on the following assumptions.

DOE assumes, as a point of comparison between brownfield and greenfield sites, that the land at brownfield sites has recently been disturbed such that native soils and vegetation are no longer present. It was assumed the industrial nature of brownfield sites makes them unlikely to contain substantial surface water, wetlands, sensitive habitats, threatened, endangered and other sensitive species, and likely to have been previously evaluated for historic and cultural resources. In addition, brownfield sites are assumed to be relatively close to a population center, be serviced by a roadway, and have nearby utility hookups. As a result, unless otherwise stated, the impacts of construction and operation at brownfield sites were considered to be similar to existing facilities.

One exception to these assumptions is impacts on communities with environmental justice concerns. Environmental justice impacts would be dependent on local and regional conditions of a proposed site, the potential adverse effects, and the presence of communities with environmental justice concerns in the ROI. Analysis of construction and operation impacts at a brownfield site would require site-specific analysis to determine whether disproportionate and adverse impacts would be expected. In the absence of site-specific information, resource area impacts for each activity were used to determine the degree of potential impacts on communities with environmental justice concerns, should they exist in future project locations. Therefore, when resource area impacts are generally expected to be SMALL, it is reasonable to assume resource area impacts on communities with environmental justice concerns would also be SMALL at a brownfield site. DOE expects that site-specific environmental justice analysis would be considered as part of the licensing process for any new facility by the NRC, Agreement States, or other Federal agencies.

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[60] Brownfield sites could contain hazardous substances, pollutants, or other industrial contamination, which are expected to be addressed and remediated on a site-specific basis.

Undeveloped (Greenfield) Sites: Construction at greenfield sites generally would have a higher potential for impacts than at existing facilities or brownfield sites. This is based on the following assumptions, which indicate that greenfield sites are, in most cases, more sensitive to environmental disturbance than existing facilities and brownfield sites.

DOE assumes land at greenfield sites have not been previously disturbed, or were disturbed long ago, such that native plants and soils are substantially established on the site. The undisturbed and undeveloped nature of greenfield sites makes it more likely that wetlands, sensitive habitats, threatened, endangered and other sensitive species, and historic and cultural resources may be present. Additionally, greenfield sites are assumed to be farther from population centers, need development of an access roadway, and have utilities at a greater distance from the site. Despite their undisturbed nature, it is still expected that they would be relatively accessible to population centers with access to workers and supporting infrastructure requirements. As a result, unless otherwise stated, impacts caused by construction at greenfield sites were typically higher than existing facilities and brownfield sites.

Environmental justice impacts would be dependent on local and regional conditions of a proposed site, the potential for adverse effects, and the presence of communities with environmental justice concerns in the ROI. Construction and operation at a greenfield site would require site-specific analysis to determine whether disproportionate and adverse impacts would be expected. In the absence of site-specific information, resource area impacts for each activity were used to determine the degree of potential impacts to communities with environmental justice concerns, should they exist in future project locations. Therefore, when resource area impacts are generally expected to be SMALL, it is reasonable to assume resource area impacts on communities with environmental justice concerns would also be SMALL at a greenfield site. DOE expects that site-specific environmental justice analysis would be required as part of the licensing process for any new facility by the NRC, Agreement States, or other Federal agencies.

3.0.2 Organization of this Chapter

While impacts for 16 resource areas were considered in this EIS, only the resource areas with potentially MODERATE or LARGE impacts associated with at least one of the three siting scenarios (i.e., existing facility, brownfield site, or greenfield site) are presented under each Proposed Action and post-Proposed Action activity in Chapter 3 to focus the discussion on impacts that would need to be considered by DOE decision-makers.

This approach provides a range of potential environmental consequences for a range of possible facility locations while focusing on the more significant information for the decision-makers to consider and is consistent with CEQ NEPA regulations (40 CFR 1502.2(b)) that states: "Environmental impact statements shall discuss impacts in proportion to their significance. There shall be only brief discussion of other than significant issues," and (40 CFR 1502.15) that states: "Data and analyses in a statement shall be commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced. Agencies shall avoid useless bulk in statements and shall concentrate effort and attention on important issues." As well as the DOE NEPA guidance (DOE, 2004a) that states: "When applying the sliding-scale approach to NEPA analysis, the preparer should analyze issues and impacts with the amount of detail commensurate with their importance. Proposals with clearly small environmental impacts usually will require less depth and breadth of analysis either in identifying alternatives or analyzing their impacts."

See Appendix A, *Environmental Consequences Supporting Information*, for information on resources with SMALL impacts. DOE thoroughly reviewed the analysis in relevant NRC existing NEPA documents (Leidos, 2023) and agrees with the NRC justifications for SMALL impacts. For the NRC's full analysis of SMALL impacts, see the relevant NEPA documents, which are incorporated by reference and listed for each specific activity in Appendix A.

The sections in this chapter describe the environmental consequences of construction and operation of one HALEU facility per activity. As described in Section 2.1, *Proposed Action and Related Activities,* under the Proposed Action, multiple facilities could be constructed and operated for each of the HALEU activities (e.g., enrichment, deconversion). In addition, multiple facilities for different activities could be located at a single site. For example, HALEU enrichment, HALEU deconversion, and HALEU storage facilities could be co-located. The possibility of multiple facilities and/or co-location of HALEU facilities is discussed in Section 3.8, *Potential Multiple Facilities and Simultaneous Activities.*

3.1 Uranium Mining and Milling

To produce 50 MT/yr of HALEU, approximately 2,500 MT of U_3O_8 would need to be produced. If all uranium was mined through conventional methods, and assuming an ore composition of 0.1%, this would correspond to 2.6 million MT/yr of uranium-bearing ore needing to be mined. To achieve production of 290 MT of HALEU, approximately 14,600 MT of U_3O_8 and 15.4 million MT of uranium-bearing ore would need to be mined.

This EIS considers two main uranium extraction methods: ISR mining and conventional mining and milling. NEPA documentation for both methods is available as mines and mills have been utilized for uranium recovery as part of the LEU fuel cycle (see Appendix A, *Environmental Consequences Supporting Information*, and Appendix B, *Facility NEPA Documentation*). The function and operation of these facilities is identical in both the LEU and HALEU fuel cycle. Ore is extracted and processed to produce the same yellowcake needed as feed material for the conversion facility. The only difference is the amount of ore and yellowcake required to produce equivalent quantities of LEU and HALEU (roughly four times more for HALEU than LEU at about 5%). In this analysis, that difference is addressed by the number of mines necessary to recover the uranium ore. This discussion does not address SMALL impact ratings for either extraction method. For example, if ISR mining had potentially MODERATE impacts but conventional mining and milling had SMALL impacts, only ISR would be discussed. As a result, conventional milling is not discussed further in this section. The White Mesa Uranium Mill located in San Juan County, Utah, is currently the only operating mill in the United States. Operations would occur within the existing facility and no additional construction activities associated with continued operation, other than the potential construction of new lined tailings impoundments, would be expected. Additional impacts would be considered SMALL across all resource areas due to the disturbed nature of the site. For full analysis of impacts, see the incorporated NEPA documents listed in Appendix A, Section A.1.2.2, *Existing NEPA Documentation*.

This HALEU EIS analyzed the impacts of existing mines in addition to construction of new mines across a variety of site conditions. To accommodate unknown project locations, this analysis differentiates impacts between existing sites, brownfield sites,[61] and greenfield sites. The basis for all impact ratings, including SMALL, were developed from the source documents listed in Appendix A, Section A.1.2.2, *Existing NEPA Documentation*. Additional details on the impacts of uranium mining and milling are presented in Appendix A, Section A.1, *Uranium Mining and Milling.* Table 3.1-1 presents a summary of environmental consequences associated with uranium mining and milling. After the table, see Section 3.1.1, *Land Use*, through Section 3.1.11, *Environmental Justice*, for summaries of the impacts

[61] Brownfield in this instance implies a region that has previously been utilized for mining operations other than uranium mining.

associated with the respective resources that were determined to have potentially MODERATE or LARGE impacts.

Table 3.1-1. Summary of Environmental Consequences – Uranium Mining and Milling

Activity	*Located at Existing LEU Fuel Cycle Facility*	*Located at Other Non-Uranium Fuel Cycle Facility Industrial Site*	*Located on Previously Undisturbed Land*
Uranium Mining and Milling	Impacts to some resource areas are SMALL, but larger (MODERATE to LARGE) impacts for resource areas at specific mines are possible. Due to the rural settings of most mines, development and operations have the potential for SMALL to MODERATE impacts on traffic. Development of mines also has the potential for SMALL to MODERATE impacts on ecological resources, and historic and cultural resources and SMALL to MODERATE (existing facilities) or LARGE (industrial or undisturbed sites) impacts on socioeconomics, though with proper management these impacts may be mitigated. The impacts to some resource areas differ depending upon the mine type. In-situ recovery facilities have potentially SMALL to MODERATE impacts to land use, visual resources, noise, and accidents and SMALL to LARGE impacts on water use. Conventional mines show the potential for up to MODERATE impacts for geology and soils. One proposed conventional mine also shows potential for disproportionate and adverse effects on communities with environmental justice concerns. These impacts would be expected to be SMALL to MODERATE. The MODERATE and LARGE potential environmental consequences are generally associated with site-specific conditions and land-disturbing activities, which are transient in nature. Mitigations are expected to be identified as appropriate to minimize impacts and would likely reduce LARGE impacts to MODERATE.		

Key: LEU = low-enriched uranium

3.1.1 Land Use

Impacts on land use are expected to range from SMALL to MODERATE during the decommissioning phase of **existing ISR mines**. This is due to land disturbance caused by an increased use of earth- and material-moving equipment and other heavy machinery during the reclamation process. This impact is expected to be temporary and would not extend beyond the decommissioning phase. The impacts of construction and operation at a **brownfield site** would be expected to be similar as those for existing mines as the size of the facility, the production rate, and its location in the uranium production regions, would likely be within the bounds of the existing facilities that were evaluated in the available NEPA documents. Construction and operation at a **greenfield site** would likely be similar to the impacts described for brownfield facilities with minor variation in decommissioning intensity to restore the land back to its previous use (i.e., undeveloped).

3.1.2 Visual and Scenic Resources

Impacts on visual and scenic resources would be SMALL to MODERATE at **existing ISR facilities.** These impacts would primarily occur during construction and well field development, where vertical drilling rig masts contrast with the existing topography. The visual impacts of construction and operation at a **brownfield site** would be expected to be similar as those for existing mines because of the characteristics of brownfield sites. Construction and operation at a **greenfield site** could have SMALL to MODERATE impacts to visual disturbances even though impacts may be more pronounced in rural, previously undeveloped areas where the baseline visual landscape is less disturbed. The amount of disturbance is relatively small as ISR structures do not encompass a large area and are usually less than 100 feet tall. Vegetation clearing and introduction of drilling rigs and roadways could also result in visual contrasts with the baseline landscape.

3.1.3 Geology and Soils

The general impacts to geology and soils from conventional mine construction and operation at **existing facilities** range from SMALL to MODERATE. Construction and operation impacts to geology and soils from **existing conventional mines** would be highly site dependent and largely based on the type, size, and local characteristics of the mine. Impacts to geology and soils from exploration are typically SMALL but larger amounts of rock removed from the geological formation during construction and operations would be more likely to cause permanent changes to the geological formation and could be MODERATE. These impacts could be mitigated through following of BMPs such as implementing a spill prevention plan, use of erosion and sedimentation control, and proper reclamation activities after the end of the operations phase. The impacts of construction and operation at a **brownfield site** would be expected to be similar to those for existing facilities because of the previously developed and disturbed nature of the site. In addition to the impacts described under the existing facilities scenario, construction and operation at a **greenfield site** could have MODERATE impacts related to soils due to increased susceptibility to erosion, and therefore runoff, with the loss of vegetation.

3.1.4 Water Resources

Although generally ISR mining impacts on groundwater and surface water are SMALL, site-specific characteristics can result in the potential for MODERATE to LARGE impacts. Typically, sites with deep groundwater with little hydrological connections to surface waters would experience SMALL impacts from the construction, operation, aquifer restoration, and decommissioning of an **existing ISR facility.** However, a leak or spill of lixiviant could result in MODERATE to LARGE impacts, if the affected groundwater table that is located close to the ground surface is an important source of water for local domestic or agricultural uses or is hydraulically connected to other important aquifers. These conditions are site specific and therefore could also occur at **brownfield** or **greenfield sites**.

3.1.5 Ecological Resources

Construction and operation impacts on ecological resource from **existing ISR and conventional mines** could have SMALL to MODERATE impacts on ecological resources depending on the resources disturbed and mitigation measures employed to offset the impacts. The level of impact would be dependent on site-specific characteristics and the presence of the resource (including threatened and endangered species) in proximity to activities. ISR and conventional mining activities at any location would have to take into consideration current ecological conditions present at the site and comply with the applicable regulatory requirements at that location. The impacts of construction and operation at a **brownfield site** would be similar to the impacts described under the existing facilities scenario, as brownfield sites are assumed to be disturbed such that native soils, vegetation, sensitive habitats, threatened, endangered, and other sensitive species are unlikely to be present. Construction and operation at a **greenfield site** could also result in SMALL to MODERATE impacts caused by land-clearing activities in higher-diversity habitats. Land-clearing activities as part of new construction would likely result in increased erosion, stormwater runoff, and loss of vegetation. Additionally, impacts on wildlife could include habitat fragmentation, disturbance, and injury or mortality—as habitats within the footprint disturbed by construction would be reduced or altered. Loss of habitat could result in a long-term reduction in wildlife abundance and diversity. The degree of impact could be limited due to the implementation of BMPs, but would be dependent upon the ecological characteristics of the selected site. The magnitude of impact would depend on the size of a new facility or extension to an existing facility and the amount of land disturbance. Inventory of threatened or endangered species would be expected to be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing/avoiding adverse impacts. Therefore, ecological resources impacts would likely be SMALL to MODERATE, depending on site-specific habitat and presence of threatened or endangered species.

3.1.6 Historic and Cultural Resources

Due to the localized nature of land-disturbing activities during construction at **existing ISR and conventional mines**, impacts on historic and cultural resources are anticipated to be SMALL, but could be MODERATE if a mine or facility is located on or adjacent to cultural or historic resources. The impacts of construction and operation at a **brownfield site** are expected to be similar as those for existing mines because of the previously developed nature of the site. Construction impacts at a **greenfield** site could range from SMALL to MODERATE. Construction at a greenfield site would require ground disturbance of previously undisturbed areas, which creates greater potential for impacts on historic and cultural resources. Under all three scenarios (i.e., existing, brownfield, and greenfield), the license or permit applicant would be required, to adhere to procedures regarding the discovery of historic and cultural resources during initial construction, operation, aquifer restoration, and decommissioning. Impacts to historic and cultural resources could be mitigated through measures such as license/permit conditions.

3.1.7 Noise

In general, mines are located within relatively rural areas with limited sensitive noise receptors present. It is anticipated that potential noise impacts would be greatest during construction or expansion of **existing ISR facilities** due to the use of heavy equipment (e.g., bulldozers, graders, drill rigs, etc.). Potential noise impacts during these activities would be SMALL to MODERATE. During construction and operation at existing conventional mines, over-the-road heavy haul trucks, on-road and off-road vehicle traffic, and, if necessary, blasting, would potentially cause SMALL to MODERATE noise impacts. Construction and operation noise impacts at a **brownfield site** would be SMALL to MODERATE, because a brownfield site would likely be surrounded by compatible land uses. Construction and operation at a **greenfield site** could have similar impacts as an existing facility (SMALL to MODERATE) as the environmental setting of a greenfield site would be expected to align with the rural location and limited sensitive noise receptors of most of the existing facilities. However, the extent of noise impacts would be site specific and would depend on adjacent land uses and receptors.

3.1.8 Public and Occupational Health (Facility Accidents)

Radiological and nonradiological accidents could involve processing equipment failures such as yellowcake slurry spills, or radon gas or uranium particulate releases. Consequences of accidents to workers and the public would be generally low, with the exception of a dryer explosion, which could result in worker dose above NRC limits. The likelihood of such an accident would be low, and therefore the risk would also be low. An example of a potential nonradiological accident impact includes high-consequence chemical release events (e.g., ammonia) for both workers and nearby populations. As a result of operators following commonly applied chemical safety and handling protocols, the likelihood of such release events would be low based on historical operating experience at NRC-licensed facilities. Consequently, the impacts on public and occupational health at an **existing ISR facility** are considered to be SMALL to MODERATE. The construction and operation impacts on public and occupational health from a facility accident during construction and operation at a **brownfield site** are expected to be similar to those described under the existing scenario as the siting criteria (which typically includes a safe buffer zone between the facility and the public) would be site dependent to ensure public safety across different location scenarios. This means that despite higher population numbers in traditionally urban areas, the effects would not be substantially more severe, as appropriate buffer zones would be in place. Construction and operation impacts on public and occupational health from a facility accident at a **greenfield site** are also expected to be similar for the same reasons.

3.1.9 Traffic

Construction and operation impacts on traffic at an **existing ISR mine** would range from SMALL to MODERATE. The majority of daily vehicle traffic would be generated by commuting personnel, with a small number of truck shipments per day. Construction and operation impacts on traffic at an **existing conventional mine** would range from SMALL to MODERATE, depending on the number and size of mining facilities that could be operating in a mining location. Many truck trips would be required to transport the uranium ore to a mill. Construction and operation at a **brownfield** or a **greenfield site** could be similar to the impacts described at existing facilities because traffic levels would not be dependent upon siting and they generally would be located in rural, less developed areas.

3.1.10 Socioeconomics

Construction and operation impacts on socioeconomics at **existing ISR** and conventional mines would result predominantly from employment and demands on the existing public and social services, housing, infrastructure (schools, utilities), and the local work force. The use of outside workers would be expected to have a MODERATE (beneficial) impact to communities with high unemployment rates due to the potential increase in indirect job opportunities and contribution to the local economy (i.e., purchasing goods and services). But if the majority of construction workers are pulled from the local workforce, the socioeconomic impacts would be SMALL. Construction and operation at a **brownfield** or a **greenfield site** could potentially cause LARGE impacts if a majority of workers chose to reside in a more rural area with a low population density, as the workers could adversely affect housing availability and community services such as education, fire protection, law enforcement, and medical resources.

