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Draft Versatile Test Reactor Environmental Impact Statement

Summary

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COVER SHEET

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Cooperating Agencies: None

Title: *Draft Versatile Test Reactor Environmental Impact Statement* (VTR EIS) (DOE/EIS-0542)

Location: Idaho, South Carolina, Tennessee

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This document is available on the DOE NEPA website (http://energy.gov/nepa/nepa-documents) for viewing and downloading.

Abstract: This *Versatile Test Reactor Environmental Impact Statement* (VTR EIS) evaluates the potential environmental impacts of proposed alternatives for the construction and operation of a new test reactor, as well as associated facilities that are needed for performing post-irradiation evaluation of test articles and managing spent nuclear fuel (SNF). In accordance with the Nuclear Energy Innovation Capabilities Act of 2017 (NEICA) (Pub. L. 115–248), DOE assessed the mission need for a versatile reactor-based fast-neutron source (or Versatile Test Reactor) to serve as a national user facility. DOE determined that there is a need for a fast-neutron spectrum VTR to enable testing and evaluating nuclear fuels, materials, sensors, and instrumentation for use in advanced reactors and other purposes. In accordance with NEICA, DOE is pursuing construction and operation of the 300 megawatt (thermal) VTR. The reactor would be a pool-type, sodium-cooled reactor that uses a uranium-plutonium-zirconium metal fuel. The analysis also includes the potential impacts from post-irradiation examination of test articles, management of spent fuel, and activities necessary for VTR driver fuel production.

The Idaho National Laboratory (INL) VTR Alternative would include the construction of the VTR adjacent to the Materials and Fuels Complex (MFC) at the INL Site. Existing MFC facilities, some requiring new equipment, would be used for post-irradiation examination and conditioning SNF. The Oak Ridge National Laboratory (ORNL) VTR Alternative would include the construction of a VTR and a hot cell building at ORNL. The hot cell building would provide post-irradiation examination and SNF conditioning capabilities. Both alternatives would require construction of a concrete pad for dry storage of SNF pending shipment

to an offsite storage or disposal facility. DOE does not intend to separate, purify, or recover fissile material from VTR driver fuel.

DOE also evaluates options for preparing the uranium/plutonium/zirconium feedstock for use in the reactor driver fuel (fuel needed to run the reactor) and for fabricating the driver fuel. Feedstock preparation would be performed using new capabilities installed in an existing building at the INL Site or the Savannah River Site (SRS). Fuel fabrication would be performed using existing or newly installed equipment in existing buildings at the INL Site or SRS.

Preferred Alternative: DOE's Preferred Alternative is the INL VTR Alternative. DOE would construct and operate the VTR at the INL Site adjacent to the MFC. Existing facilities within the MFC would be modified and used for post-irradiation examination of test assemblies. SNF would be treated to remove the sodium and converted into a form that would meet the acceptance criteria for a future permanent repository. The treated SNF would be temporarily stored at a new storage pad near the VTR.

DOE has no preferred option at this time for where it would perform reactor fuel production (feedstock preparation or driver fuel fabrication) for the VTR. This EIS evaluates options for both processes at the INL Site and at SRS. DOE will state its preferred options for feedstock preparation and driver fuel fabrication in the Final VTR EIS, if preferred options are identified before issuance.

Public Involvement: DOE issued a Notice of Intent to Prepare an environmental impact statement for a Versatile Test Reactor in the *Federal Register* (84 FR 38021) on August 5, 2019, to solicit public input on the scope and environmental issues to be addressed in this VTR EIS. Comments received during the August 5 through September 4, 2019, scoping period were considered in the preparation of this Draft EIS. Comments on this Draft EIS will be accepted following publication of the U.S. Environmental Protection Agency Notice of Availability. Comments can be submitted to the address provided above or emailed to VTR.EIS@nuclear.energy.gov. Opportunities to provide oral comments will be announced in news media near the DOE sites 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.

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Acronyms and Abbreviations

AoA	Analysis of Alternatives
ATR	Advanced Test Reactor
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EBR-II	Experimental Breeder Reactor II
EFF	Experimental Fuels Facility
EIS	environmental impact statement
FCF	Fuel Conditioning Facility
FFTF	Fast Flux Test Facility
FMF	Fuel Manufacturing Facility
GEH	GE Hitachi Nuclear Energy
GHG	greenhouse gases
HFEF	Hot Fuel Examination Facility
HFIR	High Flux Isotope Reactor
IMCL	Irradiated Materials Characterization Laboratory
INL	Idaho National Laboratory
LAMDA	Low Activation Materials Design and Analysis Laboratory
LANL	Los Alamos National Laboratory
LFTR	lead/lead-bismuth-cooled fast test reactor
LLNL	Lawrence Livermore National Laboratory
MFC	Materials and Fuels Complex
MSFTR	molten-salt-cooled fast test reactor
MTHM	metric tons of heavy metal
NEAC	Nuclear Energy Advisory Council
NEICA	Nuclear Energy Innovation Capabilities Act
NEPA	National Environmental Policy Act
NOI	Notice of Intent
NRC	Nuclear Regulatory Commission
PIDAS	Perimeter Intrusion Detection and Assessment System
PNNL	Pacific Northwest National Laboratory
R&D	research and development
RVACS	Reactor Vessel Auxiliary Cooling System
ORNL	Oak Ridge National Laboratory
PRISM	Power Reactor Innovative Small Module
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
TREAT	Transient Reactor Test Facility
VTR	Versatile Test Reactor
ZPPR	Zero Power Physics Reactor

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S.1 Introduction

As required by the Nuclear Energy Innovation Capabilities Act of 2017 (NEICA) (Pub. L. 115–248), the U.S. Department of Energy (DOE) assessed the mission need for a versatile reactor-based fast-neutron[1] source (or Versatile Test Reactor [VTR]) to serve as a national user facility. DOE has determined that there is a need for a VTR and, in accordance with NEICA, is pursuing construction and operation of the VTR. To this end, DOE has prepared this environmental impact statement (EIS) in accordance with the National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) and DOE NEPA regulations (40 Code of Federal Regulations [CFR] 1500 through 1508 and 10 CFR 1021, respectively). This EIS evaluates alternatives for a VTR and associated facilities for the irradiation and post-irradiation examination of test and experimental fuels and materials. The analysis also addresses options for VTR driver fuel production and evaluates the management of spent nuclear fuel from the VTR.

DOE's mission includes advancing the energy, environmental, and nuclear security of the United States and promoting scientific and technological innovation in support of that mission. DOE's 2014 to 2018 Strategic Plan (DOE 2014) states that DOE will "support a more economically competitive, environmentally responsible, secure and resilient U.S. energy infrastructure." Specifically, "DOE will continue to explore advanced concepts in nuclear energy that may lead to new types of reactors with further safety improvements and reduced environmental and nonproliferation concerns."