3.1.11 Environmental Justice

Construction and operation impacts on communities with environmental justice concerns at **existing ISR and conventional mines** are likely to be SMALL. Construction, operation, and decommissioning of these mines would not be expected to result in disproportionate and adverse impacts on communities with environmental justice concerns living near or within the ROI. Impacts on communities with environmental justice concerns from construction and operation of a conventional mine at the proposed Roca Honda site (**brownfield site**) in McKinley and Cibola Counties, New Mexico, are expected to be SMALL to MODERATE. These impacts would likely result in disproportionate and adverse effects on McKinley County's 91.7% minority population (USCB, 2023a) and Cibola County's 78.7% minority population (USCB, 2023b). Because the percentage of minority individuals residing within the geographic unit of analysis meets or exceeds 50%, these counties are both considered communities with environmental justice concerns that could be disproportionately and adversely impacted. McKinley County's low-income population (33.5% (USCB, 2023c)) is 15.9% higher than New Mexico state's low-income population (17.6%) (USCB, 2023d) and is therefore considered a community with environmental justice concerns with potential to be disproportionately impacted. The proportion of low-income populations in Cibola County (27.3%) (USCB, 2023e) is slightly higher than the State of New Mexico, but not in a meaningful way.

In general, environmental justice impacts as described in the *Draft Environmental Impact Statement for Roca Honda Mine* include socioeconomic benefits, adverse physical health impacts from working conditions, and traffic delays. Traffic delays could result in restricted or delayed access to recreational and youth facilities; safety risks to recreationists, and restricted or delayed access to hospital or healthcare facilities and institutional places of worship or traditional locations for spiritual activities. In addition, impacts could occur from diminished quality of religious, spiritual, or cultural sites, and disturbance and health risks to children from increased fugitive dust and tailpipe emissions. The Roca Honda EIS is currently on hold while the operator waits for better market conditions (USDA, 2013). A Supplement to the EIS is being prepared to add an alternative to address the communities' concerns. Site selection at other **brownfield sites** and **greenfield sites** are expected to consider environmental, socioeconomic, and environmental justice factors. Impacts would be dependent on local and regional conditions for a proposed site, the potential adverse effects, and the presence of communities with environmental justice concerns in the ROI. At this time, DOE is unable to determine whether disproportionate and adverse impacts would be expected at either brownfield or greenfield sites as these impacts rely on site-specific analysis. However, the degree of impact is estimated to range from SMALL to MODERATE based on the range of mining and milling impacts on other resource areas. DOE expects that site-specific environmental justice analysis would be considered as part of the licensing process for any new facility by the NRC, Agreement States, or other Federal agencies.

3.2 Uranium Conversion

Only one domestic conversion facility currently exists in the United States: the Honeywell International Metropolis Works Uranium Conversion Facility (the Metropolis Works Plant, or "the Metropolis facility") near Metropolis, Illinois. The Metropolis facility has the licensed capacity to process up to 15,000 MT/yr of UF_6. To meet the amount of HALEU required under the Proposed Action, about 20% of the plant's capacity would need to be utilized. See the incorporated NEPA documents listed in Appendix A, Section A.2.2.2, *Existing NEPA Documentation*, for prior NEPA analysis for the Metropolis site, which is used in this HALEU EIS to develop the assessment of the potential impacts of converting about 2,500 MT/yr of U_3O_8 annually into the 3,100 MT/yr of UF_6 for subsequent use in a HALEU enrichment facility. The function and operation of this facility would be identical in both the LEU and HALEU fuel cycle. The same yellowcake received from an ISR or mill is converted to the same UF_6 needed as feed material for enrichment facilities. The only difference is the amount of yellowcake/UF_6 required to produce equivalent quantities of LEU and HALEU (roughly four times more for HALEU than LEU at about 5%). In this analysis, that difference is addressed by the capacity of the existing conversion facility.

Existing NEPA documentation regarding construction of a new conversion facility is unavailable,[62] so the NEPA documentation for construction and operation of a deconversion facility was used as the basis for the analysis of the construction of a new conversion facility—the *Environmental Impact Statement for the Proposed Fluorine Extraction Process and Depleted Uranium Deconversion Plant in Lea County, New Mexico – Final Report* (NUREG-2113) (the "Fluorine/Depleted Uranium EIS") (NRC, 2012b). Because a new HALEU conversion facility is expected to operate at a smaller capacity than the existing Metropolis facility, the environmental consequences are expected to be bounded by the consequences of operation of the Metropolis facility at full capacity as analyzed in the *Environmental Assessment for the Proposed Renewal of Source Material License SUB–526 Metropolis Works Uranium Conversion Facility (Massac County, Illinois). Honeywell International, Docket No. 040-03392* ("the Metropolis EA") (NRC, 2019) produced during the license renewal for that facility.[63]

To accommodate the possibility of a new conversion facility and unknown project locations, this analysis follows the previously discussed approach, which differentiates impacts between existing sites,

[62] The Metropolis EA (NRC, 2019) was prepared to support relicensing of the facility and therefore only evaluates continued operations.

[63] The NRC renewed the license for the Metropolis facility in March 2020, which expires on March 24, 2060.

brownfield sites, and greenfield sites. Construction impacts for brownfield sites and greenfield sites were extrapolated from the International Isotopes Fluorine Products, Inc. (IIFP) NEPA documentation (i.e., the Fluorine/Depleted Uranium EIS) (NRC, 2012b). The impact ratings for the uranium conversion activity were developed from the incorporated NEPA documents listed in Appendix A, Section A.2.2.2, *Existing NEPA Documentation*. Table 3.2-1 presents a summary of environmental consequences associated with uranium conversion under each of the three site scenarios. Section 3.2.1, *Ecological Resources*, through Section 3.2.3, *Socioeconomics*, summarize the impacts associated with the respective resources that were determined to have potential MODERATE or LARGE impacts. For a full analysis of potential impacts, including SMALL impacts, see the incorporated NEPA documents listed in Appendix A, Section A.2.2.2.

Table 3.2-1. Summary of Environmental Consequences – Uranium Conversion

Activity	***Located at Existing LEU Fuel Cycle Facility***	***Located at Other Non-Uranium Fuel Cycle Facility Industrial Site***	***Located on Previously Undisturbed Land***
Uranium Conversion	Overall, the potential environmental consequences are SMALL for all resource areas.	Additional MODERATE impacts may also be seen because of construction in the area of socioeconomics. Impacts would be predominately associated with construction activities and should be amenable to mitigation.	Additional MODERATE impacts may also be seen in the areas of ecological resources and historic and cultural resources. Impacts would be predominately associated with construction activities and should be amenable to mitigation.

Key: LEU = low-enriched uranium

Notes: As most resource area impacts are expected to be SMALL, it is reasonable to assume that resource area impacts on communities with environmental justice concerns would also be SMALL at brownfield and greenfield sites. However, site-specific analysis would be needed to determine whether disproportionate and adverse impacts could occur. Site-specific information is not available at this time but will be required as a part of the NRC NEPA process.

3.2.1 Ecological Resources

Operations at the **existing Metropolis facility** would have no significant impact[64] on the ecological resources in the action area, additional construction and modifications are not required at this facility. Ecological impacts of construction and operation of a new facility at a **brownfield** site would be SMALL if new construction were to occur entirely within previously developed and disturbed lands. Construction and operation of a new facility at a **greenfield** site could have SMALL to MODERATE impacts on ecological resources depending on the resources disturbed, and mitigation and the minimization measures employed. Land-clearing activities as part of new construction would likely result in increased erosion, stormwater runoff, and loss of vegetation. Additionally, impacts on wildlife could include habitat fragmentation, disturbance, and injury or mortality—as habitats within the footprint disturbed by construction would be reduced or altered. Loss of habitat could result in a long-term reduction in wildlife abundance and diversity. The degree of impact, while limited due to the relatively small size of the facility and the implementation of BMPs, would be dependent upon the ecological characteristics of the selected site. An inventory of threatened or endangered species would be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing/avoiding adverse impacts. Therefore, ecological resources impacts would likely be SMALL to MODERATE, depending on site-specific habitat and presence of threatened or endangered species.

[64] Because the source document for impacts information for the Metropolis facility is an EA and Finding of No Significant Impact (FONSI), this section uses the term "no significant impact," which is used interchangeably with SMALL impacts.

3.2.2 Historic and Cultural Resources

Operations at the **existing Metropolis facility** would have no significant impact on historic and cultural resources based on the nature of the proposed continued conversion activities, with no new construction or ground disturbance. Impacts of construction of a new conversion facility at an existing uranium fuel cycle facility or **brownfield site** would likely be SMALL because of the previously developed nature of the site and no significant impacts would result from operations. Construction impacts at a **greenfield site** could range from SMALL to MODERATE. Construction at a greenfield site would require ground disturbance of previously undisturbed areas, which creates greater potential for impacts on historic and cultural resources. The degree of construction impacts, while limited due to the relatively small size of the facility and the expected implementation of BMPs, would be dependent upon the characteristics of the selected site. Impacts to historic and cultural resources could be mitigated through measures such as license conditions.

3.2.3 Socioeconomics

Operations at the **existing facility** (the Metropolis facility) would have no significant impacts on socioeconomics as there would be no change in existing socioeconomic conditions. The socioeconomic impacts associated with constructing a new conversion facility at a **brownfield site** would be expected to be SMALL to MODERATE given the potential for a larger in-migrating population, which would cause more strain on public services. The economic impacts (e.g., increased jobs, income, and tax revenues) would likely be considered beneficial to the local and regional economy. Construction of a new conversion facility at a **greenfield site** could potentially cause SMALL to MODERATE impacts if a majority of workers chose to reside in a rural area with a low population density, as the number of workers could adversely affect housing availability and community services such as education, fire protection, law enforcement, and medical resources.

3.3 Uranium Enrichment

As part of the Proposed Action, a HALEU enrichment facility would enrich natural uranium to at least 19.75% and less than 20 weight percent U-235. Several options are available to support the domestic commercial production of HALEU enriched to at least 19.75 and less than 20 weight percent U-235:

- Construction of a new enrichment facility capable of using natural uranium as feed and producing HALEU enriched to at least 19.75 and less than 20 weight percent U-235
- Modification of existing enrichment facilities that currently generate LEU
- Use of existing enrichment facilities to generate LEU and augmentation of the existing facilities with new facilities to enrich the LEU to HALEU
- Expansion of capacity at the existing HALEU demonstration project

This HALEU EIS evaluates the option of constructing new enrichment facilities for HALEU production because this option would bound the environmental impacts of other options for construction of smaller facilities. Existing NEPA documentation for enrichment facilities primarily addresses the enrichment to LEU levels of less than 5% U-235, though the ACP in Piketon, Ohio, has NEPA documentation that includes enrichment of up to less than 20% U-235 (NRC, 2021e) (see Appendix A, *Environmental Consequences Supporting Information*, and Appendix B, *Facility NEPA Documentation*). This documentation addresses a range of construction, from augmenting existing capabilities to constructing entirely new facilities. Unlike mining and milling and conversion, enrichment operations are expected to be impacted by the change to HALEU enrichment from LEU enrichment. HALEU cascade operations would use centrifuges of similar design as those used in the enrichment of uranium to commercial LEU levels (less than 5% U-235) and to LEU+ levels (up to less than 10% U-235). HALEU product collection, storage, and transport would require some modifications compared to the same actions in an LEU enrichment facility. Preventing an accidental criticality would require administrative controls (potentially more stringent than for LEU product) and could require equipment modifications for feed withdrawal from the centrifuges. While there are differences between the LEU and HALEU enrichment processes, this is a minimal part of the enrichment process (a relatively small quantity of HALEU material compared to feed material and DU) and thus should not greatly change the assessment of impacts between an LEU enrichment facility and a HALEU enrichment facility.

Existing NEPA documents include those for enrichment at Centrus, UUSA, and GLE facilities. Each of the existing enrichment facilities reviewed has a higher licensed separative work unit (i.e., SWU) capacity for uranium enrichment than would be required for a HALEU enrichment facility associated with the Proposed Action. SWUs are a measure of the work required to produce a desired amount and level of enriched uranium based on a quantity of feed material. As stated in Section 2.1, *Proposed Action and Related Activities*, DOE could enter into multiple enrichment contracts to produce up to 290 MT of HALEU over the 6-year operational period of a 10-year enrichment contract. (For analysis purposes, this EIS assumes a maximum production rate of 38 MT of UF_6 per year, for an enrichment facility, with a total enrichment rate of 75 MT of UF_6 per year.) A facility producing 38 MT of HALEU would require about 1,500 MT of UF_6 as feed material (about 1,000 MT of uranium) and require about 1.1 million SWUs per year to enrich to between 19.75 and less than 20 weight percent HALEU. (For the Proposed Action assumed HALEU production rate of 50 MT per year, 75 MT of HALEU as UF_6 would be produced from 3,100 MT of UF_6 [about 2,100 MT of uranium] per year as feed material, and require about 2.2 million SWUs per year.) The three enrichment facilities have, or would have had, licensed capacity for between 3 million and 10 million SWUs, with a corresponding feed material requirement of between 3,700 and 12,500 MT of uranium, assuming the product was LEU enriched to 4.4%. Therefore, the impacts presented in the NEPA documents prepared for those facilities would bound the impacts of construction and operation of a HALEU enrichment facility.

To accommodate the possibility of a new enrichment facility and unknown project locations, this analysis follows the previously discussed approach, which differentiates impacts between existing sites, brownfield sites, and greenfield sites. Environmental consequences from a facility that enriches natural uranium between 19.75 and less than 20 weight percent HALEU is expected to be comparable to those at a facility that enriches to LEU levels. Therefore, to accommodate the lack of an existing HALEU enrichment facility, NEPA documents for existing LEU enrichment facilities (i.e., Centrus and UUSA) were used. NEPA documents also exist for an enrichment facility at a greenfield site (i.e., GLE). The GLE EIS provides the basis for environmental impacts of construction and operation at a greenfield site. Impacts at a brownfield site are extrapolated from the source documents for the above facilities. Table 3.3-1 presents a summary of environmental consequences associated with uranium enrichment. Section 3.3.1, *Water Resources*, through Section 3.3.8, *Environmental Justice*, summarize the impacts associated with the respective resource areas that were determined to have potentially MODERATE or LARGE impacts. For a full analysis of potential impacts, including SMALL impacts, see the incorporated NEPA documents listed in Appendix A, Section A.3.2.2, *Existing NEPA Documentation*.

Table 3.3-1. Summary of Environmental Consequences – Uranium Enrichment

Activity	***Located at Existing LEU Fuel Cycle Facility***	***Located at Other Non-Uranium Fuel Cycle Facility Industrial Site***	***Located on Previously Undisturbed Land***
Uranium Enrichment	For an existing site or other industrial site, impacts are generally SMALL for most resources. Impacts to ecological resources, water resources, and impacts driven in part by the local population have the potential for MODERATE (traffic and environmental justice) or LARGE (socioeconomics) impacts, particularly on regions with smaller populations. No disproportionate and adverse environmental justice impacts would be expected at existing facilities.		At a greenfield site, additional MODERATE impacts may occur to historic and cultural resources, infrastructure, and noise. Impacts would be predominately associated with construction activities and should be amenable to mitigation.

Key: LEU = low-enriched uranium

3.3.1 Water Resources

Impacts on water quality from construction and operation of a HALEU enrichment facility at an **existing facility** are likely to be SMALL. Discharges resulting from construction and operation would be expected to comply with all relevant permits, including applicable National Pollutant Discharge Elimination System (NPDES) requirements and discharge limits. Protocols would be in place to minimize the potential for an inadvertent release of contaminants, such as in the event of a leak or spill, and to mitigate impacts should such an event occur. BMPs for capturing and treating effluent on-site would be expected to be included to prevent untreated waters from leaving the site. Operation of a HALEU enrichment facility at an existing facility could have SMALL to MODERATE impacts on water consumption. This consumption could impact water levels, particularly at sites using groundwater as the source of water. Construction and operation impacts on water quality at a **brownfield** site are likely to be similar to an existing facility, as these sites would be expected to have limited natural surface water features and existing systems for retaining stormwater discharges. Likewise, water consumption impacts at a brownfield site would likely be similar to the existing facilities scenario. Construction and operation impacts to both water quality and water consumption at the GLE site (**greenfield site**) were SMALL but other greenfield sites could potentially be SMALL to MODERATE depending on site-specific conditions. If floodplains, wetlands, or areas with sensitive water resources could not be avoided, consultation and permitting under the Federal Clean Water Act, as well as state and local water regulations, may be required.

3.3.2 Ecological Resources

Impacts on ecological resources from construction and operation of a HALEU enrichment facility at an **existing enrichment facility** are likely to be SMALL to MODERATE. Wetlands, Federal and state, rare, threatened, and endangered species are known to occur at or near the existing enrichment facilities. The existence of substantial wetlands at the Centrus site would likely result in a MODERATE impact to ecological resources. Wetlands could be impacted by alteration of groundwater flow and surface water runoff, soil erosion and sedimentation, and contamination. Construction and operation impacts to ecological resources at a **brownfield** site would likely be SMALL, as activity would not be expected to disturb special status species or reduce sensitive habitat. Construction and operation impacts on ecological resources at the GLE site (**greenfield site**) would likely be SMALL to MODERATE, and other greenfield sites could have SMALL to MODERATE impacts depending on the resources disturbed, and mitigation measures employed. Land-clearing activities as part of new construction would likely result in increased erosion, stormwater runoff, and loss of vegetation. Additionally, impacts on wildlife could include habitat fragmentation, disturbance, and injury or mortality—as habitats within the footprint disturbed by construction would be reduced or altered. Loss of habitat could result in a long-term reduction in wildlife abundance and diversity. The degree of impact, while limited due to the relatively small size of the facility and the implementation of BMPs, would be dependent upon the ecological characteristics of the selected site. An inventory of threatened or endangered species would be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing/avoiding adverse impacts. Therefore, ecological resources impacts would likely be SMALL to MODERATE, depending on site-specific habitat and presence of threatened or endangered species.

3.3.3 Historic and Cultural Resources

Impacts on historic and cultural resources from construction and operation of a HALEU enrichment facility at **existing enrichment facilities** are likely to be SMALL. Construction and operation impacts on historic and cultural resources at a **brownfield site** would likely be SMALL, as construction and operation activity would likely occur in developed or previously disturbed areas. Site selection for a new HALEU enrichment facility at a brownfield site would be expected to avoid areas with historic and cultural resources, and include measures to identify resources and mitigate potential impacts through National Historic Preservation Act Section 106 and NEPA processes. Construction and operation impacts on historic and cultural resources at the GLE site (**greenfield site**) were expected to be SMALL to MODERATE, as the GLE site is located within a region containing high concentrations of historic and cultural resources. Due to potential impacts on undiscovered historic and cultural resources, the NRC set license conditions that would require GLE to consider the potential effects on historic and cultural resources from any ground-disturbing activities in unsurveyed areas and development of Common Procedure CP-24-201 to address the unanticipated discovery of human remains or artifacts (NRC, 2012a). Clearing of other greenfield sites for facility development could also have SMALL to MODERATE impacts; however, the degree of the impact would be dependent on the resources present.