Advanced reactors that operate in the fast-neutron spectrum offer the potential to have inherent safety characteristics incorporated into their designs. They can operate for long periods without refueling and reduce the volume of newly generated nuclear waste. Effective testing and development of advanced reactor technologies requires the use of fast neutrons comparable to those that would occur in actual advanced reactors. A high flux of fast neutrons allows accelerated testing, meaning that a comparatively short testing period would accomplish what would otherwise require many years to decades of exposure in a test environment with lower energy neutrons, a lower flux, or both. This accelerated testing would contribute to the development of materials and fuels for advanced reactors and generate data allowing advanced reactor developers, researchers, DOE, and regulatory agencies to improve performance, understand material properties, qualify improved materials and fuels, evaluate reliability, and ensure safety. Accelerated testing capabilities would also benefit these same areas for the current generation of light-water reactors.

Many commercial organizations and universities are pursuing advanced nuclear energy fuels, materials, and reactor designs that complement DOE and its laboratories' efforts to advance nuclear energy. These designs include thermal[2] and fast-spectrum reactors that target improved fuel resource utilization and waste management, and the use of materials other than water for cooling. Their development requires an adequate infrastructure for experimentation, testing, design evolution, and component qualification. Available irradiation test capabilities are aging (most are over 50 years old). These capabilities are focused on testing materials, fuels, and components in the thermal neutron spectrum and do not have the ability to support the needs for fast reactors (i.e., reactors that operate using fast neutrons). Only limited fast-neutron-spectrum testing capabilities, with restricted availability, exist outside the United States.

A number of studies evaluating the needs and options for a fast-neutron spectrum test reactor have been conducted. The *Advanced Demonstration and Test Reactor Options Study* (INL 2017a) identified a

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[1] Fast neutrons are highly energetic neutrons (ranging from 0.1 million to 10 million electron volts [MeV] and travelling at speeds of thousands to tens of thousands kilometers per second) emitted during fission. The fast-neutron spectrum refers to the range of energies associated with fast neutrons.

[2] Thermal neutrons are neutrons that are less energetic than fast neutrons (generally, less than 0.25 electron volt and travelling at speeds of less than 5 kilometers per second), having been slowed by collisions with other materials such as water. The thermal neutron spectrum refers to the range of energies associated with thermal neutrons.

strategic objective to "provide an irradiation test reactor to support development and qualification of fuels, materials, and other important components/items (e.g., control rods, instrumentation) of both thermal and fast neutron-based…advanced reactor systems." The DOE Nuclear Energy Advisory Committee (NEAC) issued an *Assessment of Missions and Requirements for a New U.S. Test Reactor* (NEAC 2017), confirming the need for fast-neutron testing capabilities in the United States and acknowledging that no such facility is readily available domestically or internationally. Developing the capability for large-scale testing, accelerated testing, and qualifying advanced nuclear fuels, materials, instrumentation, and sensors is essential for the United States to modernize its nuclear energy infrastructure and to develop transformational nuclear energy technologies that re-establish the United States as a world leader in nuclear technology commercialization.

A summary of preliminary requirements that a fast-neutron test reactor should fulfill includes providing:

- A high peak neutron flux with a prototypic fast-reactor-neutron-energy spectrum (i.e., neutron energy greater than 0.1 million electron volts); the target flux is 4×10^{15} neutrons per square centimeter per second or greater.
- A high neutron dose rate for materials testing (quantified as displacements per atom); the target is 30 displacements per atom per year or greater.
- An irradiation length that is appropriate for fast reactor fuel testing; the target is 0.6 meter to 1 meter.
- A large irradiation volume within the core region; the target is 7 liters.
- Innovative testing capabilities through flexibility in testing configuration and testing environment (coolants).
- The ability to test advanced sensors and instrumentation for the core and test positions.
- Expedited experiment life cycle by enabling easy access to support facilities for experiments fabrication and post-irradiation examination.
- Management of the reactor driver fuel[3] (fuel needed to run the reactor) while minimizing cost and schedule impacts.
- Access to the facility for testing as soon as possible by using proven technologies with a high technology readiness level.

> - 4×10^{15} neutrons per square centimeter per second = 2.6×10^{16} neutrons per square inch per second
> - 0.6 meter to 1 meter = 2 feet to 3.3 feet
> - 7 liters = 0.25 cubic feet

Having identified the need for the VTR, NEICA directs DOE "to the maximum extent practicable, complete construction of, and approve the start of operations for, the user facility by not later than December 31, 2025." DOE's *Mission Need Statement for the Versatile Test Reactor (VTR) Project, A Major Acquisition Project* (DOE 2018a) embraces the development of a well-instrumented, sodium-cooled, fast-neutron-spectrum test reactor in the 300 megawatt-thermal power level range. The deployment of a sodium-cooled, fast-neutron-spectrum test reactor is consistent with the conclusions of the test reactor options study (INL 2017a) and the NEAC recommendation (NEAC 2017). On February 28, 2019, Secretary of Energy Rick Perry announced the launch of the VTR project as a part of modernizing the nuclear research and development (R&D) user facility infrastructure in the United States.

[3] Driver fuel is the fuel required to run the reactor. Driver fuel assemblies are distinguished from other assemblies in the reactor. Reflector assemblies made of non-fuel material (e.g., HT-9 stainless steel) surround the driver fuel assemblies and function to reduce neutron leakage (i.e., they scatter [or reflect] many neutrons back into the core that would otherwise escape). Around the outside of the reflector assemblies are shield assemblies made of non-fuel material (e.g., HT-9 stainless steel) and containing neutron-absorbing boron carbide to reduce neutron damage to the reactor structural components.

S.2 Purpose and Need for Agency Action

The purpose of this DOE action is to establish a domestic, versatile, reactor-based fast-neutron source and associated facilities that meet identified user needs (e.g., providing a high neutron flux of at least 4×10^{15} neutrons per square centimeter per second and related testing capabilities). Associated facilities include those for the preparation of VTR driver fuel and test/experimental fuels and materials and those for the ensuing examination of the test/experimental fuels and materials; existing facilities would be used to the extent possible. The United States has not had a viable domestic fast-neutron-spectrum testing capability for over two decades. DOE needs to develop this capability to establish the United States' testing capability for next-generation nuclear reactors—many of which require a fast-neutron spectrum for operation—thus enabling the United States to regain technology leadership for the next generation nuclear fuels, materials, and reactors. The lack of a versatile fast-neutron-spectrum testing capability is a significant national strategic risk affecting the ability of DOE to fulfill its mission to advance the energy, environmental, and nuclear security interests of the United States and promote scientific and technological innovation. This testing capability is essential for the United States to modernize its nuclear energy industry. Further, DOE needs to develop this capability on an accelerated schedule to avoid further delay in the U.S. ability to develop and deploy advanced nuclear energy technologies. If this capability is not available to U.S. innovators as soon as possible, the ongoing shift of nuclear technology dominance to other nations will accelerate, to the detriment of the U.S. nuclear industrial sector.

S.3 Proposed Action

DOE proposes to construct and operate the VTR at a suitable DOE site. DOE would use existing or expanded, co-located, post-irradiation examination capabilities as necessary to accomplish the mission. DOE would also use or expand existing facility capabilities to produce VTR driver fuel and to manage radioactive wastes and spent nuclear fuel. The DOE facilities would be capable of receiving test articles from the user community, as well as fabricating test articles for insertion in the VTR.

Candidate sites for construction and operation of the VTR include the Idaho National Laboratory (INL) near Idaho Falls, Idaho, and the Oak Ridge National Laboratory (ORNL), near Oak Ridge, Tennessee. DOE would perform most post-irradiation examination in existing, modified, or new facilities near the VTR, although there may be instances when test items would be sent to another location for evaluation. DOE would produce VTR driver fuel at the INL Site or the Savannah River Site (SRS) near Aiken, South Carolina. **Figure S–1** shows the locations of these DOE sites. Chapter 2 describes the alternatives and options evaluated in this VTR EIS.

S.4 Public Involvement

On August 5, 2019, DOE published a Notice of Intent (NOI) in the *Federal Register* (84 FR 38021) to prepare this VTR EIS to evaluate the potential environmental impacts of constructing and operating a VTR capability. Publication of the NOI initiated a 30-day public scoping period. During the scoping period, DOE hosted two interactive webcasts on August 27 and 28, 2019. On the webcasts, DOE presented information to the public about the NEPA process and the VTR project. DOE also invited participants to provide public comment on the scope of the VTR EIS.

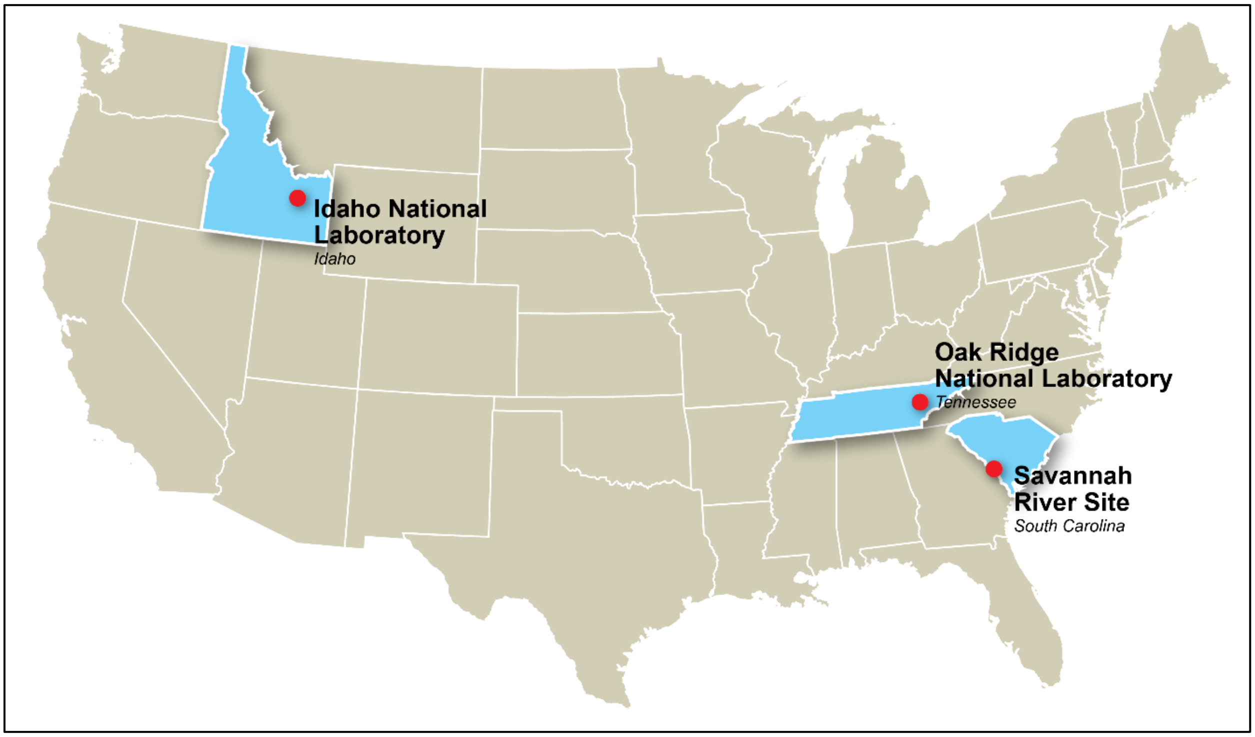

Figure S–1. Location of Facilities Evaluated in this VTR EIS

DOE received 45 comment documents,[4] in which 173 comments[5] were identified. Analysis of written and oral public comments submitted during the scoping period helped DOE further identify concerns and potential issues considered in the VTR EIS.

DOE is offering opportunities for public review and comment, including public hearings, on this Draft VTR EIS. Public involvement opportunities and public hearing information will be announced in newspapers in communities near potentially affected areas and in other communications with stakeholders. Comments received during the public comment period will be evaluated in preparing the Final VTR EIS. Comments received after the close of the public comment period will be considered to the extent practicable. DOE plans to publish the Final VTR EIS in 2021. DOE will issue a ROD no sooner than 30 days after publication of the U.S. Environmental Protection Agency's Notice of Availability of the Final VTR EIS.

S.5 Decisions to be Supported

This VTR EIS provides the DOE decision-maker with important information regarding potential environmental impacts for use in the decision-making process. In addition to environmental information, DOE will consider other factors (e.g., cost, schedule, strategic objectives, technology needs, and safeguards and security) when making its decision. Decisions to be made by the DOE decision-maker regarding the VTR EIS project are whether to:

[4] A comment document is a communication in the form of a letter, an electronic communication (email), a transcription of a recorded phone message, or a transcript from an individual speaker at a public meeting or hearing, that contains comments from a sovereign nation, government agency, organization, or member of the public regarding the VTR EIS.

[5] A comment is a statement or question regarding the EIS content that conveys approval or disapproval of proposed actions, recommends changes, or seeks additional information.

- Construct a VTR to create a fast-neutron source;
- Establish, through modification or construction, co-located facilities for post-irradiation examination of test products and for management of spent VTR driver fuel;
- Locate the VTR at the INL Site or at ORNL; and
- Establish VTR driver fuel production capabilities for feedstock preparation and fuel fabrication at the INL Site, SRS, or a combination of the two sites.

S.6 Alternatives and Options Analyzed

DOE proposes to construct and operate the VTR at a suitable DOE site. DOE would use or expand existing, co-located, post-irradiation examination capabilities to accomplish this mission. Where necessary, expanding capabilities would require construction of new facilities. DOE would also use or expand existing facility capabilities to fabricate VTR driver fuel and test items[6] and to manage radioactive wastes.