3.3.4 Infrastructure

Impacts on infrastructure from construction and operation of a HALEU enrichment facility at **existing enrichment facilities** are likely to be SMALL. Construction and operation impacts on infrastructure at a **brownfield site** would likely be similar to the impacts described under the existing facilities scenario. Operation of facilities would have similar infrastructure demands regardless of where the facility would be located; fuel, electricity, and water demands are relatively unaffected by location. There most likely would be existing infrastructure at a developed industrial site. Construction and operation impacts on the local infrastructure at the GLE site (**greenfield site**) are likely to be SMALL, as it is not anticipated that the utility quantities required would put strain on availability for local consumers. Construction and operation at other greenfield sites could be higher as access roads may need to be built, electrical and water system improvements (including building connections to existing infrastructure) may be more extensive than would be expected at a developed site. Additionally, the utility needs at a greenfield site may adversely impact existing customers. Considering the unknowns and the uncertainties associated with locating the HALEU fuel cycle facilities at other greenfield sites, the potential impacts could be SMALL to MODERATE depending on the extent of infrastructure utility construction required.

3.3.5 Noise

Impacts on noise from construction and operation of a HALEU enrichment facility at **existing facilities** were SMALL. Construction and operation impacts on noise at a **brownfield site** would be SMALL, as these areas would likely have existing noise sources and compatible surrounding land uses. Construction and operation impacts on noise at the GLE site (**greenfield site**) were expected to be SMALL to MODERATE. This was largely due to vehicular traffic to and from the GLE facility during construction. The intermittent noise along local roadways could have MODERATE impacts on the nearest subdivision, but would be temporary. The extent of noise impacts at other greenfield locations would be site specific and would depend on adjacent land uses and receptors. Site selection for a HALEU enrichment facility is expected to include criteria for land use compatibility, which would reduce the potential for noise impacts on sensitive receptors. Operational noise would primarily be confined to the interior of buildings.

3.3.6 Traffic

Impacts on traffic from construction and operation of a HALEU enrichment facility at the **existing enrichment facilities** are likely to be SMALL to MODERATE as all roadways had excess capacity per the most recent average annual daily traffic (AADT) data. During construction, truck and worker traffic volumes had MODERATE impacts due to high congestion levels during peak commuting hours. During operations, it was estimated that impacts from worker traffic volumes would range from SMALL to MODERATE depending on the existing capacity of nearby public roadways. Construction and operation impacts on traffic would vary based on site-specific conditions but would likely be SMALL to MODERATE for construction for **brownfield sites**. Brownfield sites are likely to be similar to the existing enrichment facility sites with nearby populations centers and sufficient access roadways and infrastructure. Therefore, there is likely to be more existing traffic near brownfield sites, but also significant infrastructure to handle the traffic. Construction and operation impacts on traffic at the GLE site (**greenfield site**) were expected to be SMALL to MODERATE for similar reasons as described in the existing enrichment facilities scenario. Other greenfield sites are likely to have a similar impact rating as greenfield site facilities are expected to be further from population centers and have smaller capacity access roadways. Therefore, there is likely to be less existing traffic near greenfield sites, but also less infrastructure to handle the traffic.

3.3.7 Socioeconomic

Impacts on socioeconomics from construction and operation of a HALEU enrichment facility at an **existing enrichment facility** are likely to be SMALL to LARGE. The total increase in jobs at existing facilities (about 1% or less increase) could impact several socioeconomic indicators including housing, tax revenue, social services, and schools. At two of the sites assessed, the impact on at least some of these indicators was MODERATE. At one site, the potential for LARGE impacts was identified due to housing availability. However, the socioeconomic impact severity level is highly dependent upon the existing socioeconomic conditions of the ROI. Assuming that any new site selected for the HALEU enrichment facility has socioeconomic indicators with similar characteristics as those associated with the three sites used for NEPA analysis, similar SMALL to LARGE impacts would be anticipated. Construction and operation impacts on socioeconomics at a **brownfield site** are expected to be similar to those described for existing enrichment facilities because both would likely have nearby populations centers and access to workers and social services. Construction and operation impacts on socioeconomics at the GLE site (**greenfield site**) were expected to be SMALL. Potential impacts for other greenfield sites—both adverse and beneficial (e.g., increased job opportunities, income levels, public spending and tax revenues)—would be SMALL to LARGE, depending on the number and distribution of an in-migrating population within the region of influence. In general, potential impacts would be SMALL if the greenfield site were located in close proximity to an urban area(s) with sufficient resources—workers, housing, community services—such that a small in-migrating workforce would be required. By contrast, a sparsely populated area is not as likely to have, or be able to support, an adequate labor pool. In such instances, workers migrating into the area, frequently with their families, can severely impact the available housing market and community services, resulting in MODERATE to LARGE impacts.

3.3.8 Environmental Justice

Impacts on communities with environmental justice concerns from construction and operation of a HALEU enrichment facility at **existing enrichment facilities** are likely to be SMALL but could potentially be MODERATE to accommodate potentially larger impacts associated with housing availability concerns near the Centrus site. Construction, operation, and decommissioning of the HALEU enrichment facility would not be expected to result in disproportionate and adverse effects on communities with environmental justice concerns within the ROI. Impacts on communities with environmental justice concerns from construction and operation at the GLE site (**greenfield site**) were expected to be SMALL to MODERATE due to increased noise, dust, traffic, employment, and housing impacts. These impacts would be short term and limited to on-site activity and would not be expected to cause disproportionate or adverse impacts. Site selection at other **brownfield sites** and **greenfield sites** are expected to consider environmental, socioeconomic, and environmental justice factors. Impacts would be dependent on local and regional conditions for a proposed site, the potential adverse effects, and the presence of communities with environmental justice concerns in the ROI. At this time, DOE is unable to determine whether disproportionate and adverse impacts would be expected at either brownfield or greenfield sites as these impacts rely on site-specific analysis. However, the degree of impact is estimated to range from SMALL to MODERATE based on the range of enrichment impacts on other resource areas. Site-specific environmental justice analysis would be required as part of the licensing process for any new facility by the NRC.

3.4 HALEU Deconversion

HALEU deconversion would occur after the HALEU enrichment process. A HALEU deconversion facility could produce uranium oxide, uranium metal, or other more exotic forms of HALEU. The processes for deconversion of UF_6 to oxide or metal are well-understood technologies and performed routinely for LEU and DU. Because information is lacking regarding construction and operation of deconversion facilities that could produce other forms of HALEU that may be required for some advanced reactor fuels, this HALEU EIS concentrates on deconversion to uranium oxide and uranium metal. Although not analyzed, construction and operation of a HALEU deconversion facility that would produce other unique forms of HALEU would be expected to have similar impacts. Regardless, project-specific NEPA documentation would be completed by the NRC before construction and operation of any new deconversion facility.

There is currently no **existing deconversion facility** in the United States capable of producing HALEU in the quantities required by the Proposed Action. A facility would need to be constructed. The facility would convert commercially generated HALEU from UF_6 into UO_2 or metal for ANR fuel and into fluorine products. The deconversion facility could be co-located with an enrichment facility, co-located with a fuel fabrication facility, or be located as a standalone facility. In addition, a HALEU storage facility could be co-located with the HALEU deconversion facility.

Existing NEPA documents include those for the Portsmouth DUF_6 Conversion Facility, Paducah DUF_6 Conversion Facility, and IIFP DUF_6 Conversion Facility (DOE, 2004b; DOE, 2004c; NRC, 2012b). For comparison, the IIFP facility would be able to process 3,400 MT of DUF_6 per year, the Portsmouth DUF_6 Conversion Facility can process 13,500 MT of DUF_6 per year, and the Paducah DUF_6 Conversion Facility can process 18,000 MT of DUF_6 per year. Multiple HALEU deconversion facilities could process 76 MT/yr of HALEU in the form of UF_6 and produce 56 MT/yr of HALEU in the form of an oxide or 50 MT/yr of HALEU in the form of metal.[65] Therefore, many of the attributes of the DUF_6 conversion facilities would be much larger than needed for the HALEU deconversion facility and would likely bound the impacts of construction and operation of a HALEU deconversion facility.

To accommodate a new deconversion facility and unknown project locations, this analysis follows the previously discussed approach, which differentiates impacts between existing sites, brownfield sites, and greenfield sites. Environmental consequences from deconversion of UF_6 to oxide or metal at a new HALEU facility are expected to be comparable to existing DU deconversion facilities. Therefore, to accommodate the lack of an existing HALEU deconversion facility, NEPA documents for existing DU deconversion facilities were used (i.e., Paducah and Portsmouth). Impacts at a **brownfield** site were extrapolated from the DU deconversion facility source documents listed in Appendix A, Section A.4.2.2, *Existing NEPA Documentation*. NEPA documents also exist for a DU deconversion facility at a greenfield site (i.e., IIFP). (See the incorporated NEPA documents listed in Section A.4.2.2.) The IIFP site provides the basis for environmental impacts at a **greenfield** site. Table 3.4-1 presents a summary of environmental consequences associated with HALEU deconversion. Section 3.4.1, *Ecological Resources*, through Section 3.4.3, *Socioeconomics*, summarize the impacts associated with the respective resource areas that were determined to have potentially MODERATE or LARGE impacts. For a full analysis of potential impacts, including SMALL impacts, see the incorporated NEPA documents listed in Appendix A, Section A.4.2.2.

Table 3.4-1. Summary of Environmental Consequences – HALEU Deconversion

Activity	*Located at Existing LEU Fuel Cycle Facility*	*Located at Other Non-Uranium Fuel Cycle Facility Industrial Site*	*Located on Previously Undisturbed Land*
HALEU Deconversion	Overall, the potential environmental consequences are SMALL for all resource areas except socioeconomics which may have MODERATE impacts if the in-migration of workers is larger than expected (fewer local workers employed).		MODERATE impacts may also be seen as a result of construction in the areas of ecological resources and historic and cultural resources. Impacts would be predominately associated with construction activities and should be amenable to mitigation.

Key: HALEU = high-assay low-enriched uranium; LEU = low-enriched uranium

Notes: As most resource area impacts are expected to be SMALL, it is reasonable to assume that resource area impacts on communities with environmental justice concerns would also be SMALL at brownfield and greenfield sites. However, site-specific analysis would be needed to determine whether disproportionate and adverse impacts could occur. Site-specific information is not available at this time but will be required as a part of the NRC NEPA process.

3.4.1 Ecological Resources

Ecological impacts to construct a new deconversion facility at an **existing fuel cycle facility** are expected to be SMALL. Impacts on ecological resources would also be expected to be SMALL if new construction were to occur within a **brownfield site**, as these areas are subject to frequent disturbance from human activity, grounds maintenance, or disruptions from ongoing facility operations, and native habitats are no longer present or have likely degraded over time. Previously developed and disturbed areas are not likely

[65] For analysis purposes, this EIS assumes a conversion rate of 25 MT per year for the deconversion facility. Multiple contracts could result in 290 MT of HALEU, at an assumed conversion rate supporting 50 MT of HALEU per year.

to support habitat for wildlife other than for those species adapted to human disturbance (such as transient small mammals, insects, and birds). Impacts on ecological resources at the IIFP site (**greenfield site**) were expected to be SMALL, as no unique habitats or threatened and endangered species are located at the proposed site. New construction occurring within other greenfield sites could have SMALL to MODERATE impacts on ecological resources depending on the resources disturbed and the mitigation and minimization measures employed. Land-clearing activities as part of new construction would likely result in increased erosion, stormwater runoff, and loss of vegetation. Additionally, impacts on wildlife could include habitat fragmentation, disturbance, and injury or mortality—as habitats within the footprint disturbed by construction would be reduced or altered. Loss of habitat could result in a long-term reduction in wildlife abundance and richness. The degree of impact, while limited due to the relatively small size of the facility and the implementation of BMPs, would be dependent upon the ecological characteristics of the selected site. An inventory of threatened or endangered species would be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing/avoiding adverse impacts. Therefore, ecological resources impacts would likely be SMALL to MODERATE, depending on site-specific habitat and presence of threatened or endangered species.

3.4.2 Historic and Cultural Resources

Construction and operation of a new deconversion facility at an **existing LEU fuel cycle facility** or **brownfield site** would be expected to result in SMALL impacts on historic and cultural resources, as prior development of these areas has likely already impacted resources that may have been present. Impacts on historic and cultural resources at the IIFP site (**greenfield site**) were expected to be SMALL. Construction of a HALEU deconversion facility in other greenfield sites would require disturbance of previously undisturbed areas, with greater potential for the presence of historic or cultural resources, than placement of a facility in an area that is already developed or improved. Clearing of undeveloped areas for facility development would have a higher potential to result in adverse effects to such resources; however, the degree of the impact would be dependent on the significance and amount of (National Register of Historic Places eligibility) resources present. This could result in SMALL to MODERATE impacts.

3.4.3 Socioeconomics

Socioeconomic impacts to construct a new deconversion facility at an **existing fuel cycle facility** are expected to be SMALL but could potentially be SMALL to MODERATE if a larger-than-analyzed workforce migrated into the ROI, which would introduce a greater strain on public services. The socioeconomic impacts associated with constructing a new deconversion facility at a **brownfield site** would be expected to be SMALL to MODERATE given the potential for a larger in-migrating population, which would cause more strain on public services. The economic impacts (e.g., increased jobs, income, and tax revenues) would likely be considered beneficial to the local and regional economy. Construction and operations impacts at the IIFP site (**greenfield site**) would have SMALL impacts on socioeconomics given the small workforces requirements and resulting population influx associated with modification. Construction of a new deconversion facility at other greenfield sites could potentially cause SMALL to MODERATE impacts if a majority of workers chose to reside in the host county, particularly at one of the sites where the host county is more rural in natural and has lower population numbers (and a low population density), as the higher numbers could adversely affect housing availability and community services such as education, fire protection, law enforcement, and medical resources.

3.5 HALEU Storage

To bound the impacts, it is assumed that HALEU storage facilities would be new structures. The analysis performed addresses impacts from the construction and operation of a storage facility capable of storing half (145 MT) of the HALEU. To support the potential HALEU production under the Proposed Action, a total of up to 290 MT of HALEU could be stored at multiple storage facilities, assuming the entire inventory created under the Proposed Action is stored.

NEPA coverage specifically addressing the construction and operation of a new HALEU storage facility does not exist. However, several NEPA documents are relevant to the current analysis. These NEPA documents evaluate building construction where a storage facility could be sited and include example affected environment and impact analyses information. The incorporated NEPA documents listed in Appendix A, Section A.5.2.2, *Existing NEPA Documentation*, evaluate building construction at potential locations for a HALEU storage facility and include example affected environment and impact analyses information used in developing the estimation of impacts associated with HALEU storage.

To accommodate a new storage facility and unknown project locations, this analysis follows the previously discussed approach, which differentiates impacts between existing sites, brownfield sites, and greenfield sites. To do so, DOE developed a conceptual design for a 145-MT HALEU storage facility and used this design to assess the impacts associated with the construction and operation of such a facility. Co-location of the storage facility at an **existing fuel cycle facility** would have SMALL impacts due to the small size of the storage facility, small number of employees, and the lack of any activities beyond receipt, storage, inspection, and shipment of the HALEU. Impacts at **brownfield sites** and **greenfield sites** were extrapolated using the existing NEPA documents listed in Appendix A, Section A.5.2.2, *Existing NEPA Documentation*. Table 3.5-1 presents a summary of environmental consequences associated with HALEU storage. Section 3.5.1, *Ecological Resources*, and Section 3.5.2, *Historic and Cultural Resources*, summarize the impacts associated with the respective resource areas that were determined to have potentially MODERATE or LARGE impacts. Additional details on HALEU storage are presented in Appendix A, Section A.5, *HALEU Storage.*

Table 3.5-1. Summary of Environmental Consequences – HALEU Storage

Activity	*Located at Existing Uranium Fuel Cycle Facility*	*Located at Other Non-Uranium Fuel Cycle Facility Industrial Site*	*Located on Previously Undisturbed Land*
HALEU Storage	Construction and operation of a HALEU storage facility would disturb approximately 1 acre, there would be no routine emissions of hazardous or radioactive materials, and the facility would be operated by only a few employees; therefore, the impacts of construction and operation of such a facility would likely be SMALL for all resource areas regardless of the location.		Due to site-specific conditions at a greenfield site, potentially MODERATE impacts to ecological resources and historic and cultural resources could result. Impacts would be predominately associated with construction activities and should be amenable to mitigation.

Key: HALEU = high-assay low-enriched uranium

Notes: As most resource area impacts are expected to be SMALL, it is reasonable to assume that resource area impacts on communities with environmental justice concerns would also be SMALL at brownfield and greenfield sites. However, site-specific analysis would be needed to determine whether disproportionate and adverse impacts could occur. Site-specific information is not available at this time but will be required as a part of the NRC NEPA process.

3.5.1 Ecological Resources

Ecological impacts to construct a new HALEU storage facility at an **existing fuel cycle facility** are expected to be SMALL, as construction would only be expected to disturb 1 acre. Impacts on ecological resources could also be SMALL if new construction were to occur within a **brownfield site**, as these areas are subject to frequent disturbance from human activity, grounds maintenance, or disruptions from ongoing facility operations, and native habitats are no longer present or have likely degraded over time. Construction and operation impacts at a **greenfield site** could have SMALL to MODERATE impacts on ecological resources depending on the resources disturbed and the mitigation and minimization measures employed. The degree of impact, while limited due to the relatively small size of the facility and the implementation of BMPs, would be dependent upon the ecological characteristics of the selected site. An inventory of threatened or endangered species would be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing/avoiding adverse impacts. Therefore, ecological resources impacts would likely be SMALL to MODERATE, depending on site-specific habitat and presence of threatened or endangered species.

3.5.2 Historic and Cultural Resources

Construction and operation of a new HALEU storage facility at an **existing fuel cycle facility** or **brownfield site** would likely occur on previously surveyed and disturbed areas and, therefore, would likely have SMALL impacts on historic and cultural resources. Construction of a HALEU storage facility at a **greenfield site** has the potential to impact historic and cultural resources. The degree of impact, while limited due to the relatively small size of the facility (1 acre of land) and the expected implementation of BMPs, would be dependent upon the historic and cultural characteristics of the selected site. Because of this, construction impacts are expected to be SMALL to MODERATE. Impacts from operations would be SMALL.