DOE proposes to use the GE Hitachi Nuclear Energy (GEH) Power Reactor Innovative Small Module (PRISM), a pool-type reactor, as the basis for VTR's design. The PRISM design would require several changes, notably the elimination of electricity production and the accommodation for experimental locations within the core. The PRISM design[7] of a sodium-cooled, pool-type reactor satisfies the need to use a mature technology. The VTR would be an approximately 300-megawatt (thermal) reactor based on and sharing many of the design and passive safety features of the GEH PRISM. It also would incorporate technologies adapted from previous sodium-cooled fast reactors (e.g., the Experimental Breeder Reactor II [EBR-II] and the Fast Flux Test Facility [FFTF]). The VTR's reactor, primary heat removal system, and safety systems would be similar to those of the PRISM design. VTR, like PRISM, would use metallic alloy fuels. The conceptual design for the first VTR driver fuel core is an alloy of 70 percent uranium, 20 percent plutonium, and 10 percent zirconium (by weight). Reactor fuel production is addressed in Section S.6.4.

Figure S–2 shows the conceptual site layout of the VTR complex. The major facilities in the complex include an electrical switchyard, the reactor facility, 10 large sodium-to-air heat exchangers, and an operational support facility. **Figure S–3** shows a cutaway view of the conceptual design of the reactor facility, whose longest dimensions would be about 180 feet by 280 feet. The reactor vessel, containing the core of the VTR, would extend 90 feet below grade. Other below-grade elements of the facility include the reactor head access area (over the core), secondary coolant equipment rooms, test assembly storage areas, and fuel cask pits. The reactor and experiment hall operating area that extends 90 feet above grade would allow the receipt and movement of fuel and experiments into and out of the core and storage areas.

The VTR core design would differ from that of PRISM because it needs to meet the requirement for a high-flux test environment that accommodates several test and experimental assemblies. Experiments would be placed in some locations normally occupied by driver fuel in the PRISM. Heat generated by the VTR during operation would be dissipated through a heat rejection system consisting of intermediate heat exchangers within the reactor vessel, a secondary sodium-cooling loop, and air-cooled heat exchangers. This system and the Reactor Vessel Auxiliary Cooling System (RVACS) would provide shutdown and emergency cooling. The RVACS would remove decay heat from the sodium pool by transferring the

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[6] As a user facility, the VTR would provide experimental capabilities for entities outside of DOE. These other entities could also fabricate test items for placement in the reactor.

[7] The PRISM design is based on the EBR-II reactor, which operated for over 30 years. The PRISM design most similar to the VTR is the 471 megawatt thermal MOD-A design. The U.S. Nuclear Regulatory Commission review of the PRISM reactor, as documented in NUREG-1368, *Preapplication Safety Evaluation Report for the Power Reactor Innovative Small Module (PRISM) Liquid-Metal Reactor* (NRC 1994), concluded that "no obvious impediments to licensing the PRISM design had been identified."

thermal energy through the reactor vessel and guard vessel walls (with convective heat transfer through the argon gas in the annular gap between vessels) to naturally circulating air being drawn down through the inlets of four cooling chimneys, through risers on the exterior of the guard vessel, and up through the outlets of the cooling chimneys. The RVACS chimneys would be about 100 feet tall, extending above the experiment support area. No water would be used in either of the reactor cooling systems.

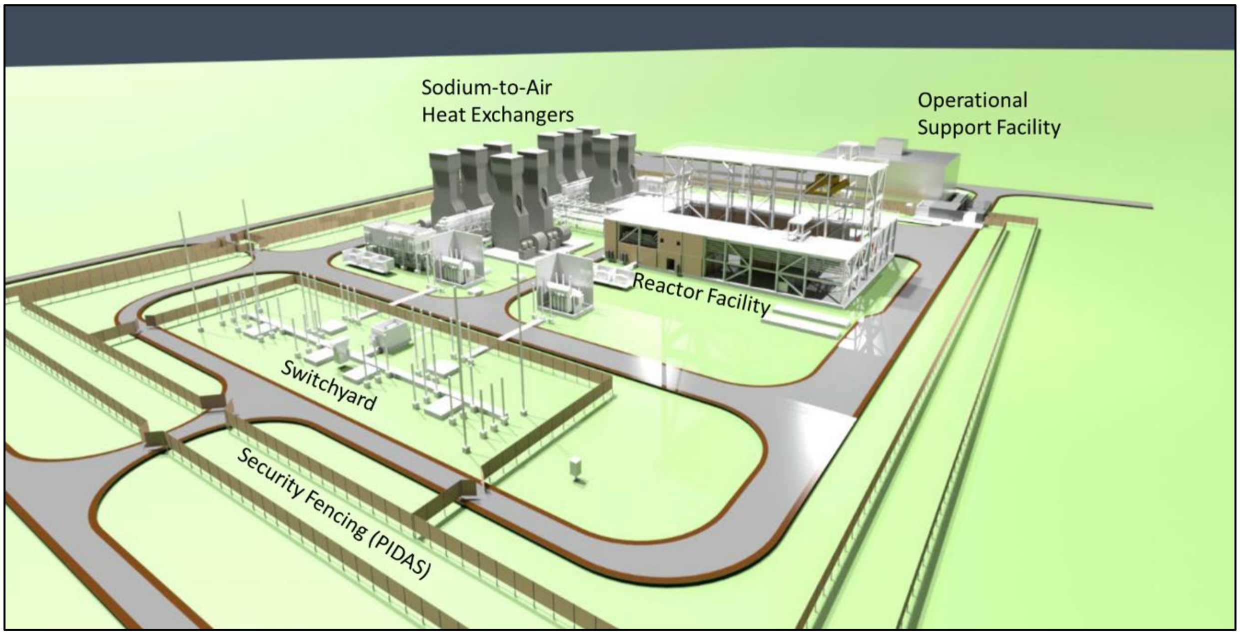
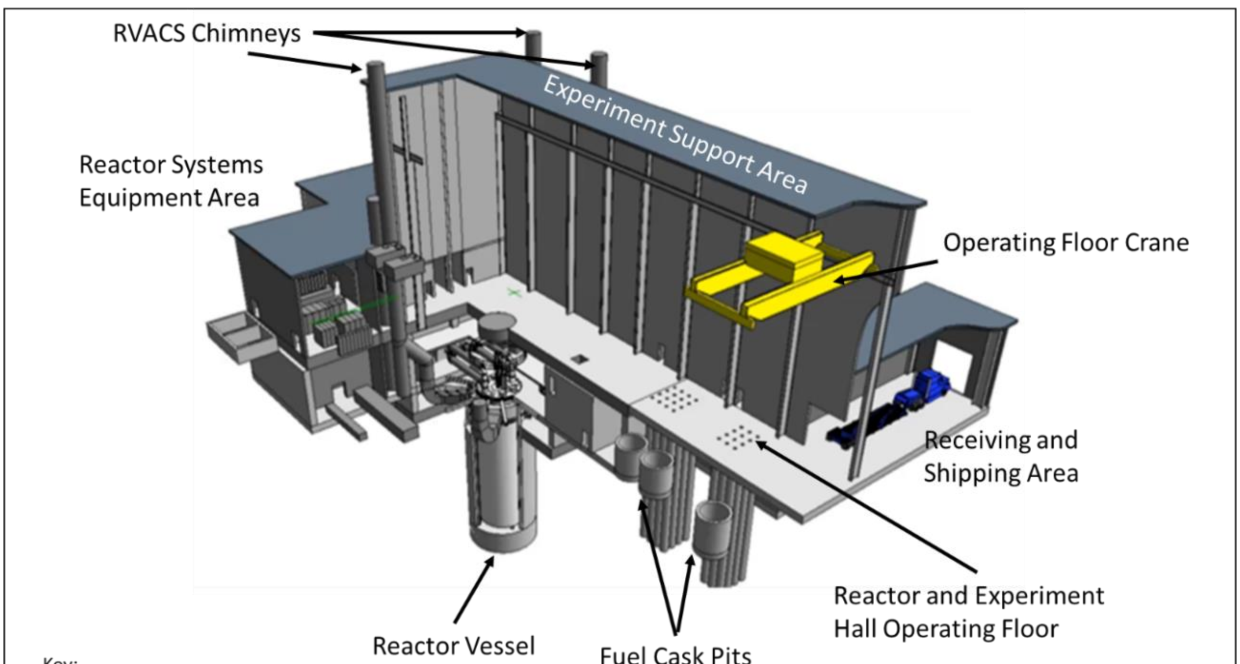


Figure S–2. Conceptual Site Layout



Key:
RVACS – Reactor Vessel Auxiliary Cooling System
Source: Modified from Bumgardner 2019

Figure S–3. Conceptual Design of the Versatile Test Reactor Facility

The core of the VTR would comprise 66 driver fuel assemblies (see **Figure S–4**). The core would be surrounded by rows of reflector assemblies (114 total assemblies), which would be surrounded by rows of shield assemblies (114 total assemblies). Non-instrumented experiments (containing test specimens) could be placed in multiple locations in the reactor core or in the reflector region, by replacing a driver fuel or reflector assembly (test pins may also be placed within a driver fuel assembly). Instrumented experiments, which would provide real-time information while the reactor is operating, would require a penetration in the reactor cover for the instrumentation stalk and could only be placed in six fixed locations. One of these six locations can accommodate a "rabbit" test apparatus th at would allow samples to be inserted and/or removed while the reactor is in operation. The number of instrumented test locations, plus the flexibility in the number and location of non-instrumented tests would strengthen the versatility of the reactor as a test facility.

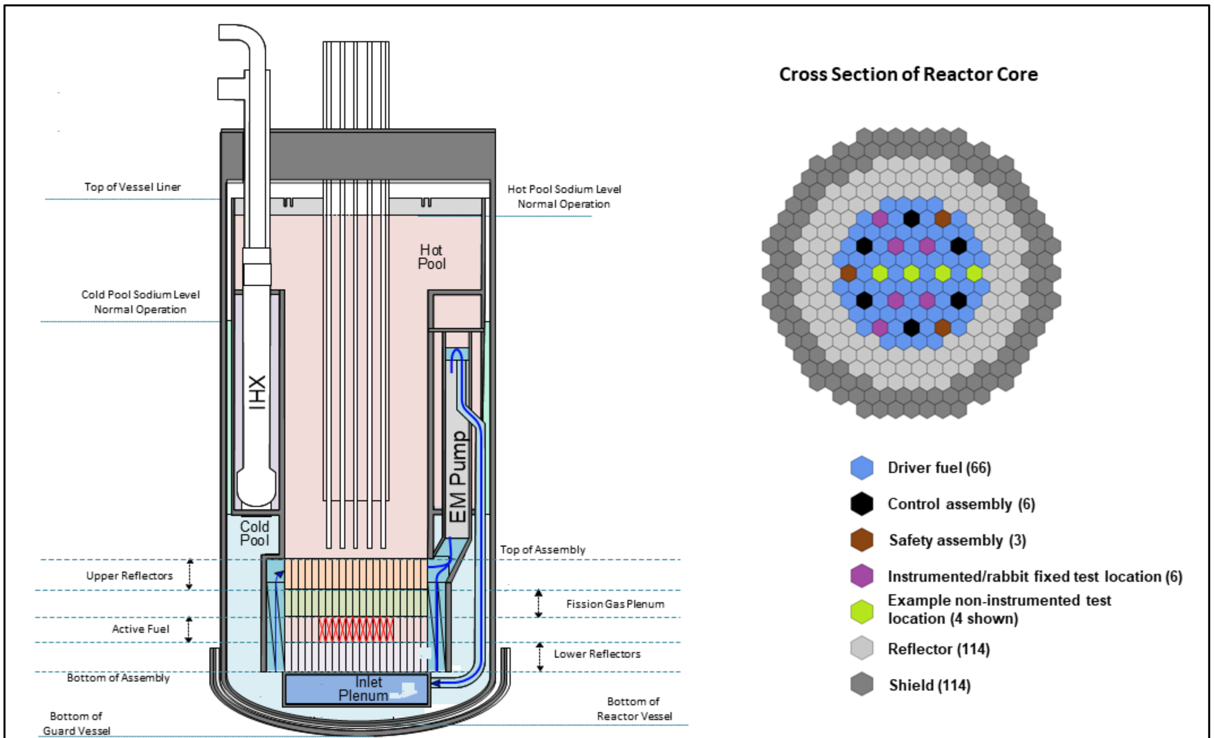
Driver (fuel) assembly contains the fuel needed to power the reactor and produces the fast neutron flux necessary for irradiation of test assemblies or specimens.

Reflector assembly surrounds the central part of the core that contains driver assemblies and test assemblies and contains material to reflect neutrons back into the central part of the core.

Shield assembly is positioned outside of the reflector assemblies within the core and contains material to absorb neutrons that pass through the reflector.

Test assembly contains the test specimen and any equipment needed to support the experiment. Instrumented test assemblies could be as long as 65 feet. Non-instrumented assemblies would be the same length as driver assemblies (less than 13 feet).

Test specimen is the material being exposed to a fast neutron flux to determine the effects of the exposure and includes any capsule necessary to support the test. The test specimen can be no more than about 31 inches long.



Key:
EM – electromagnetic
IHX – Intermediate heat exchanger
Source: INL 2019c, 2020c.