3.6 Transportation

The Proposed Action would require the transportation of radioactive materials between the facilities associated with HALEU production. Because of conservative assumptions, the transportation analysis is expected to bound the impacts regardless of the location of facilities at **existing facilities**, **brownfield sites**, or **greenfield sites**.[66] The impacts of transporting radioactive materials for the Proposed Action would be SMALL across all location scenarios. The impacts of transportation of these materials are evaluated in more detail in Appendix A*, Environmental Consequences Supporting Information.* Table A-7 in Appendix A summarizes the results of the transportation impacts for the various Proposed Action activities, along with the sources of NEPA documentation and major assumptions. As shown in that table, and consistent with the expectation as concluded in 10 CFR 51[67], the impacts of transporting radioactive materials associated with the Proposed Action and post-Proposed Action HALEU-related activities would be SMALL.

Table 3.6-1 presents a summary of environmental consequences associated with transportation. Section 3.6.1, *Impacts Across Activities*, briefly describes the analysis of impacts due to transportation

[66] The transportation analysis used the maximum distances between existing facilities and therefore presents a conservative estimate of impacts. This analysis likely bounds the impacts of transportation between existing facilities, brownfield sites, and greenfield sites.

[67] 10 CFR 51.52 includes a basis for the evaluation of environmental effects of transporting nuclear material for fuel cycle facilities and reactor operations. Transportation of material impacts for the Proposed Action are consistent with this basis.

across all Proposed Action and post-Proposed Action activities. The impacts of GHGs emitted by transportation vehicles is evaluated in Section 4.3.2, *Greenhouse Gases and Climate Change*.

Table 3.6-1. Summary of Environmental Consequences – Transportation

Activity	*Located at Existing Uranium Fuel Cycle Facility*	*Located at Other Non-Uranium Fuel Cycle Facility Industrial Site*	*Located on Previously Undisturbed Land*
Transportation	The radiological impacts from low levels of radiation emitted during incident-free transportation and from the accidental release of radioactive materials and the nonradiological impacts from accident fatalities resulting from the physical forces of the accident are SMALL for all transportation activities between HALEU fuel cycle facilities.		

Key: HALEU = high-assay low-enriched uranium

3.6.1 Impacts Across Activities

The NRC issued two Generic Environmental Impact Statements (GEISs) for uranium recovery using the conventional mining and milling (NRC, 1980) and ISR mining (NRC, 2009a). These GEISs concluded that the impacts of transporting various radioactive materials to and from the uranium recovery sites would be SMALL. The NRC has also issued Environmental Assessments (EAs) or EISs for the conversion facility, enrichment facilities, and fuel fabrication facilities, all showing the impacts of radioactive materials transportation to be SMALL, as well.

The Proposed Action activities, including uranium recovery, conversion, and shipments of UF_6 to and from enrichment facilities are similar to those for the activities evaluated in the NEPA documents described in the previous paragraph. The transport of HALEU in the form of UF_6 to the fuel fabrication facilities is also similar to those used in the LWRs fuel cycle, but with a criticality modified packaging with lower quantities of enriched uranium per shipment. The HALEU fuel may be used in ANRs, as well as research reactors. Several of the potential non-LWR designs are expected to deploy non-UO_2 fuels (e.g., uranium metal, uranium carbide, uranium in a molten salt, etc.) or rely on up-recycled fissile material. In the ANR GEIS (NUREG-2249) (NRC, 2021c), the NRC evaluated the various potential fuel fabrication needs for ANRs. In Section 3.14 of the ANR GEIS, the NRC concluded that Table S-3 is expected to bound the impacts for ANRs that rely on uranium oxycarbide/UO_2 fuels resulting in SMALL impacts (NRC, 2021c, pp. 3-169). The fabrication of other types of reactor fuels would require project-specific analysis. The treatment and management of the SNF in both the LWRs and the ANRs using HALEU are the same. Consistent with the findings in the NRC 2014 final rule on the environmental effects of continued storage of SNF (10 CFR 51) and NUREG-2157, the *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NRC, 2014), the ANR GEIS concluded that impacts from continued storage of SNF for 60 years, including the potential impacts of transporting the SNF to a final repository would be SMALL. For the transportation of SNF, the NRC staff concluded that the radiological doses would be expected to continue to remain below the regulatory dose limits during continued storage and all of the related activities would have small environmental impacts (NRC, 2014, p. § 4.16).

Notwithstanding the above conclusions, an evaluation of transportation impacts for the Proposed Action activities was conducted (see Appendix A, Section A.6, *Transportation*). As discussed in Appendix A, the human health transportation risk analysis in this HALEU EIS incorporates by reference resource conditions and impact considerations of the existing primary generic NEPA documents, as well as other related online/available sources including site-specific NEPA documents and Federal and state databases. The analysis provides a range of potential impacts that could occur for transporting various radioactive materials (e.g., feed, product, and wastes) from each HALEU production activity.

3.7 Related Post-Proposed Action Activities

In addition to the above actions that are a direct part of the Proposed Action, discussions of other actions that would be expected from use of the 290 MT of HALEU produced under the Proposed Action are acknowledged as reasonably foreseeable activities, but are discussed in less detail given their more uncertain nature. These actions include the following:

- Construction and operation of a facility or facilities for fabrication of metal, oxide, and TRISO reactor fuel
- Construction and operation of commercial advanced reactors that use HALEU fuel and the use of HALEU fuel in existing demonstration, test, and isotope production reactors
- HALEU SNF storage and disposition

These actions are dependent upon decisions outside of the Proposed Action activities. The extent to which these actions happen and if so, where they would happen is unknown and highly speculative. Therefore, detailed assessment of their total impacts is not possible. These activities are described in more detail in Section 2.1.7.1, *HALEU Fuel Fabrication Facilities*, Section 2.1.7.2, *HALEU-Fueled Reactors*, and Section 2.1.7.3, *HALEU Spent Nuclear Storage and Disposition*.

3.7.1 HALEU Fuel Fabrication Facilities

Fuel fabrication is the last step in the process of turning uranium into nuclear fuel. HALEU fuel fabrication facilities would convert HALEU into fuel for nuclear reactors. Depending on the reactor design, a fuel fabrication facility could produce nuclear fuels of varying forms such as uranium oxide fuel, metal fuel, molten salt fuel, TRISO particle fuel, uranium nitride fuel, and advanced ceramic fuel. Because information on construction and operation of facilities to fabricate metal fuel, molten salt fuel, uranium nitride fuel, and advanced ceramic fuel is lacking, this EIS concentrates on fabrication of uranium oxide fuel and TRISO fuel. The analysis in this section is based on one fuel fabrication facility with a capacity to produce 28 MT/yr of HALEU fuel in the form of an oxide. In order to produce 56 MT/yr of HALEU fuel in the form of an oxide (equivalent to 50 MT of HALEU metal fuel) to supply advanced reactors, multiple HALEU fuel fabrication facilities would be needed. See Appendix A, Section A.7.1, *HALEU Fuel Fabrication*, for relevant source documents and additional information.

A fuel fabrication facility could be sited anywhere in the United States as long as the facility meets NRC siting requirements. The production of HALEU may be accomplished through modification of an existing fuel fabrication facility or through development of a new fuel fabrication facility. To accommodate a new HALEU fuel fabrication facility and unknown project locations, this analysis addresses locating each HALEU fuel fabrication facility at **existing uranium fuel fabrication facility** sites, **brownfield sites**, and **greenfield sites**.

To accommodate the possibility of a new fuel fabrication facility and unknown project locations, this analysis follows the previously discussed approach, which differentiates impacts between existing sites, brownfield sites, and greenfield sites. Environmental consequences from a facility that fabricates HALEU fuel are expected to be similar to those at a facility that fabricates LEU fuel. Therefore, to accommodate the lack of an existing HALEU fuel fabrication facility, NEPA documents for existing LEU facilities (i.e., Framatome FFF, GNF-A, and the Westinghouse Electric Company FFF) were used. An Environmental Report also exists for a fuel fabrication facility at a greenfield site (i.e., TRISO-X FFF). These NEPA documents provide a basis for the environmental impacts at a greenfield site. Impacts at a brownfield site are extrapolated from the source documents for the above facilities. The incorporated NEPA documents are listed in Appendix A, Section A.7.1.2.2, *Existing NEPA Documentation*.

The LEU fuel fabrication facilities considered in this analysis have throughputs ranging from 400 to 1,600 MT uranium per year. To achieve the Proposed Action of 290 MT of HALEU, approximately 50 MT/yr of HALEU metal fuel (or 56 MT of HALEU oxide fuel) would need to be produced. This would likely be produced in multiple fuel fabrication facilities. Therefore, many of the attributes of the LEU fuel fabrication facilities would be much larger than needed for a HALEU fuel fabrication facility and would likely bound the impacts of a HALEU fuel fabrication facility. Table 3.7-1 presents a summary of environmental consequences associated with HALEU fuel fabrication. Section 3.7.1.1, *Visual and Scenic Resources*, through Section 3.7.1.9, *Environmental Justice*, summarize the impacts associated with the respective resource areas that were determined to have potentially MODERATE or LARGE impacts. Additional details on HALEU fuel fabrication are presented in Appendix A, Section A.7.1, *HALEU Fuel Fabrication.*

Table 3.7-1. Summary of Environmental Consequences – HALEU Fuel Fabrication Facility

Activity	*Located at Existing Uranium Fuel Cycle Facility*	*Located at Other Non-Uranium Fuel Cycle Facility Industrial Site*	*Located on Previously Undisturbed Land*
HALEU Fuel Fabrication Facility	Overall, the potential environmental consequences are SMALL for land use, air quality, ecological resources, infrastructure, noise, waste management, and public and occupational health – normal operations. SMALL to MODERATE impacts were identified for visual resources, geology and soils, water resources, historic and cultural resources, public and occupational health – accidents, traffic, socioeconomics, and environmental justice. All but public and occupational health – accidents are related to construction and site-specific conditions. Mitigative actions would be expected to be identified during site-specific environmental analyses.		Potentially MODERATE impacts in ecological resources could result from construction at a greenfield site. Mitigative actions would be expected to be identified during site-specific environmental analyses.

Key: HALEU = high-assay low-enriched uranium

3.7.1.1 Visual and Scenic Resources

Impacts on visual and scenic resources from construction and operation of a HALEU fuel fabrication facility at an **existing fuel fabrication facility** are likely to be SMALL to MODERATE. The visual character at existing fuel fabrication facilities is unlikely to change with the addition of the structures needed for a HALEU fuel fabrication facility. Temporary visual intrusions may result from the use of tall cranes and large construction equipment, but these impacts would be temporary and localized. Impacts on visual and scenic resources from construction and operation at a **brownfield site** would be similar to the impacts described for an existing site given the new facility most likely would be in an area zoned for industrial use, and new structures would be similar in character and size to existing structures. Impacts to visual and scenic resources from construction and operation at the TRISO-X FFF (**greenfield site**) are expected to be SMALL. Impacts to visual and scenic resources at other greenfield sites could be MODERATE due to visual disturbances being more pronounced in rural, previously undeveloped areas where the baseline visual landscape is less disturbed. Vegetation clearing and introduction of drilling rigs and roadways could also result in visual contrasts with the baseline landscape.

3.7.1.2 Geology and Soils

Impacts on geology and soils from construction and operation of a HALEU fuel fabrication facility at an **existing fuel fabrication facility** are likely to be SMALL to MODERATE. Potential impacts include disturbance of up to approximately 40 acres of previously disturbed soils, soil erosion due to ground disturbance, and the potential for spills due to construction and operations. Impacts to soils from the construction of a HALEU fuel fabrication facility include erosion, compaction, and sedimentation, mainly due to grading and excavation activities. Implementation of BMPs for erosion control and spill prevention would be expected to limit these impacts to a SMALL to MODERATE level. MODERATE impacts were estimated for the existing GNF-A fuel fabrication facility site near Wilmington, North Carolina, due to the potential to disturb existing soil contamination. Impacts on geology and soils from construction and operation at a **brownfield site** would likely have the same impacts as described in the existing fuel fabrication facility. However, many of the existing LEU facilities are designed to produce LEU fuel at capacities that are much larger than 50 MT/yr[68] assumed for this EIS. Therefore, the impacts from the Proposed Action are expected to be bounded by the existing NEPA documents, but are expected to be smaller in scale. Impacts on geology and soils from construction and operation at the TRISO-X FFF (**greenfield site**) are expected to be SMALL. Impacts from construction and operation at other greenfield sites are expected to be similar to the TRISO-X FFF, but specific site characteristics would also need to be considered. To address uncertainties about sensitive geologies and erosion potentials, impacts would likely be SMALL to MODERATE, but they are likely to be smaller in scale than previously evaluated NEPA documents.

3.7.1.3 Water Resources

The small permitted and monitored effluent discharges from construction and operation of a HALEU fuel fabrication facility at an **existing fuel fabrication facility** would be expected to have generally SMALL impacts to water quality, although site-specific conditions (such as proximity to surface waters and availability of municipal water supply) could result in MODERATE impacts. Additionally, water consumption, either from surface waters or groundwater is unlikely to impact water levels, although site-specific environmental analysis would likely be required if a facility is constructed in an area not previously analyzed. Construction and operation impacts on water resources at a **brownfield site** would be expected to be similar to the impacts described under existing facilities. Impacts on water resources from construction and operation at the TRISO-X FFF (**greenfield site**) are expected to be SMALL. Construction and operation impacts on water resources at other greenfield sites could be SMALL to MODERATE and would depend on site-specific conditions. If floodplains or areas with sensitive water resources could not be fully avoided, consultation and permitting under the Federal Clean Water Act, as well as state and local water regulations, may be required. Generally, low levels of contaminants and the use of BMPs for capturing and treating effluent on-site would be expected to be included to prevent process waters from leaving the site. As necessary, NPDES permits would be required for authorized discharges during construction or operation to the surface waters near any proposed facility.

3.7.1.4 Ecological Resources

Impacts on ecological resources from construction and operation of a HALEU fuel fabrication facility at an **existing fuel fabrication facility** are likely to be SMALL. Construction of a HALEU fuel fabrication facility at new locations has the potential to impact terrestrial and aquatic resources, wetlands, and threatened

[68] 50 MT per year is the production rate assumed for the analysis of Proposed Action production total of 290 MT of HALEU.

and endangered species. Construction and operation at a **brownfield site** would likely be SMALL, as these areas are subject to frequent disturbance from human activity, grounds maintenance, or disruptions from ongoing facility operations, and native habitats are no longer present or have likely degraded over time. Impacts on ecological resources from construction and operation at the TRISO-X FFF (**greenfield site**) are expected to be SMALL. Construction and operation impacts at other greenfield sites could have SMALL, to MODERATE impacts on ecological resources depending on the resources disturbed and the mitigation and minimization measures employed. The degree of impact, while limited due to the relatively small size of the facility and the implementation of BMPs, would be dependent upon the ecological characteristics of the selected site. An inventory of threatened or endangered species would be developed during site-specific reviews to identify unique or special habitats, and Endangered Species Act consultations conducted with the U.S. Fish and Wildlife Service would assist in reducing/avoiding adverse impacts. Therefore, ecological resources impacts would likely be SMALL to MODERATE, depending on site-specific habitat and presence of threatened or endangered species.

3.7.1.5 Historic and Cultural Resources

Impacts on historic and cultural resources from construction and operation of a HALEU fuel fabrication facility at an **existing fuel fabrication facility** are likely to be SMALL to MODERATE as construction at the Framatome or Ultra Safe Nuclear Corporation site have the potential to be in areas that contain historic and cultural resources. This range accommodates the uncertainty of a new HALEU fuel facility's proximity to historic and cultural resources. Impacts on historic and cultural resources during construction and operation at a **brownfield site** would likely be similar and would have SMALL to MODERATE impacts as construction would occur on previously surveyed and disturbed areas. Site selection for a new HALEU fuel fabrication facility at a brownfield site would be expected to avoid areas with known cultural resources, and measures to identify resources and mitigate potential impacts through National Historic Preservation Act Section 106 and environmental review processes. Impacts on historic and cultural resources from construction and operation at the TRISO-X FFF (**greenfield site**) are expected to be SMALL. The degree of impact at other greenfield sites would be dependent upon the characteristics of the selected site, and impacts to historic and cultural resources could be mitigated through measures such as license conditions. Because of this, construction impacts at other greenfield sites are expected to be SMALL to MODERATE.

3.7.1.6 Public and Occupational Health—Facility Accidents

The most significant radiological accident consequences, of the accident scenarios analyzed in **existing fuel fabrication facilities**, are those associated with a fire or an inadvertent nuclear criticality. Criticality could be fatal to an involved worker. Facility design would reduce the likelihood of a fire and the use of safe-by-design components would prevent an inadvertent nuclear criticality. The radiological accidents would have low consequences and risk to the public and therefore, SMALL impacts. Chemical accidents could have SMALL to MODERATE impacts to the public if they were to occur although the chance of occurrence is low. The construction and operation impacts on public and occupational health at a facility accident during construction and operation at a **brownfield site** are expected to be similar to those described under the existing scenario, as the citing criteria (which defines a safe buffer zone between the facility and the public) would be site dependent to ensure public safety across different location scenarios. This means that despite higher population numbers in traditionally urban areas, the effects would not be more severe as appropriate buffer zones would be expected to be in place. Impacts on public and occupational health in facility accidents from construction and operation at the TRISO-X FFF (**greenfield site**) are expected to be SMALL to MODERATE. Construction and operation impacts on public and occupational health at other greenfield sites are also expected to be similar to the impacts described at an existing site.

3.7.1.7 Traffic

Impacts on traffic from construction and operation of a HALEU fuel fabrication facility at an **existing fuel fabrication facility** could result in increased roadway congestion, delays, and safety hazards, especially during peak morning and evening commuting hours and some roadways would experience relatively high increases in daily traffic volumes. However, most of the new total AADT volumes would be expected to be within "Daily Design Capacity" volumes of these roadways as long as baseline AADT volumes do not substantially increase over the project timeframe. Because the total daily traffic volumes would be near or within the "Daily Design Capacity" volumes, the level of traffic impacts at the existing fuel fabrication facilities would be expected to range from SMALL to MODERATE during construction and operation. Construction and operation impacts to traffic would vary based on site-specific conditions but would likely be SMALL to MODERATE for construction for both **brownfield sites** and **greenfield sites**, including the TRISO-X FFF. Site selection for a HALEU facility is expected to include criteria for adequate site access and transportation infrastructure. These could include existing and projected AADT volumes and corresponding level of service values on principal roadways serving the site; weight, and size restrictions along potential truck routes; and major land development and/or infrastructure projects that would directly impact the principal roadways. Any project-related traffic studies conducted for the project would expect to be coordinated with local, county, and state transportation departments.