Figure S–4. Versatile Test Reactor and Core Conceptual Designs

The VTR mission requires capabilities to examine the test specimens after irradiation in the VTR to determine the effects of a high flux of fast neutrons. Highly radioactive test specimens would be removed from the VTR after a period of irradiation ranging from days to years. Test specimens would then be transferred to a fully enclosed, radiation-shielded facility where they could be remotely disassembled, analyzed, and evaluated. The examination facilities are "hot-cell" facilities (see **Figure S–5**).[8] These hot cells include concrete walls and multi-layered, leaded-glass windows several feet thick. Remote manipulators allow operators to perform a range of tasks on test specimens within the hot cell while protecting them from radiation exposure. An inert atmosphere is required in some hot cells. An inert atmosphere of argon would be used[9] in the hot cell to which test assemblies are initially transferred after removal from the VTR. The inert atmosphere may be necessary to prevent test specimen degradation or unacceptable reactions (e.g., pyrophoric) that could occur in an air atmosphere. The post-irradiation hot cell facilities would be in close proximity to the VTR. After initial disassembly and examination in the inert atmosphere hot cell, test specimens may be transferred to other post-irradiation examination facilities for additional analysis.

Figure S–5. Exterior and Interior Views of Hot Cell Facilities

The VTR would generate up to 45 spent fuel assemblies per year.[10] DOE would use existing or new facilities at the locations identified in the site-specific alternatives for the management of spent driver fuel. Spent driver fuel assemblies would be temporarily stored within the reactor vessel for about 1 year. Upon removal from the reactor vessel, surface sodium coolant would be washed off the assembly, and the assembly would be transported in a transfer cask to a new onsite spent fuel pad. After several years (at least 3 years), during which time the radioactive constituents would further decay, the assemblies would be transferred in a cask to a spent fuel treatment facility. The sodium that was enclosed within the spent driver fuel pins to enhance heat transfer would be removed using a melt-distill-package process. The spent fuel would be chopped, and the chopped material consolidated, melted, and vacuum distilled to separate the sodium from the fuel. To meet safeguards requirements, diluent would be added to the remaining spent fuel to reduce the fissile material concentration. The resulting material would be

[8] A 360 degree tour of the exterior of the INL Hot Fuel Examination Facility (HFEF) hot cell is available at https://inl.gov/wp-content/uploads/360tours/HFEF/HFEFTour.html.

[9] Not all test specimens would require an inert atmosphere during disassembly, analysis, and evaluation. However, separate facilities are not proposed for test specimens that do not require initial post-irradiation examination in an inert atmosphere.

[10] Typically less than a quarter of the VTR driver fuel assemblies would be replaced at the end of a test cycle. However, there could be atypical conditions when it would be necessary to replace a larger number of assemblies after a test cycle. In such instances, more than 45 assemblies could be removed from the core in a single year.

packaged in containers and temporarily stored in casks on the spent fuel pad, pending transfer to an offsite storage or disposal facility.

Specific action alternatives proposed in this EIS include alternative DOE national laboratory sites for the construction and operation of the VTR, the provision of post-irradiation examination facilities, and the interim management of spent fuel. Under all action alternatives, the VTR would be an approximately 300-megawatt thermal, sodium-cooled, pool-type, metal-fueled reactor based on the GEH PRISM.

S.6.1 No Action Alternative

Under the No Action Alternative, DOE would not pursue the construction and operation of a VTR. To the extent they are capable and available for testing in the fast-neutron-flux spectrum, DOE would continue to make use of the limited capabilities of existing facilities, both domestic and foreign. Domestic facilities that would likely be used, without modification, would include the INL Advanced Test Reactor and the ORNL High Flux Isotope Reactor. DOE would not construct new or modify any existing post-irradiation examination or fuel treatment facilities to support VTR operation. Existing post-irradiation examination and fuel treatment facilities would continue to support operation of the existing reactors. Because there would not be a VTR under the No Action Alternative, there would be no need to produce VTR driver fuel. Therefore, no new VTR driver fuel production capabilities would be pursued. The No Action Alternative would not meet the purpose and need identified for the VTR.

S.6.2 Idaho National Laboratory Versatile Test Reactor Alternative

Under the INL VTR Alternative, DOE would site the VTR east of the Materials and Fuels Complex (MFC) at the INL Site and use existing hot cell and other facilities at the MFC for post-irradiation examination and spent fuel treatment. This location was selected primarily because the project would make use of numerous facilities at MFC along with the anticipated small environmental impacts of siting the facility there. The VTR complex would occupy about 25 acres. Additional land would be disturbed during the construction of the VTR complex for such items as temporary staging of VTR components, construction equipment, and worker parking. In total, construction activities (anticipated to last 51 months) would result in the disturbance of about 100 acres, inclusive of the 25 acres occupied by the completed VTR complex.

The MFC is the location of the Hot Fuel Examination Facility (HFEF), the Irradiated Materials Characterization Laboratory (IMCL), the Experimental Fuels Facility (EFF), the Fuel Conditioning Facility (FCF), the Fuel Manufacturing Facility (FMF) and the decommissioned Zero Power Physics Reactor (ZPPR). The HFEF and IMCL (and other analytical laboratory facilities) would be used for post-irradiation examination and the FCF for spent fuel treatment. The EFF, FCF, FMF, and ZPPR would be used for VTR driver fuel production (see Section S.6.4.1). The existing Perimeter Intrusion Detection and Assessment System (PIDAS) security fencing around FMF and ZPPR would be extended to encompass most of the VTR facility.

Materials and Fuels Complex Facilities to Support the Versatile Test Reactor

Fuel Fabrication

- EFF – Experimental Fuels Facility
- FCF – Fuel Conditioning Facility
- FMF – Fuel Manufacturing Facility
- ZPPR – Zero Power Physics Reactor

Post-Irradiation Examination

- HFEF – Hot Fuel Examination Facility
- IMCL – Irradiated Materials Characterization Laboratory

Fuel Treatment

- FCF – Fuel Conditioning Facility

Following irradiation, test and sample articles would be transferred to the HFEF first. The HFEF, a Hazard Category 2 nuclear facility[11] contains two large hot cells. The main cell is 70 feet by 30 feet with an inert argon atmosphere. The second cell has an air atmosphere. HFEF has the capability to handle fuel pins up to 13 feet long and the VTR test assemblies (excluding extensions removed prior to transfer to the HFEF) would be less than 13 feet long. HFEF hot cells provide shielding and containment for remote examination (including destructive and non-destructive testing), processing, and handling of highly radioactive materials (INL 2017b).

The IMCL, a Hazard Category 2 nuclear facility, has a modular design that provides flexibility for future examination of nuclear fuel and materials. The IMCL would be used for the study and characterization of radioactive fuels and materials at the micro- and nanoscale to assess irradiation damage processes. Shielded hot cell, glovebox, and hood capabilities are included in the facility (INL 2019b).

Existing facilities within the MFC would need minor modifications to support fabrication of test articles or to support post-irradiation examination of irradiated test specimens withdrawn from the VTR. (HFEF would need new, in-cell handling equipment for experiment movement and examination; the FCF would need a hot cell window to be replaced and new in-cell equipment to enable handling of driver fuel assemblies.) These types of activities are ongoing within the MFC. These facilities and their associated operational staff provide an extensive capability to perform the anticipated post-irradiation examination activities that the VTR would create (INL 2020a).

A new spent fuel pad would be constructed within the VTR site. The spent fuel pad would consist of an approximately 11,000-square foot concrete slab with a 2,500-square foot approach pad. Spent driver fuel would be temporarily stored at the VTR within the reactor vessel, followed by a period of storage on the spent fuel pad. After the fuel cools sufficiently, it would be transferred in a cask to FCF. FCF is a Hazard Category 2 nuclear facility located within a PIDAS. The FCF contains two hot cell facilities, one with an air atmosphere and one with an inert argon atmosphere. Its primary mission is to support the treatment of DOE-owned, sodium-bonded metal fuel. At FCF, the fuel would be conditioned using a melt-distill-package process. The fuel would be chopped, using existing equipment at the FCF. The chopped material would be consolidated, melted, and vacuum distilled to separate the sodium from the fuel. DOE does not intend to separate, purify, or recover fissile material from VTR driver fuel. Following addition of a diluent, the mixture would be packaged in containers, placed in storage casks, and temporarily stored on the new spent fuel pad until shipped to an offsite location (either an interim storage facility or a permanent repository when either becomes available for VTR fuel).

Under the conceptual design, the existing infrastructure, including utilities and waste management facilities, would be used to support construction and operation of the VTR. The current infrastructure is adequate to support the VTR with minor upgrades and modifications. Radioactive wastes would be shipped off site for treatment and/or disposal.

[11] DOE defines hazard categories of nuclear facilities by the potential impacts identified by hazard analysis and has identified radiological limits (quantities of material present in a facility) corresponding to the hazard categories. Hazard Category 1 – Hazard Analysis shows the potential for significant offsite consequences (reactors fall under this category). Hazard Category 2 – Hazard Analysis shows the potential for significant on-site consequences beyond localized consequences. Hazard Category 3 – Hazard Analysis shows the potential for only significant localized consequences. Below (Less Than) Hazard Category 3 applies to a nuclear facility containing radiological materials with a final hazard categorization less than Hazard Category 3 facility thresholds (DOE 2018b).

S.6.3 Oak Ridge National Laboratory Versatile Test Reactor Alternative

Under the ORNL VTR Alternative, the VTR would be sited at ORNL at a site previously considered for other projects, about a mile east of the ORNL main campus. The major structures for the VTR would be the same as those described for the INL VTR Alternative. In addition, a new hot cell, a joint post-irradiation examination and spent fuel treatment facility, would be constructed adjacent to the VTR. Although there are facilities with hot cells at ORNL that would be used for post-irradiation examination of test materials, none of the available hot cells operates with an inert atmosphere. A new spent fuel pad of the same dimensions as described under INL VTR Alternative would also be constructed.

The new hot cell facility would be approximately 172 feet by 154 feet and comprise four levels (including one level extending 19 feet below grade). The lower three levels would be constructed of concrete and brick masonry. The fourth level, a high bay area, would be of mostly steel construction and would rise to about 84 feet above grade. The facility would house four hot cells, two for post-irradiation examination and two for spent fuel treatment. Each pair of hot cells would include a decontamination hot cell and an inert atmosphere hot cell. Construction would occur in parallel with the construction of the VTR and be completed in the same 51-month period. Construction activities would result in disturbance of about 150 acres, with the completed VTR complex, including the hot cell facility, occupying less than 50 acres. The VTR facility, hot cell facility, and spent fuel pad would be located within a single PIDAS.

In addition to the new hot cell facility, existing facilities at ORNL would be used for supplemental or advanced post-irradiation examination for materials that do not require an inert environment. Hot cells within the Irradiated Fuels Examination Laboratory (Building 3525) and the Irradiated Material Examination and Testing Facility (Building 3025E) would be used to supplement the capabilities of the new post-irradiation examination facility. The Irradiated Fuels Examination Laboratory is a Hazard Category 2 nuclear facility and contains hot cells that are used for examination of a wide variety of fuels (ORNL 2015). The Irradiated Material Examination and Testing Facility is a Hazard Category 3 nuclear facility and contains hot cells that are used for mechanical testing and examination of highly irradiated structural alloys and ceramics (ORNL 2014). In addition, the Low Activation Materials Design and Analysis Laboratory (LAMDA) would be used for the examination of materials with low radiological content that do not require remote manipulation. LAMDA supports the measurement of physical, chemical, and electric properties of samples (ORNL 2017).

Spent driver fuel would be managed the same as described under the INL VTR Alternative - temporarily stored at the VTR reactor vessel, stored on the spent fuel pad, then conditioned and packaged. Treatment of the spent fuel would occur in an inert atmosphere hot cell located in the new hot cell facility adjacent to VTR. Containerized spent fuel would be placed in storage casks and temporarily stored on the new spent fuel pad until shipped to an offsite location (either an interim storage facility or a permanent repository when either becomes available for VTR fuel).

Under the conceptual design, the existing ORNL infrastructure would be extended to the VTR site. The location selected for the VTR is relatively undeveloped and does not have sufficient infrastructure (e.g., roads, utilities, security) to support construction and operation of the VTR. Radioactive waste would be shipped off site for treatment and/or disposal. Waste management capabilities provided by the project (e.g., treatment or packaging of radioactive liquid waste) and facilities within ORNL would be used to support waste management during construction and operation of the VTR.

S.6.4 Reactor Fuel Production Options

The VTR design envisions the use of metallic fuel. The initial VTR core would consist of a uranium/plutonium/zirconium alloy (U/Pu/Zr) fuel that would be 70 percent uranium (uranium enriched to 5 percent uranium-235[12]), 20 percent plutonium, and 10 percent zirconium, a blend identified as U-20Pu-10Zr. VTR driver fuel used in later operations could consist of these elements in different ratios and could use plutonium with uranium of varying enrichments, including depleted uranium or uranium enriched above 5 percent. Annual heavy metal requirements would be approximately 1.8 metric tons of fuel material (between 1.3 metric tons and 1.4 metric tons of uranium and between 0.4 and 0.54 metric tons of plutonium, depending on the ratio of uranium to plutonium) (INL 2019a; Pasamehmetoglu 2019).[13] Feedstock for this fuel could be acquired from several existing sources.

Enriched uranium for VTR fuel production would be available from sources within the DOE complex and from commercial vendors. DOE's plan for providing uranium for fabricating VTR driver fuel is to acquire metallic uranium from a domestic commercial supplier. If another source of uranium were to be selected, DOE would conduct a review to determine if additional NEPA analysis would be needed. Other possible sources are DOE managed inventories of excess uranium acquired from many sources, including U.S. defense programs and the former DOE uranium enrichment enterprise. Some of the uranium is enriched and could be down-blended for use in VTR driver fuel.