3.7.1.8 Socioeconomics

Impacts on socioeconomics from construction and operation of a HALEU fuel fabrication facility at an **existing fuel fabrication facility** could result in SMALL to MODERATE impacts depending on the size of the in-migrating workforce and where they choose to reside. For example, the impacts to a host county, especially if it is rural in nature with a low population, may be MODERATE if a large percentage of the incoming workforce wanted to live close to work. Similarly, economic impacts would be SMALL to MODERATE depending on the size of the incoming population, but they would all be considered beneficial. The construction and operation impact on socioeconomics during construction and operation at a **brownfield site** are expected to be similar to those described under the existing scenario. Impacts on socioeconomics from construction and operation at the TRISO-X FFF (**greenfield site**) are expected to be SMALL. Construction and operation at other greenfield sites is expected to be similar to the impacts (SMALL to MODERATE) described under the existing scenario.

3.7.1.9 Environmental Justice

Impacts on communities with environmental justice concerns from construction and operation of a HALEU fuel fabrication facility at an **existing fuel fabrication facility** are likely to be SMALL. Construction, operation, and decommissioning of a HALEU fuel fabrication facility would not be expected to result in disproportionate and adverse impacts to communities with environmental justice concerns within the ROI. Impacts on communities with environmental justice concerns from construction and operation at the TRISO-X FFF (**greenfield site**) are expected to be SMALL but could potentially be SMALL to MODERATE if a HALEU facility was placed at the proposed GLE facility (**greenfield site**). This increased impact rating is due to increased noise, dust, traffic, employment, and housing impacts on communities with environmental justice concerns. These impacts would be short term and limited to on-site activity. Impacts at these facilities would not be expected to cause disproportionate or adverse impacts due to the lack of communities with environmental justice concern in the immediate vicinity of these sites. Site selection at other **brownfield sites** and **greenfield sites** are expected to consider environmental, socioeconomic, and environmental justice factors. Impacts would be dependent on local and regional conditions for a proposed site, the potential adverse effects, and the presence of communities with environmental justice concerns in the ROI. At this time, DOE is unable to determine whether disproportionate and adverse impacts would be expected at either brownfield or greenfield sites as these impacts rely on site-specific analysis. However, the degree of impact is estimated to range from SMALL to MODERATE based on the range of fuel fabrication impacts on other resource areas. Site-specific environmental justice analysis would be required as part of the licensing process for any new facility by the NRC.

3.7.2 HALEU-Fueled Reactors

HALEU could be used to power ANRs. Commercial HALEU-fueled reactors would be licensed by the NRC. Table 3.7-2 presents a summary of environmental consequences associated with HALEU-fueled reactors. This section also briefly describes the analysis of impacts associated with HALEU use in ANRs. The construction and operation of these reactors are discussed in more detail in Appendix A, Section A.7.2, *Construction and Operation of Reactors.*

Table 3.7-2. Summary of Environmental Consequences – HALEU Use in Advanced Nuclear Reactors

Activity	*Located at Existing Uranium Fuel Cycle Facility*	*Located at Other Non-Uranium Fuel Cycle Facility Industrial Site*	*Located on Previously Undisturbed Land*
HALEU Use in ANRs	The impacts from use of HALEU in advanced reactors are based on generic analyses in the ANR GEIS (NRC, 2021c). Therefore, no distinctions are made between impacts for the three site categories generally applied to the Proposed Action activities. The NRC in its evaluation of the impacts of advanced reactor construction and operation (NRC, 2021c) deferred impact assessments for some resource areas to site-specific analysis. The NRC identified the impacts as undetermined due to the site-specific nature of these impacts that could not be assessed generically. Selected topics in water resources, ecological resources, historic and cultural resources, public and occupational health – normal operations, and public and operational health – accidents, and environmental justice were given this designation. The analysis of environmental justice impacts was also deferred to a site-specific analysis.		

Key: ANR GEIS = Advanced Nuclear Reactor Generic Environmental Impact Statement; HALEU = high-assay low-enriched uranium; NRC = U.S. Nuclear Regulatory Commission

DOE's evaluation of impacts of construction and operation of HALEU-fueled reactors is based on the ANR GEIS (NRC, 2021c). The Draft ANR GEIS evaluates the potential environmental impacts of 121 issues relevant to constructing, operating, and decommissioning of ANRs. The 121 issues are spread across 20 topics that correspond to the resource areas and other topics evaluated in an EIS. The Draft ANR GEIS identifies 100 issues as Category 1 issues. Category 1 issues are those that the NRC staff has preliminarily determined that a generic conclusion regarding the potential environmental impacts of issuing a permit or license for an ANR can be reached, provided that the project is bounded by relevant Plant Parameter Envelope[69] and Site Parameter Envelope (SPE)[70] values and assumptions. Additionally, Category 1 issues are those that the NRC staff has preliminarily determined will result in no more than a SMALL adverse

[69] The PPE is a set of reactor- and owner-engineered parameters that are expected to bound the characteristics of a reactor that might be deployed.

[70] The SPE is a set of site parameters that are expected to bound the characteristics of a site where a reactor might be deployed. The SPE makes no differentiation between sites that could be considered brownfield or greenfield. This differentiation of impacts between existing fuel cycle facilities, brownfield sites, and greenfield sites used in the assessment of impacts from Proposed Action activities is thus not applicable to reactor siting and only a single impact assessment for each resource area is provided.

impact or will have a beneficial impact. The Draft ANR GEIS identifies 19 issues as Category 2 issues, which are those that the NRC staff has preliminarily determined cannot be resolved generically and for which the NRC staff, in its Draft Supplemental EIS,[71] must analyze in detail. Five of the 19 issues (i.e., purpose and need, need for power, site alternatives, energy alternatives, and system design alternatives) are not related to environmental impacts, which leaves 14 issues of concern. Finally, there are two issues related to electromagnetic fields that are designated as N/A (i.e., impacts are uncertain), which are neither Category 1 nor Category 2. The two issues that are uncertain currently cannot be evaluated because the relationship of these issues to their impacts is uncertain. The 14 Category 2 issues that the NRC has determined it will need to evaluate on a project and site-specific basis are listed below (NRC, 2021c):

1. Operations impacts on surface water quality degradation due to chemical and thermal discharges
2. Construction impacts on important terrestrial species and habitats—resources regulated under the Endangered Species Act (16 U.S.C. 1531–1544)
3. Operations impacts on important terrestrial species and habitats—resources regulated under the Endangered Species Act
4. Construction impacts on important aquatic species and habitats—resources regulated under the Endangered Species Act and Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.) (the "Magnuson-Stevens Act")
5. Operations thermal impacts on aquatic biota
6. Operations impacts and other effects of cooling-water discharges on aquatic biota
7. Operations impacts on important aquatic species and habitats—resources regulated under the Endangered Species Act and Magnuson-Stevens Act
8. Construction impacts on historic and cultural resources
9. Operation impacts on historic and cultural resources
10. Severe accidents
11. Construction environmental justice impacts
12. Operation environmental justice impacts
13. Climate change
14. Cumulative impacts

Therefore, it is likely that most issues (100 of 121 issues evaluated in the Draft ANR GEIS) arising from construction and operation of HALEU-fueled reactors would be Category 1 issues with SMALL impacts, and as described above, only 14 issues would need to be evaluated by the NRC on a project and site-specific basis. Project-specific NEPA documentation would be prepared by the NRC before any HALEU-fueled reactors are constructed and operated.

As described in Section 2.1.7.2, *HALEU-Fueled Reactors*, HALEU could also be used in demonstration and test reactors, and for isotope production. The use of HALEU fuel in existing demonstration, test, and isotope production reactors would be within the authorized operating envelope for the reactors and is not likely to appreciably change the environmental impacts of operation of the reactors. For new

[71] An NRC Supplemental EIS would be prepared for a specific reactor. A Supplemental EIS would tier from the ANR GEIS.

demonstration, test, and isotope production reactors, the impacts would be expected to be similar to those described above for new HALEU-fueled reactors in general.

3.7.3 HALEU Spent Nuclear Fuel Storage and Disposition

Table 3.7-3 presents a summary of environmental consequences associated with HALEU SNF storage and disposition. SNF storage and disposition is discussed in more detail in Appendix A, *Environmental Consequences Supporting Information*. SMALL impacts are not discussed further. For a full analysis of potential impacts, including SMALL impacts, see the incorporated NEPA documents listed in Appendix A, Section A.7.3.1.2, *Existing NEPA Documentation*.

This HALEU EIS does not anticipate the Proposed Action would require or result in the construction of additional SNF storage or disposal capacity. It is possible that some HALEU SNF may require treatment before storage or disposal, but the type of treatment needed is not known, and therefore the impacts of that treatment would be speculative. Additional NEPA evaluation would need to be completed for such SNF treatment methods.

Table 3.7-3. Summary of Environmental Consequences – HALEU Spent Nuclear Fuel Storage and Disposition

Activity	***Located at Existing Uranium Fuel Cycle Facility***	***Located at Other Non-Uranium Fuel Cycle Facility Industrial Site***	***Located on Previously Undisturbed Land***
HALEU SNF Storage and Disposition	At-reactor storage of HALEU SNF would have SMALL impacts for most resource areas. Because the reactor sites are unknown, there is the potential for MODERATE impacts from nonradioactive waste management and ecological resources (special status species and habitat) and historic and cultural resources. The HALEU SNF generated by activities related to the Proposed Action would not substantially add to the overall impacts of managing the nation's inventory of SNF.		

Key: HALEU = high-assay low-enriched uranium; SNF = spent nuclear fuel

Notes: As most resource area impacts are expected to be SMALL, it is reasonable to assume that resource area impacts on communities with environmental justice concerns would also be SMALL at brownfield and greenfield sites. However, site-specific analysis would be needed to determine whether disproportionate and adverse impacts could occur. Site-specific information is not available at this time but will be required as a part of the NRC NEPA process.

3.7.3.1 Storage of Spent Nuclear Fuel at the Reactor

In August 2014, the NRC published the *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel* (NRC, 2014) (the "SNF Storage GEIS"). The NRC considers the continued storage of SNF an activity that is similar for all commercial nuclear power plants and storage facilities. Therefore, a generic analysis was an appropriate, effective, and efficient method of evaluating the environmental impacts of continued storage. Because the timing of repository availability is uncertain, the SNF Storage GEIS analyzed potential environmental impacts over three possible timeframes: a short-term timeframe, which includes 60 years of continued storage after the end of a reactor's licensed life for operation; an additional 100-year timeframe (60 years plus 100 years) to address the potential for delay in repository availability; and a third, indefinite timeframe to address the possibility that a repository never becomes available. Section 3.7.3.1.1, *Ecological Resources*, through Section 3.7.3.1.3, *Waste Management – Nonradioactive Waste*, summarize the impacts associated with the respective resource areas that were determined to have potentially MODERATE or LARGE impacts. Impacts to other resource areas were determined to be SMALL.

3.7.3.1.1 Ecological Resources

Overall, three timeframes were addressed in the SNF Storage GEIS with potential impacts that could be SMALL, MODERATE, or LARGE. With regard to spent fuel pools at the reactor site, impacts on state-listed species and marine mammals would most likely be less than those experienced during the licensed life for operation of the reactor because of the smaller size of the spent fuel pool's cooling system and lower water demands when compared to those of an operating reactor. With regard to dry cask storage of spent fuel at an independent spent fuel storage installation (ISFSI), given the small size and ability to site ISFSI facilities away from sensitive ecological resources, the NRC concluded that continued storage of spent fuel in at-reactor ISFSIs would likely have minimal impacts on state-listed species, marine mammals, migratory birds, and bald and golden eagles. Impacts from indefinite storage, by extending the operation of the ISFSI on state-listed species, marine mammals, migratory birds, and bald and golden eagles would be minimal. In the unlikely situation that the continued operation of an ISFSI could affect federally listed species or designated critical habitat, and if the criteria are met in 50 CFR 402 for initiation or reinitiation of Endangered Species Act Section 7 consultation, then the NRC would be required to initiate or reinitiate Section 7 consultation with the National Marine Fisheries Services or U.S. Fish and Wildlife Service. The degree of impact, while limited due to the relatively small size of the facility and the implementation of BMPs, would be dependent upon the ecological characteristics of the selected site, and, therefore, could be SMALL, MODERATE, or LARGE (NRC, 2014).

3.7.3.1.2 Historic and Cultural Resources

Short-term storage at a reactor site is expected to have at most a SMALL additional impact when considered with the potential impact from construction and operation of a nuclear reactor. Long-term storage and indefinite storage could have SMALL to LARGE impacts. Impacts from continued operations and routine maintenance are expected to be SMALL during the long-term storage timeframe, similar to those described in the short-term storage timeframe. However, the NRC analysis addressed the possibility that additional construction could be required for long-term (construction of a dry transfer system) or indefinite storage (construction of a replacement ISFSI). Such actions would require site-specific environmental reviews and compliance with the National Historic Preservation Act of 1966 before making a decision on the licensing action (NRC, 2014).

It is possible that historic and cultural resources would be affected by construction activities during the long-term/indefinite timeframe because the initial ISFSI could be located within a less-disturbed area with historic and cultural resources. Further, the analysis considers uncertainties inherent in analyzing this resource area over long timeframes. These uncertainties include any future discovery of historic and cultural resources; resources that gain significance within the vicinity and the viewshed (e.g., nomination of a historic district) due to improvements in knowledge, technology, and excavation techniques (NRC, 2014).

3.7.3.1.3 Waste Management – Low-Level, Mixed, and Nonradioactive Waste

Indefinite Storage – Impacts would be SMALL to MODERATE. It is expected that sufficient low-level waste disposal capacity would be made available when needed. A relatively small quantity of mixed waste would be generated from indefinite storage, and proper management and disposal regulations would be followed. The amount of nonradioactive waste that would be generated and impacts to nonradioactive waste landfill capacity are difficult to accurately estimate for the indefinite storage timeframe and therefore could result in SMALL to MODERATE impacts (NRC, 2014).

3.7.3.2 Storage of Spent Nuclear Fuel at Consolidated Interim Storage Facilities

The NRC awarded construction and operating licenses to two consolidated interim storage facilities (CISFs) for SNF: (1) the Interim Storage Partners (ISP) CISF for SNF at the Waste Control Specialists facility in Andrews County, Texas; and (2) the Holtec International CISF for SNF in Lea County, New Mexico.

The environmental impacts associated with license applications for the ISP CISF for SNF at the Waste Control Specialists facility in Andrews County, Texas, and the Holtec International CISF for SNF in Lea County, New Mexico, were evaluated in the *Environmental Impact Statement for Interim Storage Partners LLC's License Application for a Consolidated Interim Storage Facility for Spent Nuclear Fuel in Andrews County, Texas* (NUREG-2239) (NRC, 2021d) and the *Environmental Impact Statement for the Holtec International's License Application for a Consolidated Interim Storage Facility for Spent Nuclear Fuel in Lea County, New Mexico* (NUREG-2237) (NRC, 2020), respectively. Both EISs concluded that impacts for construction, operation, and decommissioning of the facilities would have SMALL to MODERATE impacts for ecological resources and socioeconomics. For both facilities the amount of SNF produced as a result of implementation of the Proposed Action (up to 290 MT) would be a small portion of the total inventory of uranium authorized for storage (initial capacities of 5,000 and 8,680 MT, respectively). The addition of the relatively small amount of Proposed Action SNF to the much larger quantity of SNF analyzed in the NRC EISs for storage at CISFs would not result in a change to the analyzed impacts and would therefore be expected to have a SMALL impact in all resource areas.

3.7.3.3 Disposal of Spent Nuclear Fuel

The program for a geologic repository for SNF at Yucca Mountain, Nevada, has been terminated. However, DOE remains committed to meeting its obligations under the Nuclear Waste Policy Act to dispose of SNF (DOE, 2022). In the interim, as described above, SNF is being safely stored.

3.7.3.4 Conclusions

As discussed in Section 3.7.3.1, *Storage of Spent Nuclear Fuel at the Reactor*, at-reactor storage of SNF would have SMALL impacts for most resource areas. As described in this section, there is the potential for MODERATE to LARGE impacts on special status species and habitat, historic and cultural resources, and SMALL to MODERATE impacts from nonradioactive waste management. See Section 3.7.3.1 for more information.

The total HALEU SNF generated by the implementation of the Proposed Action would contain 290 MT of HALEU. This is 0.8% of the 40,000 MT uranium analyzed in the NRC EIS for storage at the proposed ISP CISF in Andrews County, Texas (NRC, 2021d, pp. 1-3) and 3.4% of the 8,680 MT uranium analyzed in the NRC EIS during the first phase of the proposed Holtec CISF in Lea County, New Mexico (NRC, 2022b, pp. 2-1). In addition, this is 0.4% of the 86,584 MT heavy metal of SNF in inventory in the United States in 2021 (DOE, 2021, p. 2). Because the HALEU SNF expected to be generated under the Proposed Action would be a small addition to existing commercial power reactor SNF, it would not be expected to add substantially to the overall impacts of managing and dispositioning SNF.

3.8 Potential Multiple Facilities and Simultaneous Activities

The potential environmental consequences are presented in previous sections of Chapter 3, *Affected Environment and Environmental Consequences*, for each Proposed Action activity for an individual location under three possible scenarios: (1) at an existing uranium fuel cycle facility, (2) at a new facility constructed on a brownfield site, and (3) at a new facility constructed on a greenfield site. While this

EIS evaluates potential environmental consequences associated with standalone locations for each of the Proposed Action activities, it is likely that the Proposed Action activities would take place at the same time and that multiple facilities may be used to accomplish each of the Proposed Action activities. It is also likely that locations of multiple facilities for any individual Proposed Action activity or simultaneous Proposed Action activities would be in different geographical locations that would not have overlapping ROIs and therefore would not have potential environmental consequences to the same receptors or populations for any given resource area. These conditions would apply to all the activities and resource areas except for nationwide and global impacts relating to transportation, ozone depletion, and climate change. Nationwide and global impacts are cumulative in nature and therefore, are discussed in Chapter 4, *Cumulative Effects*.

As described in Section 2.1, *Proposed Action and Related Activities*, HALEU production facilities could be located at the same site (i.e., co-located). For example, uranium enrichment, HALEU deconversion, and HALEU storage facilities could be co-located, and HALEU deconversion, HALEU storage, and HALEU fuel fabrication facilities could be co-located. As previously discussed, the selection of specific locations and facilities will not be a part of the Record of Decision for this EIS. Because environmental consequences information for the specific locations is not available, the impacts of co-location of HALEU facilities cannot be accurately estimated at this time. Although the impacts of co-located HALEU facilities are not estimated in this HALEU EIS, co-located facilities would likely share infrastructure and resources resulting in smaller overall facilities and reduced impacts. For example, co-located facilities could share office, warehouse, and parking facilities, and could share utility, waste management, and security infrastructure. This would likely result in efficiencies and could reduce the number of workers needed, material transports, and related impacts. Also, the HALEU storage facility would be so small (1 acre disturbed and only six employees needed) in comparison to other facilities that the additive impacts of co-location would be minimal. Although the impacts of co-located facilities are not estimated in this HALEU EIS, the available NEPA documents for the Framatome FFF, Columbia FFF, and GNF-A FFF included conversion of UF_6 to oxide and the fabrication of LEU reactor fuel. Therefore, these NEPA documents analyze co-location of LEU fuel cycle activities that would be similar to HALEU deconversion and HALEU fuel fabrication. Therefore, the impacts for a co-located HALEU deconversion and HALEU fuel fabrication facility at the Framatome FFF, Columbia FFF, and GNF-A FFF would likely be similar to the impacts described in Section 3.7.1, *HALEU Fuel Fabrication Facilities*, and Appendix A, Section A.7.1, *HALEU Fuel Fabrication*. In any event, co-located HALEU production facilities would be licensed by the NRC and subject to additional site-specific NEPA evaluation that would examine the impacts of co-location.

3.9 Nonproliferation and Terrorism Concerns

DOE received 26 comments from 13 individuals, including 10 individuals representing organizations, requesting that the EIS scope include consideration of U.S. and international proliferation and nonproliferation concerns associated with use and misuse of HALEU and supporting technologies with the implementation of the Proposed Action. One organization stated that "DOE must prepare a Nonproliferation Impact Assessment on the 'Proposed Action' and on any alternatives to it." Another organization suggested that the National Nuclear Security Administration, in coordination with DOE-NE, should assess nonproliferation and security risks associated with HALEU, its potential for expanded global use, and foster an international effort, which could be facilitated by the International Atomic Energy Agency (IAEA), to examine and address these risks. Another organization suggested "the EIS needs to fully assess the increased proliferation and security risks associated with the production, processing, and use of HALEU on the scale necessary to supply power reactors." Several of the commenting organizations, including the Union of Concerned Scientists (Lyman, 2018; Lyman, 2021) have previously expressed written nonproliferation concerns over the use of the widescale deployment of HALEU materials.

Others indicated that there were many proliferation issues associated with the use of HALEU fuel and that those issues should be considered in the EIS. The basic concern expressed was that the EIS should consider that higher enrichment of HALEU fuel makes it much more likely to be misused and that the security requirements should be much higher. Several expressed concerns that the EIS should address the international implications of U.S. deployment of HALEU fuels and suggested that the NRC, the IAEA, and others initiate studies to reduce the proliferation risks.

DOE acknowledges that the widescale deployment of HALEU fuels in U.S. reactors, which could be facilitated by the Proposed Action, does present different proliferation concerns than the use of LEU, but believes that (1) adequate controls are in place to reduce the proliferation concerns to acceptable levels and that (2) the benefits of use of HALEU in advanced reactors outweighs the potential proliferation risks. The U.S. Atomic Energy Commission considered the nonproliferation aspects in making the original determination of the boundary between LEU and HEU as part of the Atoms for Peace initiative and DOE has since accumulated decades of experience with the use of HALEU fuels and proliferation concerns. HALEU fuel was initially developed as a nonproliferation measure to replace the use of HEU in research reactors with a lower-enriched fuel that did not present the proliferation risks of HEU. The program to deploy HALEU fuel for research reactors instead of HEU has been widely implemented worldwide. Both the NRC domestically and the IAEA internationally have addressed the use of HALEU fuel and have implemented appropriate controls. Finally, the adoption and use of HALEU fuels is consistent with the March 2, 2023, National Security Memorandum 19 to Counter Weapons of Mass Destruction Terrorism and Advance Nuclear and Radioactive Material Security signed by President Biden. NRC regulations distinguish among uranium enriched to less than 10% U-235 (LEU), enriched to between 10% and 20% U-235 (HALEU), and that enriched to 20% or greater (HEU). The IAEA only distinguishes between material enriched to less than 20% U-235 (LEU) and that enriched to 20% or greater (HEU) for nonproliferation; it distinguishes between 10% and 20% for security at an elevated Category II security level from light water reactor fuel (IAEA NSS-13/INFCIRC 225/Rev 5).

Several organizations, including the National Academies of Science (NAS, 2023), have studied advanced reactors and reviewed many topics, including the proliferation impacts of the use of HALEU fuel. Specifically, the 2023 NAS report recommended the following:

> "**Finding 19:** Expanding the global use of high-assay low-enriched uranium (HALEU) would potentially exacerbate proliferation and security risks because of the potentially greater attractiveness of this material for nuclear weapons compared with the low-enriched uranium used in light water reactors. The increased number of sites using and states producing this material could provide more opportunity for diversion by state or nonstate actors" (NAS, 2023, p. 182).
>
> "**Recommendation M:** The U.S. National Nuclear Security Administration, in coordination with the U.S. Department of Energy's Office of Nuclear Energy, should assess proliferation and security risks associated with high-assay low-enriched uranium (HALEU) and its potential for expanded global use. In parallel, the U.S. Government should foster an international effort, which could be facilitated by the International Atomic Energy Agency, to examine and address these risks" (NAS, 2023, p. 182).
>
> "**Finding 20:** All of the advanced reactor fuel cycles will require rigorous measures for safeguards and security commensurate with the potential risks they pose."

> "**Recommendation N:** The U.S. Government should support the International Atomic Energy Agency's (IAEA's) development and application of effective safeguards for advanced reactor technologies by authorizing, via the U.S. interagency process, IAEA access through the eligible facilities list, especially to those advanced reactor systems for which the IAEA does not currently have safeguards experience. Developers of these types of advanced reactors and fuel cycle facilities should provide facility information to the IAEA to help with integration of safeguards considerations into the design process" (NAS, 2023, p. 183).
>
> "**Recommendation O:** The U.S. Nuclear Regulatory Commission should initiate a rulemaking to address the security and material accounting measures for high-assay low-enriched uranium (HALEU) and other attractive nuclear materials that may be present in advanced reactor fuel cycles" (NAS, 2023, p. 183).

These recommendations were also repeated by one of the scoping commenters and cited by another commenter.

With implementation of the Proposed Action, there would be increased production and presence of HALEU materials at U.S. enrichment facilities, storage facilities, deconversion facilities, fuel fabrication facilities, reactors, spent fuel, and transportation activities. According to NRC safeguard rules and requirements, inventories of 10 kg or more of uranium enriched between 10% and less than 20% U-235 are designated as NRC Category II, special nuclear material of moderate strategic significance. The NRC has determined this designation to be adequate for the protection of these inventories.

DOE expects that any new assessment would affirm the conclusion that the merits of the use of HALEU outweigh the nonproliferation risks involved. That conclusion itself is consistent with the original delineation between LEU and HEU made in the 1950s by the Atomic Energy Commission and ultimately implemented by the IAEA.

Specific Proliferation and Terrorism Concerns with the Deployment of HALEU

The scoping comments identify proliferation concerns related to the increased production and use of HALEU materials.

In fact, HALEU is defined to be "low" attractiveness from a proliferation perspective (Ebbinghaus et al., 2013). Furthermore, the IAEA defines LEU containing less than 20% U-235 as indirect use material, meaning it requires further enrichment to HEU for use in a nuclear weapon. The primary obstacle to enriching uranium to HEU is developing enrichment technology and infrastructure.

Likewise, concerns have been expressed overusing HALEU in a radiological dispersal device. However, HALEU up to 20% U-235 is not a major radiological concern since there is no appreciable difference in radiotoxicity between LEU and HALEU. Moreover, there are other more common radioactive sources that would be of higher concern.

Physical Security and Safeguards Requirements for HALEU

HALEU is a more attractive material for diversion and misuse than LEU and, more than 10 kg of U-235 as HALEU is considered an NRC Category II material. The IAEA also categorizes 10 kg or more of 10% to 20% enriched U-235 to category II for physical security (IAEA NSS13/table 1, p. 20). The NRC indicates that it is leveraging the agency's current experience (e.g., in licensing the fabrication of Naval and Research and Test Reactor fuel and certifying transportation packages for tri-structural isotropic particle fuel [TRISO fuel]) to ensure the safe fabrication, transportation, and storage of advanced reactor fuels and is actively reviewing license applications for fuel enrichment facilities and fuel fabrication facilities to produce and utilize HALEU (NRC, 2023b). The NRC issued a report to Congress indicating that the current NRC regulatory framework has sufficient flexibility to accommodate licensing reviews and decisions related to HALEU (NRC, 2021a). Details of the NRC requirements for HALEU NRC Category II material are specified in the NRC's *Fuel Cycle: Physical Security Requirements for Facilities with Category II SNM Information Sheet* (NRC, 2023c).

NNSA is also promoting the chance to consider safeguards and security by design for new reactors, which will incorporate safeguards and security features into the design as early as possible to achieve a risk and cost informed nonproliferation benefit, thereby avoiding costly retrofits down the line. This engineering approach can include fuel cycle facilities as well.

3.10 No Action Alternative

As described in Section 2.2, *No Action Alternative*, under the No Action Alternative, DOE would not acquire, through procurement from commercial sources, up to 290 MT of HALEU nor facilitate the establishment of commercial HALEU fuel production. Without DOE funding, the development of HALEU production capacity and use in reactor designs and reactors in the United States in the future would be uncertain. Potential scenarios could range from (1) no significant HALEU production ever materializing, with most reactor designs and reactors continuing to rely on LEU and LEU+ based fuel that can be produced in existing facilities to (2) significant HALEU production eventually developing as a result of commercial and/or foreign investment.

Under the scenario where no significant HALEU production materializes, there would be no immediate change to the status quo. Existing electrical generation capacity would continue to operate. Traditional electricity generation sources, including LWRs, hydroelectric, solar, wind, and fossil-fueled plants, would continue to be relied on to supply our nation's energy demand and energy security.

This could have adverse impacts on meeting GHG reduction goals. The full-lifecycle GHG emissions of coal and natural gas-power generation sources are substantially higher than for nuclear power. For instance, coal generates 820 g CO_2e/kWh of electricity, while natural gas produces 490 g CO_2e/kWh. Even hydroelectric and solar produce lifecycle emissions at 24 g CO_2e/kWh and 41 g CO_2e/kWh, respectively. In contrast, nuclear power produces 12 g CO_2e/kWh (Schlömer et al., 2014). Therefore, using coal or natural gas (and even hydroelectric and solar) to generate electricity would result in higher GHG emissions. Those higher GHG emissions from non-nuclear power could contribute to a greater rate of climate change. For further discussion of GHGs and climate change, see Section 4.3.2, *Greenhouse Gases and Climate Change*.

If significant HALEU production and use were to eventually develop as a result of commercial and/or foreign investment unaided by DOE, the impacts of that production could be similar to the impacts evaluated in this EIS for a similar level of HALEU production and use.

3.11 Potential Mitigation Measures

As indicated in this EIS, decisions regarding locations of specific activities are not part of the Proposed Action. Therefore, no location-specific mitigation measures are identified in this HALEU EIS.

However, implementation of the Proposed Action could result in HALEU production facilities being sited at various locations. The environmental impacts of such HALEU production facilities would be evaluated by the appropriate regulatory authority (e.g., the NRC under the requirements of NEPA, Agreement States, or other Federal agencies). Such site-specific NEPA and environmental evaluations would be expected to identify mitigation measures and/or the implementation of BMPs to reduce impacts. Mitigation measures would be expected to be described in those documents and then executed and tracked as required.

Chapter 4
Cumulative Effects

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4 CUMULATIVE EFFECTS

NEPA established the CEQ to oversee Federal environmental impact regulations. CEQ defines cumulative effects[72] as "effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.1(g)(3)). Cumulative effects can result from individually minor, but collectively significant, actions taking place over a period of time. Cumulative effects can also result from environmental disruptions that occur concurrently or near each other if there is insufficient time between disruptive events for the environment to recover (Spaling, 1994). The ROI is the geographic area over which past, present, and reasonably foreseeable actions could contribute to cumulative effects and is dependent on the type of resource analyzed.

The cumulative effects methodology and assumptions are briefly described in Section 4.0, *Methodology and Assumptions*. Cumulative effects are evaluated for HALEU spent nuclear fuel storage and disposition in Section 4.1, *HALEU Spent Nuclear Fuel Storage and Disposition*. Cumulative effects on nationwide radioactive materials transportation are analyzed in Section 4.2, *Nationwide Radioactive Materials Transportation*, and cumulative effects on ozone depletion and climate change are analyzed in Section 4.3, *Global Cumulative Effects*.

4.0 Methodology and Assumptions

Cumulative effects are typically evaluated by combining the effects of a proposed action with the effects of other past, present, and reasonably foreseeable actions[73] in the ROI. These other actions include on-site and off-site projects conducted by Federal, state, and local governments, the private sector, or individuals, that are within the ROIs of a proposed action. Information about actions is typically obtained from a review of site-specific plans and NEPA documents to determine if ongoing or reasonably foreseeable projects could contribute to environmental effects at the potentially affected sites.

As described in Section 1.0.6, *Current NEPA Status,* NEPA documentation exists for many of the activities that would be associated with a HALEU fuel cycle, especially for the production of LEU (a necessary step in the enrichment process to produce HALEU). Most, but not all, of those NEPA documents (see Appendix B, *Facility NEPA Documentation*) contain cumulative effects analyses for the specific facilities and locations. Generally, these assessments mirrored the impacts associated with the activity being analyzed in the document. That is, resource areas with SMALL impacts from the proposed activity, tended to have SMALL cumulative impacts. Similarly, so did resource areas with MODERATE or LARGE impacts. However, it is not possible to extrapolate that analysis to sites where no cumulative effects analysis has been performed. Because of the large number of activities and potential facilities evaluated in this HALEU EIS and the uncertainty of the numbers and locations of facilities, a cumulative effects analysis for the majority of Proposed Action and related activities is not possible. New or modified HALEU production facilities that would be licensed and subject to additional NEPA or equivalent state evaluation would be expected to include consideration of cumulative effects by the NRC, an Agreement State, or other Federal agencies.

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72 "Effects" and "impacts" are used interchangeably in this EIS.

73 Reasonably foreseeable, as defined in 40 CFR 1508.1(aa), "means sufficiently likely to occur such that a person of ordinary prudence would take it into account in reaching a decision."

However, there are some effects that are relatively independent of the location of the facilities needed to implement the Proposed Action and the associated activities. SNF would be created by the use of up to 290 MT of HALEU in reactor fuel. This fuel would contribute to the existing SNF inventory from operating commercial LWRs. Transportation impacts are dependent upon the type of material being shipped and the distances this material is shipped. While that would vary somewhat dependent upon site selection, the analysis performed in this HALEU EIS provides a conservative estimate that is expected to bound the impacts regardless of site selection. The generation of ozone-depleting chemicals is a function of the types of activities and materials used, and not location. Finally, GHG generation is also a function of the materials used (principally the burning of fossil fuels) as well as transportation mileage. Additionally, ozone depletion and GHG generation have effects that are global in nature and not limited to a facility's local ROI. The following sections discuss these effects.

4.1 HALEU Spent Nuclear Fuel Storage and Disposition

As described in Section 2.1.7.3, *HALEU Spent Nuclear Fuel Storage and Disposition,* HALEU SNF on-site storage is assumed to occur at the reactor generating the SNF. Off-site storage and disposition of HALEU SNF is assumed to occur at the facilities to be used for management of the much larger quantity of existing commercial power reactor SNF. The impacts of storage and disposition of HALEU SNF are evaluated in Section 3.7.3, *HALEU Spent Nuclear Fuel Storage and Disposition*.

The HALEU SNF generated by the HALEU Proposed Action over multiple years of reactor operation would contain a total of 290 MT of HALEU. This is 0.4% of the 86,584 MT heavy metal of SNF in inventory in the United States in 2021 (DOE, 2021, p. 2). Because the HALEU SNF expected to be generated under the Proposed Action would be a small addition to existing commercial power reactor SNF, the HALEU SNF would not substantially contribute to cumulative impacts of managing the nation's inventory of SNF and is not discussed further.

4.2 Nationwide Radioactive Materials Transportation

As described in Section 2.1.6, *HALEU Transportation*, Proposed Action activities would require the transportation of radioactive materials between the facilities associated with HALEU production. The impacts of transportation of these materials are presented in Section 3.6, *Transportation*.

The transportation of radioactive materials throughout the United States could result in radiation exposure to transportation workers and the general population. Cumulative radiological impacts from transportation are estimated using the dose to the workers and general population because dose can be directly related to LCFs using a cancer risk coefficient.

Table 4.2-1 summarizes cumulative transportation impacts. The transportation cumulative impacts analysis presented in Section 5.6 of the Versatile Test Reactor EIS (DOE, 2022) was used as the source of information for past, present, and reasonably foreseeable actions. The analysis included historical shipments, general radioactive materials transportation that was not related to any particular action, and reasonably foreseeable actions. The timeframe of the cumulative transportation impacts analysis began in 1943 and extends to 2090. As shown in Table 4.2-1, the transportation impacts from the Proposed Action are expected to be SMALL and would not substantially contribute to cumulative impacts.

Table 4.2-1. Cumulative Transportation-Related Radiological Doses and Latent Cancer Fatalities

Category	*Worker Dose (person-rem)*	*General Population Dose (person-rem)*
Cumulative Transportation-Related Radiological Doses – 1943 to 2090 [(a)]	430,000	441,000
Total Transportation impacts from the Proposed Action activities [(b)]	28	88
Total	**430,000**	**441,000**
Total LCFs [(c)]	**258**	**265**

Key: EIS = Environmental Impact Statement; HALEU = high-assay low-enriched uranium; LCF = latent cancer fatality;
Notes:

[a] Versatile Test Reactor EIS, Section 5.6 total impacts (DOE, 2022)

[b] Maximum transportation impacts for the Proposed Action are based on 6 years of operations and the production of 290 MT of HALEU (Leidos, 2023). The HALEU transportation analysis used the maximum distances between existing facilities and therefore presents a conservative estimate of impacts. This analysis likely bounds the impacts of transportation between potential facilities located at existing facilities, brownfield sites, and greenfield sites. Worker and population dose-risk (in terms of person-rem) are estimated by dividing the corresponding LCF values by 0.0006 (DOE, 2003).

[c] Total LCFs are calculated assuming 0.0006 LCFs per person-rem of exposure (DOE, 2003)

The total number of LCFs (both workers and the general population) estimated to result from radioactive material transportation over the period between 1943 and 2090 is about 523, or an average of about 4 LCFs per year. Over this same period (148 years), approximately 88.7 million people would have died from cancer, based on National Center for Health Statistics data. Based on the same data, over the 6 years of plant operations associated with the Proposed Action, over 3.5 million people are projected to die from cancer. The annual number of cancer deaths in the United States in 2019 was about 599,600 (CDC, 2021). The annual transportation-related LCFs (LCF risks of less than 0.02 for workers and 0.05 for the public) would be 0.0007% of the total annual number of cancer fatalities; therefore, this number is indistinguishable from the natural fluctuation in the total annual death rate from cancer and the impact would be SMALL.

4.3 Global Cumulative Effects

4.3.1 Ozone Depletion

Construction and operation activities associated with the Proposed Action and related activities are expected to be accomplished using materials and equipment that would be compliant with applicable ODS laws and regulations, including 40 CFR 82, *Protection of Stratospheric Ozone*. For example, these regulations no longer allow the use of certain ozone-depleting propellants in commercial spray cans and ozone-depleting fluids previously used in air-conditioning and refrigeration systems. Because of these restrictions on the use of ODSs, the Proposed Action is not expected to use substantial quantities of ODSs. Therefore, emissions of ODSs from the Proposed Action would be expected to be very small and would represent a negligible contribution to the destruction of Earth’s protective ozone layer.

4.3.2 Greenhouse Gases and Climate Change

Recent scientific evidence indicates a connection between increasing global temperatures and GHG emissions. Climate change associated with this global warming is projected to produce negative environmental, economic, and social consequences the globe (USGCRP, 2018; IPCC, 2023).

Observed changes due to global warming include rising temperatures, shrinking glaciers and sea ice, thawing permafrost, sea level rise, a lengthened growing season, increases in droughts and severe weather, and shifts in plant and animal ranges. Projections of long-term environmental impacts due to increased atmospheric GHGs include an increasing rate of sea level rise, changing weather patterns (e.g., increases in severity of storms and droughts), reducing winter snowpacks, changing local and regional ecosystems (with potential losses of species), and increasing mortality due to excessive heat and air pollution (USGCRP, 2018; IPCC, 2023).

Activities associated with the Proposed Action could occur at numerous locations within the United States. Detailed descriptions of projections of future climate change and environmental impacts for regions of the United States that encompass these locations are available in the *Fourth National Climate Assessment-Volume II–Impacts, Risks, and Adaptation in the United States* (USGCRP, 2018). Because of the large number of activities and potential facilities evaluated in this HALEU EIS and the uncertainty of the numbers and locations of facilities, specific climate change projections for each location are not described in this HALEU EIS.

The most common GHGs emitted from natural processes and human activities include CO_2, methane, and nitrous oxide. Each GHG is assigned a global warming potential (GWP) that equates to the ability of a gas or aerosol to trap heat in the atmosphere. The GWP rating system is normalized to CO_2, which has a value of one. For example, methane has a GWP of 28 over a 100-year timeframe, which means that it has a global warming effect that is 28 times greater than CO_2 on an equal-mass basis (EPA, 2023a). To simplify GHG analyses, total GHG emissions from a source are often expressed as a CO_2e (a carbon dioxide equivalent), which is calculated by multiplying the emissions of each GHG by its GWP and adding the results to produce a single, combined emission rate representing all GHGs. The main source of GHGs from human activities is the combustion of fossil fuels, such as natural gas, crude oil (including gasoline, diesel fuel, and heating oil), and coal (USGCRP, 2018). While methane and nitrous oxide have much higher GWPs than CO_2, CO_2 is emitted in such greater quantities that it is the overwhelming contributor to global CO_2e emissions from both natural processes and human activities.

Federal agencies address emissions of GHGs by reporting and meeting reductions mandated in Federal laws, Executive Orders, and agency policies. On January 9, 2023, the CEQ released interim guidance that describes how Federal agencies should consider the effects of GHGs and climate change in their NEPA reviews (CEQ, 2023). The interim guidance explains that agencies should (1) consider the potential effects of project alternatives on climate change, as indicated by its estimated GHG emissions, (2) determine the social cost of project GHGs, (3) determine project consistency with GHG plans and goals, (4) consider mitigations that will reduce project GHGs, (5) consider impacts to communities with environmental justice concerns, and (6) consider adaptation measures that would make the actions and affected communities more resilient to the effects of climate change. The following analysis considers aspects of the CEQ 2023 interim guidance.

Atmospheric levels of GHGs and their resulting effects on climate change are due to the vast number of sources of GHGs across the globe. The direct environmental effect of GHG emissions is an increase in global temperatures, which indirectly causes numerous environmental and social effects. Therefore, the ROI and potential effects of GHG emissions from the commercialization of HALEU production are by nature global and cumulative. Given the global nature of climate change and the current state of the science, it is not possible to directly link the emissions quantified for local actions to any specific climatological change or resulting environmental impact. Nonetheless, GHG emissions resulting from the Proposed Action are quantified in this EIS for use as indicators of their potential cumulative contributions to climate change effects and for making reasoned choices among alternatives.

It is unknown at this time where the various Proposed Action activities would take place across the United States. Therefore, to provide a bounding analysis of potential GHG emissions, low- and high-emission scenarios were developed for the cumulative Proposed Action activities and the post-Proposed Action activity of reactor operations and fuel fabrication. Table 4.3-1 presents estimates of low- and high-GHG emission scenarios that could occur from these activities. Emissions from these activities would add between 774,000 to 2.91 million MT of CO_2e emissions to global GHG emissions.

Offsetting the CO_2e emissions from Proposed Action and related activities presented in Table 4.3-1 would be the expected CO_2e emissions if the power was produced by existing electrical power generation sources within regions across the United States. The total electrical power that could be generated by advanced reactors with the use of the 290 MT of HALEU fuel is estimated to be roughly 50 gigawatt-years (electricity), or 438,000,000 MW-h. Factors used to estimate CO_2e emissions associated with this power output were obtained from the EPA eGRID program (EPA, 2023b). The eGRID factors are presented as pounds of CO_2e per MW-h for the combined electrical power generation sources within regions across the United States, including both renewable (such as wind power) and non-renewable (fossil fuel) generation sources. Because the regional location of potential HALEU-fueled advanced reactors is currently unknown, the analysis bounds potential CO_2e emissions estimates based on the lowest and highest emission factors from all regions within the United States. Using the eGRID factors, total CO_2e emitted from the generation of roughly 438,000,000 MW-h by existing electrical power generation sources could range from a low of 48.2 million MT to a high of 328.5 million MT, depending upon the mix of current generation capabilities assumed. These estimates reveal that electrical power generated by HALEU-fueled ANRs (total cumulative emissions, as presented in Table 4.3-1) could result in 94% to 99% lower CO_2e emissions, compared to power generated from combinations of existing sources. The emissions differences would be more pronounced where power generation introduced into a region by the HALEU program displaces more higher-emitting fossil fuel power generation sources than lower-emitting renewable power generation sources.

Table 4.3-1 also presents estimates of the SC-GHG for low- and high-emission scenarios estimated for the cumulative Proposed Action activities. The SC-GHG is the monetary value (in U.S. dollars) of the net harm to society associated with adding GHG emissions to the atmosphere (IWG, 2021). In principle, it includes the value of all climate change impacts, including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The range of SC-GHG values listed for the cumulative Proposed Action activities in Table 4.3-1 are due to different discount rates, as presented in IWG methodology, as well as the range of expected GHGs. The estimated SC-GHG for the Proposed Action would range from $13 million to $485 million. However, as presented above, power generated by the Proposed Action would likely displace power generated from higher-emitting sources and therefore could offset these SC-GHGs, which would result in a cumulative benefit to climate change.

Communities with environmental justice concerns located in proximity to activities and facilities associated with the Proposed Action could experience disproportionate impacts from climate change. As part of the environmental review process to site these specific activities, the lead agency should engage such communities in the scoping and project planning processes to understand any unique climate-related risks and concerns. In addition, that NEPA process should identify climate adaptation measures to enable these communities to be resilient to the effects of climate change. Implementation of these measures would help mitigate potential climate change impacts to communities with environmental justice concerns from activities associated with the Proposed Action.

Table 4.3-1. Total Greenhouse Gas Emissions and Social Cost for Cumulative Activities Associated with the Proposed Action

Activity	***Total GHG Emissions (CO_2e in MT)***	
	Low-Emissions Scenario	***High-Emissions Scenario***
Uranium Ore Mining and Milling [(a)]	695,317	1,473,763
Uranium Conversion [(b)]	32,912	36,512
HALEU Enrichment [(c)]	10,481	179,019
HALEU Deconversion [(d)]	253	2,953
HALEU Storage [(e)]	1,444	1,444
HALEU Fuel Fabrication [(f)]	7,215	9,915
HALEU Use in Advanced Reactors [(g)]	14,487	14,487
Material Transport by Truck [(h)]	12,274	1,191,021
Total Cumulative Emissions	**774,383**	**2,909,114**
Social Cost of CO_2e Emissions ($) [(i)]	**13,100,000 – 133,000,000**	**46,900,000 – 485,000,000**

Key: $ = U.S. dollars; CO_2e = carbon dioxide equivalent; GHG = greenhouse gas; HALEU = high-assay low-enriched uranium; MT = metric tons

Notes:

[a] The low and high scenarios are based on ISR (low) and conventional mining and milling (high) facilities.

[b] The low and high scenarios are based on operation of the Metropolis facility (low), and construction and operation of a new facility (high).

[c] The low and high scenarios are based on operation of an enrichment facility (low), and construction and operation of a new facility that requires more separative work units compared to the low-scenario facility (high).

[d] The low and high scenarios are based on operation of a deconversion facility (low), and construction and operation of a new facility (high).

[e] The low and high scenarios are based on operation of a storage facility (low), and construction and operation of a new facility (high).

[f] The low and high scenarios are based on operation of a fuel fabrication facility (low), and construction and operation of a new facility (high).

[g] The low and high scenarios are based on construction and operation of a new facility.

[h] These are based on the range in the number of truck trips described in Section A.6, *Transportation.*

[i] The SC-GHG is calculated by multiplying the annual project GHG emissions by discount rates listed in the informal working group methodology through the life of the project (IWG, 2021).

4.3.2.1 Effects of Climate Change on the Proposed Action Activities

Change in resilience is the effect of climate change on a proposed project. There are anticipated future climate change and environmental impacts for regions of the United States that encompass the potential locations of the Proposed Action activities (USGCRP, 2018). As part of the NEPA process to site these specific activities, the environmental review should identify climate adaptation measures that would mitigate the effects of climate change on proposed HALEU activities at these locations.

Chapter 5
Resource Commitments

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5 RESOURCE COMMITMENTS

This chapter describes any unavoidable adverse environmental impacts that could result from implementation of the Proposed Action; the irreversible and irretrievable commitments of resources; and the relationship between short-term uses of the environment and long-term productivity. Unavoidable adverse environmental impacts are impacts that would occur after implementation of any mitigation measures. Resources that would be irreversibly and irretrievably committed are those that cannot be recovered or recycled and those that are consumed or reduced to unrecoverable forms. The relationship between short-term uses of the environment and long-term productivity addresses issues associated with the condition and maintenance of existing environmental resources used to support the Proposed Action and the function of these resources after their use.

5.0 Unavoidable Adverse Environmental Impacts

Implementing the Proposed Action discussed in this HALEU EIS would result in unavoidable adverse environmental impacts. The impacts associated with construction and operations of HALEU facilities as a result of the implementation of the Proposed Action are described in Chapter 3, *Affected Environment and Environmental Consequences*. Most of these impacts are expected to be SMALL. The unavoidable adverse impacts arising from the No Action Alternative are those associated with increased generation of electricity by non-HALEU energy sources as discussed in Chapter 4, *Cumulative Effects,* Section 4.3.2, *Greenhouse Gases and Climate Change*.

5.1 Irreversible and Irretrievable Commitment of Resources

Implementation of the Proposed Action would entail the commitment of land, energy (e.g., electricity, fossil fuels) and water, and materials and resources (e.g., steel, concrete, crushed stone, soil, labor, and financial resources). In general, the commitments of energy, many materials, and labor, would be irreversible and, once committed, these resources would be unavailable for other purposes. However, the commitment is consistent with the purpose of and need for the Proposed Action.

5.1.1 Land

The development of HALEU commercialization infrastructure, primarily due to the construction of new facilities and expansion of mining operations will require the allocation of land resources rendering land use for other purposes unlikely in the foreseeable future. Appropriate land use planning and optimization would be expected to be undertaken to minimize the footprint and ensure efficient use of land resources.

5.1.2 Energy and Water

Energy is a resource that is irretrievable. During construction activities, there will be an increase in energy usage and consumption primarily in the form of gas and electricity for a temporary period. Moreover, water resources will be utilized during both the construction and operational phases of potential facilities and mines. These commitments are classified as irreversible and irretrievable due to their continuous necessity throughout the facilities' operational life cycles. Efficient resource management practices, energy conservation measures, and responsible water usage would expect to be implemented to minimize the overall impact and maximize resource efficiency.

5.1.3 Materials and Resources

The construction and operation of HALEU commercialization facilities requires various materials and resources, including raw materials, labor, and financial resources. Raw materials essential for construction would include crushed stone, sand, concrete, lumber, water, diesel fuel, gasoline, and steel. Construction would consume these materials, making them an irretrievable commitment. Human resources would also be committed to said activities making them unavailable for other projects during the period of their commitment. Finally, the implementation of the Proposed Action would require the commitment of financial resources by DOE; however, these commitments are consistent with the purpose and need for the Proposed Action as described in Chapter 1, *Introduction and Purpose and Need*. Resource conservation and waste management strategies would be expected to be employed to minimize overall demand and promote responsible resource utilization.

5.2 Relationship Between Short-Term Uses of the Environment and Long-Term Productivity

Activities associated with the Proposed Action that could be short-term uses of the environment would include construction and mining activities. The environmental impacts during construction would be relatively short term and expected to be mitigated by BMPs and efforts to restore disturbed habitat, vegetation, and soils to pre-existing conditions where possible. However, losses of wildlife and introduction of small amounts of radiological and nonradiological constituents in the air are possible. There could also be small releases into the water if there are water resources in close proximity to facilities. Disposal of waste may also require energy and labor. The long-term productivity of a functioning HALEU production infrastructure aims to contribute to energy diversification and reduce GHG emissions. It should be noted that all forms of energy production require short-term uses of the environment. Of all low-carbon sources, nuclear has the lowest spatial and material requirements due to the high energy density of uranium and resulting small footprint. For this reason, it can be argued that the Proposed Action offers a comparatively higher return on investment from its short-term commitments in terms of long-term productivity and decarbonization.

Chapter 6
Permits and Consultations

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6 PERMITS AND CONSULTATIONS

6.0 Applicable Permits

Implementation of the Proposed Action would require compliance with relevant existing environmental permits and/or modifications to those permits and NRC or Agreement State licenses. Acquisition of new permits/licenses may be required, particularly in the case of construction of new facilities necessary to support activities that cannot be conducted at existing facilities. As many locations are possibilities under the Proposed Action, a detailed list of existing permits and permits to be acquired is not provided in this document. Rather, a detailed list of permits for each site would be expected to be provided by the licensee during the site-specific environmental review process conducted in support of each site, once siting decisions have been made for each of the activities analyzed in this EIS.

Generally, permits would be required to manage air emissions (nonradioactive and radioactive), liquid effluents (construction- and operations-related stormwater discharges as well as wastewater discharges), and hazardous waste management. Additionally, impacts identified to Waters of the United States could require a Clean Water Act Section 404 permit in addition to any permits required by state or local regulation. In addition to the necessary Federal permits, the construction and operation of facilities needed to implement the Proposed Action would be subject to relevant Federal, state, and local permitting and licensing requirements.

Consultations with Federal, state, and local agencies and federally recognized Indian Tribes may be required and conducted prior to the disturbance of land and are usually related to biotic, cultural, or Tribal resources. These may include consultations under the Endangered Species Act and the National Historic Preservation Act.

Ecological resource consultations generally pertain to the potential for activities to disturb threatened or endangered species, migratory birds, or their critical habitats. Cultural resource consultations relate to the potential for disruption of historic resources or archaeological sites, especially potential adverse impacts to historic properties that are listed or eligible for listing on the National Register of Historic Places. Government to government consultations between a Federal agency and Indian Tribes would be concerned with the potential for impacts on Tribal rights and interests, including the disturbance of ancestral Tribal sites, traditional and religious practices of Indian Tribes, and natural resources of importance to Indian Tribes.

While many locations are possibilities under the Proposed Action, site-specific consultations are expected to need to be undertaken once sites are identified and site-specific environmental review/NEPA analysis is conducted. Necessary consultations that have been completed for existing facilities under consideration in this HALEU EIS for potential co-location with HALEU facilities are detailed in existing NEPA documentation. As siting decisions are not part of the Proposed Action analyzed in this EIS, consultations for siting are not being conducted or planned for purposes of this EIS.

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Chapter 7
Glossary

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7 GLOSSARY

***air pollutant* —** Generally, an airborne substance that could, in high enough concentrations, harm living things or cause damage to materials. From a regulatory perspective, an air pollutant is a substance for which emissions or atmospheric concentrations are regulated, or for which maximum guideline levels have been established because of potential harmful effects on human health and welfare.

***air quality* —** The cleanliness of the air as measured by the levels of pollutants relative to standards or guideline levels established to protect human health and welfare.

***alpha particle* —** Alpha particles consist of two protons and two neutrons. They can travel only a few centimeters in air and can be stopped easily by a sheet of paper or by the skin's surface. (See *neutron*.)

***ambient air quality standards* —** Regulations prescribing the levels of airborne pollutants that may not be exceeded during a specified time within a defined area.

***aquifer* —** A body of rock that is sufficiently porous and permeable (i.e., contains spaces between the rock and soil particles that permit water to move through) to store, transmit, and yield significant quantities of groundwater to wells and springs.

***archaeological resources* —** Resources that occur in places where people altered the ground surface or left artifacts or other physical remains (e.g., arrowheads, glass bottles, pottery). Archaeological resources can be classified as either sites or isolates. Isolates generally cover a small area and often contain only one or two artifacts, while sites are usually larger in size, contain more artifacts, and sometimes contain features or structures. Archaeological resources can date to either the pre-contact, ethnographic, or post-contact eras.

***architectural resources* —** Standing buildings, facilities, wells, canals, bridges, and other such structures.

***area of potential effects* —** The geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist.

***attainment area* —** An area that the U.S. Environmental Protection Agency has designated as meeting (i.e., being in attainment of) the National Ambient Air Quality Standards for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, or particulate matter.

***average daily traffic* —** The average number of vehicles passing a specific point in both directions in a 24-hour period, normally measured throughout a year.

***average individual* —** A member of the public who receives the average dose as determined by dividing the off-site population dose by the number of people in the population.

***background man-made radiation* —** Man-made sources include medical and dental x-rays, household smoke detectors, and materials released from nuclear and coal-fired power plants.

***background natural radiation* —** Globally, humans are exposed constantly to radiation from the solar system and Earth's rocks and soil. This natural radiation contributes to the natural background radiation that always surrounds us.

***bedrock* —** Solid rock underlying loose deposits, such as soil or alluvium.

***beta particle* —** Beta particles are smaller and lighter than alpha particles and have the mass of a single electron. A high-energy beta particle can travel a few meters in air. Beta particles can pass through a sheet of paper but may be stopped by a thin sheet of aluminum or glass. (See *alpha particle*.)

blowdown — Depressurization of the mobile microreactor to equalize the pressure vessel to atmospheric pressures.

brownfield site — A previously developed, industrial location.

cancer fatality — A death resulting from cancer; also referred to as cancer mortality.

cancer incidence — The occurrence of a cancer; also referred to as cancer morbidity.

carbon dioxide equivalent (CO_2e) — To simplify greenhouse gas (GHG) analyses, total GHG emissions from a source are often expressed as a carbon dioxide (CO_2) equivalent (CO_2e), which is calculated by multiplying the emissions of each GHG by its global warming potential (GWP) and adding the results together to produce a single, combined emission rate representing all GHGs. While methane and nitrous oxide have much higher GWPs than CO_2, CO_2 is emitted in such greater quantities that it is the overwhelming contributor to global CO_2e emissions from both natural processes and human activities. (See *global warming potential*.)

collective dose — The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation. In this document, collective dose is expressed in units of person-rem.

concentration — The quantity of a substance in a unit quantity (e.g., milligrams per liter or micrograms per kilogram).

Council on Environmental Quality regulations — Regulations found in Title 40, Code of Federal Regulations, Parts 1500–1508, that direct Federal agencies in complying with the procedures of and achieving the goals of the National Environmental Policy Act.

core — The central portion of a nuclear reactor. The active core is where nuclear fission occurs.

criteria pollutants — An air pollutant that is regulated by the National Ambient Air Quality Standards. The U.S. Environmental Protection Agency must describe the characteristics and potential health and welfare effects that form the basis for setting, or revising, the standard for each regulated pollutant. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter (less than 10 microns [0.0004 inches] in diameter and less than 2.5 microns [0.0001 inches] in diameter). New pollutants may be added to or removed from the list of criteria pollutants as more information becomes available.

criticality — The normal operating condition of a reactor, in which nuclear fuel sustains a fission chain reaction. A reactor achieves criticality (and is said to be critical) when each fission event releases a sufficient number of neutrons to sustain an ongoing series of reactions.

cultural resources — A pre-contact or historic district, site, building, structure, or object considered to be important to a culture, subculture, or community for scientific, traditional, religious, or other reasons. Cultural resources are usually divided into three major categories: pre-contact and historic archaeological resources, architectural resources, and traditional cultural resources.

cumulative effects — Effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor, but collectively significant, actions taking place over a period of time (Title 40 Code of Federal Regulations Section 1508.1(g)(3)).

curie — The basis unit used to describe the intensity of radioactivity in a sample of material; it is equal to 37 billion disintegrations per second. One trillionth of a curie is a picocurie. (See *radioactivity*.)

***decibel* —** A unit used to measure the intensity of a sound or the power level of an electrical signal by comparing it with a given level on a logarithmic scale (in general use, a degree of loudness).

***decibels A-weighted* —** A-weighted decibels are an expression of the relative loudness of sounds in air as perceived by the human ear. In the A-weighted system, the decibel values of sounds at low frequencies are reduced; no correction is made for audio frequency when unweighted decibels are used. The correction is made using decibels A-weighted because the human ear is less sensitive to low audio frequencies, especially those below 1,000 hertz, than high audio frequencies.

***decommissioning* —** Removing facilities such as processing plants, waste tanks, and burial grounds from service and reducing or stabilizing radioactive contamination. Includes the following concepts: decontamination, dismantling, and return of an area to its original condition without restrictions on use or occupancy; partial decontamination; isolation of remaining residues; and continued surveillance and restrictions on use or occupancy.

***decontamination* —** The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive or chemical contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques.

***depleted uranium* —** *A* byproduct of the uranium enrichment process and refers to uranium in which the percentage of uranium-235 is less than occurs naturally (0.7%).

***disposal* —** As used in this document, the term is used for emplacing waste in a manner that ensures its isolation from the biosphere, with no intent of retrieval; as such, deliberate action would be required to gain access after emplacement.

***disposal facility* —** A natural and/or man-made structure in which waste is disposed. (See *disposal*.)

***dose (radiation)* —** As used in this document, it means total effective dose, a term referring to the amount of energy absorbed by a tissue or organ adjusted by a radiation weighting factor, a tissue weighting factor, and other factors that allows radiation of different types received through different modes of exposure to be compared on a common basis.

***emission* —** A material discharged into the atmosphere from a source operation or activity.

***enriched uranium* —** Uranium in which the concentration of the isotope uranium-235, usually expressed as a percentage, exceeds the concentration occurring in natural uranium (0.7%). Low-enriched uranium (LEU), highly enriched uranium (HEU), and high-assay low-enriched uranium (HALEU) are all enriched forms of uranium.

***Environmental Assessment (EA)* —** A concise public document prepared pursuant to the National Environmental Policy Act that provides sufficient evidence and analysis for determining whether a Federal agency should issue a Finding of No Significant Impact or prepare an Environmental Impact Statement.

***Environmental Impact Statement (EIS)* —** A detailed written statement required by Section 102(2)(C) of the National Environmental Policy Act (NEPA) for a proposed major Federal action significantly affecting the quality of the human environment. A U.S. Department of Energy (DOE) EIS is prepared in accordance with applicable requirements of the Council on Environmental Quality NEPA regulations in Title 40, Code of Federal Regulations (CFR), Parts 1500–1508 (40 CFR 1500–1508) and the DOE NEPA regulations in 10 CFR 1021. The statement includes, among other information, discussions of the environmental impacts of the proposed action and all reasonable alternatives; adverse environmental effects that cannot be avoided should the proposal be implemented; the relationship between short-term uses of the human environment and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources.

environmental justice — As defined in Executive Order 14096, *Revitalizing our Nation's Commitment to Environmental Justice for All,* environmental justice is the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* directs Federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionate and adverse effects of agency programs, policies, and activities on minority and low-income populations.

ethnographic — Refers to time periods during which specific cultures existed and related information can be systematically studied and recorded. Formal study of Native American culture in the United States is considered to have begun in the late 1800s.

exposure — Being exposed to a radioactive or chemical material.

fault — Linear geologic structures along which movement of rocks has taken place. Movement, or displacement, along the fault can be a few feet or hundreds of feet.

Finding of No Significant Impact (FONSI) — A public document issued by a Federal agency that briefly presents the reasons why an action for which the agency has prepared an Environmental Assessment has no potential to have a significant effect on the human environment, and thus, does not require preparation of an Environmental Impact Statement. (See *Environmental Assessment* and *Environmental Impact Statement*.)

fission — A reaction during which a neutron impacts an atom, causing it to split into two smaller atoms. A tremendous amount of energy is released as each atom splits. This energy can be harnessed to produce electricity.

gamma radiation — Gamma rays (and x-rays), unlike alpha or beta particles, are waves of pure energy. Gamma radiation is very penetrating and can travel several hundred feet in air. Gamma radiation requires a thick wall of concrete, lead, or steel to stop it. (See *alpha particle* and *beta particle*.)

global warming potential (GWP) — The ability of a gas or aerosol to trap heat in the atmosphere. The GWP rating system is standardized to carbon dioxide, which has a value of one. For example, methane has a GWP of 28, which means that it has a global warming effect 28 times greater than carbon dioxide on an equal-mass basis. (See *carbon dioxide equivalent*.)

greater-than-class C (low-level radioactive) waste — A type of low-level radioactive waste with concentrations of radionuclides that exceed the limits established in Title 10 Code of Federal Regulations Section 61.55 for Class C low-level radioactive waste.

greenfield site — A location that has no previously developed structure or infrastructure.

greenhouse gases (GHGs) — Gases that trap heat in the atmosphere by absorbing infrared radiation.

groundwater — Water below the ground surface in a zone of saturation.

hazardous air pollutants — Air pollutants listed in Title 40 Code of Federal Regulations Section 61.01 any of the pollutants listed in or pursuant to Section 112(b) of the Clean Air Act. Hazardous air pollutants are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental.

hazardous waste — Waste that is defined as hazardous waste under the Resource Conservation and Recovery Act (Title 42 United States Code Section 6901 et seq.) or authorized state regulation. State regulations may define a larger spectrum of materials as hazardous waste than Federal regulations.

high-assay low-enriched uranium (HALEU) — Uranium in which the concentration of the isotope uranium-235 has been increased to over 5 percent but less than 20 percent.

historic properties — Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian Tribe or Native Hawaiian organization and that meet the National Register criteria. The term eligible for inclusion in the National Register includes both properties formally determined as such in accordance with regulations of the Secretary of the Interior and all other properties that meet the National Register criteria (Title 36 Code of Federal Regulations Sections 800.16(l)(1) and (2)).

involved worker — A worker directly or indirectly involved with Proposed Action activities who may receive 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.

isotope — Any of two or more variations of an element in which the nuclei have the same number of protons (i.e., 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 and nuclear properties (e.g., carbon-12 and -13 are stable, but carbon-14 is radioactive).

latent cancer fatality (LCF) — Deaths from cancer resulting from and occurring sometime after exposure to ionizing radiation or other carcinogens. As reported in this Environmental Impact Statement, these are cancer fatalities beyond what would be expected to occur in the population absent the radiation exposure. (See *radiation effects*.)

latent cancer fatality risk (LCF risk) — Represents the probability of the occurrence of an LCF for an individual or a population group from exposure to ionizing radiation or other carcinogens when the number of LCFs is less than one.

lixiviant – A liquid medium used to selectively extract (or leach) uranium from ore bodies where they are normally found underground (in other words, in situ).

low-enriched uranium (LEU) — Uranium in which the concentration of the isotope uranium-235 has been increased above what occurs in nature (0.7%), but is below 20 percent.

low-level radioactive waste (LLW) — LLW is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e.(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material (DOE M 435.1-1, Chg 3 *Radioactive Waste Management Manual* [Adapted from: Nuclear Waste Policy Act of 1982, as amended]).

maximally exposed individual (MEI) — A hypothetical member of the public who—because of realistically assumed proximity, activities and living habits—would receive the highest radiation dose, taking into account all pathways, for a given event, process, or facility (DOE Order 458.1, Chg 4 (9-15-2020) *Radiation Protection of the Public and the Environment*) (DOE, 2020c). For purposes of this document, this individual is assumed to be at the site boundary during normal operations.

millirem — One thousandth of a rem. (See *rem.*)

mitigation — Includes: (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; or (5) compensating for an impact by replacing or providing substitute resources or environments.

mixed low-level radioactive waste (MLLW) — Low-level radioactive waste that also contains hazardous components subject to the Resource Conservation and Recovery Act (RCRA) (Title 42 United States Code Section 6901 et seq.).

mobile microreactor — A nuclear reactor with three main features:

1) Factory fabricated: all components would be fully assembled in a factor and shipped to a location.
2) Transportable: vendors able to ship the reactor by truck, shipping vessels, airplane, or railcar.
3) Self-adjusting: do not require a large number of specialized operators and would use passive safety systems that prevent any potential for overheating or reactor meltdown.

National Pollutant Discharge Elimination System (NPDES) — A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency or an authorized a state. An NPDES permit typically includes effluent limitations based on applicable technology and water quality standards, as well as monitoring and reporting requirements, and may include other provisions such as special studies or compliance schedules.

neutron — A subatomic particle with a mass similar to that of a proton and with no electric charge. Because it has no electric charge it can travel longer distances than alpha and beta particles without interacting with matter. A neutron is most effectively stopped by materials with high hydrogen content, such as water or plastic. (See *alpha particle* and *beta particle*.)

nonattainment area — An area that the U.S. Environmental Protection Agency has designated as not meeting (i.e., not being in attainment of) one or more of the National Ambient Air Quality Standards for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants, but not for others.

nonhazardous waste — Discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations or from community activities. This category does not include source, special nuclear, or byproduct material as defined by the Atomic Energy Act (Title 42 United States Code Section 2011 et seq.).

Notice of Intent (NOI) — A notice published in the *Federal Register* that an Environmental Impact Statement will be prepared and considered. The NOI is intended to briefly describe the proposed action and possible alternatives; describe the agency's proposed scoping process, including whether, when, and where any scoping meeting(s) will be held; and state the name and address of a person within the agency who can answer questions about the proposed action and the Environmental Impact Statement.

nuclear reactor — An apparatus, other than an atomic weapon, designed or used to sustain nuclear fission (dividing or splitting atoms into two or more parts) in a self-supporting chain reaction.

off-site — Denotes a location, facility, or activity occurring outside of the boundary of a site.

off-site population — Comprises members of the general public who live within 50 miles (80 kilometers) of the mobile microreactor.

on-site — Denotes a location or activity occurring within the boundary of a site.

partner nations — Partner nations are those countries with which we share common values and the goal of eradicating the scourge of terrorism, and with which we cooperate to safeguard these values and achieve this goal (U.S. Department of State, 2009).

particulate matter (PM) — Any finely divided solid or liquid material, other than uncombined (i.e., pure) water. A subscript denotes the upper limit of the diameter of particles included. Thus, PM_{10} includes only those particles equal to or less than 10 microns (0.0004 inches) in diameter; $PM_{2.5}$ includes only those particles equal to or less than 2.5 microns (0.0001 inches) in diameter.

permeability — A measure of a rock's ability to transmit fluid (in this case water); also, the rate at which the fluid can move a given distance over a given interval of time.

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

population dose — See *collective dose*.

radiation (ionizing) — 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.

radiation effects — Radiation can cause a variety of adverse health effects in humans. Health impacts of radiation exposure, whether from external or internal sources, generally are identified as somatic (i.e., affecting the exposed individual) or genetic (i.e., affecting descendants of the exposed individual). Radiation is more likely to produce somatic than genetic effects. The somatic risks of most importance are induced cancers. Both the U.S. Environmental Protection Agency and Centers for Disease Control and Prevention identify cancer as the primary long-term health effect associated with radiation exposure. Because fatal cancer is the most serious effect of environmental and occupational radiation exposures, estimates of cancer fatalities, rather than cancer incidence, are presented as a measure of impact in this document. These estimates are referred to as "latent cancer fatalities" because the cancer may take many years to develop.

radiation exposure — The average individual in the United States annually receives about 625 millirem of radiation dose from all background sources, of which about half is received from natural sources such as cosmic and terrestrial radiation and radon-220 and -222 in homes (National Council on Radiation Protection and Measurements, 1993).

radioactive decay — The spontaneous transformation of one radionuclide into a different nuclide or into a different energy state of the same radionuclide. The process results in a decrease, with time, of the number of the radioactive atoms in a sample. Decay generally involves the emission from the nucleus of alpha particles, beta particles, or gamma rays. (See *half-life*.)

radioactive waste — Any garbage, refuse, sludges, and other discarded material, including solid, liquid, semisolid, or contained gaseous material that must be managed for its radioactive content (DOE M 435.1-1, Chg 3, *Radioactive Waste Management Manual* [adapted from 40 CFR Part 240]).

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* —** An unstable isotope that undergoes spontaneous transformation, emitting radiation. (See *isotope*.)

***Record of Decision* —** A concise public document that records a Federal agency's decision(s) concerning a proposed action for which the agency has prepared an Environmental Impact Statement. The Record of Decision is prepared in accordance with the requirements of the Council on Environmental Quality National Environmental Policy Act regulations (Title 40 Code of Federal Regulations Section 1505.2). A Record of Decision identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), factors balanced by the agency in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why they were not. (See *Environmental Impact Statement*.)

***region of influence (ROI)* —** A site-specific geographic area in which the principal direct and indirect effects of actions are likely to occur and are expected to be of consequence for local jurisdictions.

***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. (See *millirem*.)

***remediation* —** The process, or a phase in the process, of rendering land or water containing radioactive or hazardous constituents, or both, environmentally safe, whether through removal, processing, entombment, or other methods.

***risk* —** The probability of a detrimental effect from exposure to a hazard. To describe impacts, risk is often expressed quantitatively as the probability of an adverse event occurring, multiplied by the consequence of that event (i.e., the product of these two factors). A separate presentation of probability and consequence to describe impacts is often informative.

***roentgen* —** A unit of exposure to ionizing radiation equal to the amount of gamma or x-rays that produces one electrostatic unit charge in a cubic centimeter of air. (See *gamma radiation.*)

***safety* —** As used in this document, protecting workers, the public, and the environment from the effects of radiation and other hazards.

***scientific notation* —** A way of presenting numbers that are very large or very small when written in decimal form, where the number is presented as a number between 1 and 10 multiplied by a power of 10. As an example, 2×10^{-2} in scientific notation is equal to the real number 0.02. That is, the number 2 is multiplied by "10 to the power of negative 2," and so the 2 is moved two places to the right of the decimal point (0.02). If the number is 2×10^{2} (2 multiplied by 10 to the power of 2), then the real number is 20. This approach is useful for very large or small numbers, such as one billionth (0.000000001) (i.e., 1×10^{-9}).

***scope* —** In a document prepared pursuant to the National Environmental Policy Act, the range of actions, alternatives, and impacts to be considered.

***scoping* —** An early and open process for determining the scope of issues and alternatives to be addressed in an Environmental Impact Statement (or other National Environmental Policy Act document) and for identifying the significant issues related to a proposed action. The scoping period begins after publication in the *Federal Register* of a Notice of Intent to prepare an Environmental Impact Statement (or other National Environmental Policy Act document). The public is invited to participate in the public scoping process.

soils — All unconsolidated materials above bedrock. Also, natural earthy materials on Earth's surface, in places modified or even made by human activity, that contain living matter and support or are capable of supporting plants out of doors.

spent nuclear fuel (SNF) — Fuel that has been removed from a reactor after being used to produce electricity. This fuel becomes very hot and radioactive as it is used in the reactor core. After the fuel is no longer useful, it is removed and transferred underwater to a pool for storage. While in storage, the fuel cools as the radioactivity decays. In time, the spent fuel may be moved to dry storage casks.

viewshed — The extent of the area that may be viewed from a particular location. Viewsheds are generally bounded by topographic features such as hills or mountains.

wetland — An area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

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Chapter 8
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Chapter 9
References

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