Existing sources of U.S. excess plutonium[14] managed by DOE and the National Nuclear Security Administration (NNSA) would be sufficient to meet the needs of the VTR project. Potential DOE/NNSA plutonium materials include surplus pit[15] plutonium (metal), other plutonium metal, oxide, and plutonium from other sources (DOE 2015). If the U.S. sources cannot be made available for the VTR project or to supplement the domestic supply, DOE has identified potential sources of plutonium in Europe. Potential impacts from transportation of plutonium from Europe are evaluated in Appendix F of this EIS.

VTR driver fuel production evaluated in this EIS involves two steps or phases – feedstock preparation and fuel fabrication. Identified inventories of surplus metallic plutonium, such as those stored at SRS or LANL and surplus pit plutonium, could be used as the source material for VTR driver fuel. This plutonium is in such a form and purity that little, if any, preparation would be required before fuel fabrication. Other sources of plutonium could include DOE supplies of non-metallic plutonium and foreign sources. Depending on the impurities of the source material, a polishing process, or a combination of processes, would be required. Several processing options are available to chemically remove impurities from the plutonium prior to mixing with uranium and zirconium. These processes may require the conversion of the material from metal to oxide and oxide to metal, and dissolution in acid solutions. Some of the processes must be performed at elevated temperatures to take advantage of the chemical properties of

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[12] Enriched refers to the concentration of the isotope uranium-235, usually expressed as a percentage, in a quantity of uranium. Low-enriched uranium (LEU), highly enriched uranium (HEU) and high assay, low-enriched uranium (HALEU) are all enriched forms of uranium. Depleted uranium is a byproduct of the enrichment process and refers to uranium in which the percentage of uranium-235 is less than occurs naturally. Additional information is given in Appendix B.

[13] The cited quantities are those for finished fuel as it is placed in the reactor and correspond to fuel that is from 20 to 27 percent plutonium. Accounting for additional material that ends up in the waste during the reactor fuel production process, up to 34 metric tons of plutonium could be needed for startup and 60 years of VTR operation.

[14] Excess plutonium includes pit and non-pit plutonium that is no longer needed for U.S. national security purposes.

[15] A pit is the central core of a primary assembly in a nuclear weapon and is typically composed of plutonium metal (mostly plutonium-239), enriched uranium, or both, and other materials.

plutonium at different temperatures. These processes would be performed in a series of gloveboxes[16] in order to limit worker radiological exposure (see **Figure S–6**).

Three potential feedstock preparation processes are under consideration: an aqueous capability, a pyrochemical capability, and a combination of the two. In the aqueous process, the plutonium feed (containing impurities) is dissolved in a nitric acid solution and through a series of extraction and precipitation steps, a polished plutonium oxide is produced. The oxide is converted to a metal in a direct oxide reduction process. In one form of the pyrochemical process (molten salt extraction), the metallic plutonium feed is combined with a salt, the mixture raised to the melting point. Impurities (americium) react with the salt, and the polished plutonium is collected at the bottom of the reaction crucible. If the pyrochemical process were selected, a direct oxide reduction process would also be required to convert plutonium dioxide feeds to plutonium metal. Either process (aqueous or pyrochemical) could be used to reclaim unusable fuel output from the fuel fabrication process. If a combination of the two processes were to be selected, a smaller aqueous line to prepare this fuel could be incorporated into the pyrochemical process (SRNS 2020).

Figure S–6. Representative Glovebox

[16] Gloveboxes are sealed enclosures with gloves that allow an operator to manipulate materials and perform other tasks while keeping the enclosed material contained. In some cases, remote manipulators may be installed in place of gloves. The gloves, glass and siding material of the glovebox are designed to protect workers from radiation contamination and exposure.

Fuel fabrication would use an injection casting process to combine and convert the metallic ingots into fuel slugs. DOE has developed a conceptual design for this capability, based on existing equipment at INL's FMF. In a glovebox, a casting furnace would be used to melt and blend the three fuel components: uranium, plutonium, and zirconium. The molten alloy then would be injected into quartz fuel slug molds. After cooling, the molds would be broken, and the fuel slugs retrieved.

- 0.625 centimeters = 0.246 inches
- 80 centimeters = 31 inches
- 165 centimeters = 65 inches

Fuel pins would be created, using 0.625-centimeter-diameter, 165-centimeter-long, HT-9 stainless steel tubes (cladding) into which a slug of solid sodium would be inserted, followed by the alloy fuel slugs. The fuel slugs and sodium would occupy about half of the volume of the fuel pin with the remainder containing argon gas at near atmospheric pressure. The ends of the tubes would be closed with top and bottom end plugs. All of these activities would take place in gloveboxes with inert atmospheres. Once fully assembled, the fuel pins would be heated sufficiently to melt the sodium and create the sodium bond with the fuel. The sodium-bonded fuel would fill about half the length of the fuel pin (80 centimeters). Fuel pins would be assembled into a fuel assembly with each fuel assembly containing 217 fuel pins. Sodium bonding and producing the fuel assemblies would be performed in an open environment. No gloveboxes would be required (INL 2019a).

Fresh fuel assemblies would be kept in storage racks at the fabrication facility until shipped to VTR. At VTR, fuel could be loaded directly into the core or temporarily placed in fuel cask pits.

Operationally, the feedstock preparation and fuel fabrication capabilities would need to generate about 66 fuel assemblies for the initial VTR core. Thereafter, the capabilities would need to produce up to 45 fuel assemblies per year.

This EIS evaluates the INL Site and SRS as potential locations for performing the activities necessary for driver fuel production for the VTR. DOE would establish and operate feedstock preparation capabilities, including plutonium polishing and conversion from oxide to metal, at either of the two sites. Independently, DOE would establish and operate all or part of the fuel fabrication capability at either site.

S.6.4.1 Idaho National Laboratory Reactor Fuel Production Options

The INL Site is a potential location for feedstock preparation, fuel fabrication, or both. All activities would occur in existing facilities, but new equipment would need to be installed. As described in the following paragraphs, DOE has identified existing MFC facilities that would be capable of supporting all fuel production activities. All of these facilities are currently in use and some (e.g., the ZPPR cell) have been identified as possible locations for future programmatic missions other than VTR reactor fuel production. Based on DOE programmatic and scheduling priorities, use of these facilities by other programs may result in their being unavailable to the VTR Program. Should this happen, modifications to enlarge an existing facility or the use of other MFC or VTR facilities would be evaluated to assess their capability to support the VTR Program. Any changes to the facilities being considered to host VTR reactor fuel production would be subject to future review under NEPA.

Under the INL Feedstock Preparation Option, polishing and conversion capabilities would be located in the FCF operating floor/high bay, the mockup area, and workshop. These activities would be performed in space converted for feedstock preparation. The existing FCF hot cells would not be used to support feedstock preparation (INL 2020b). FCF is located within a PIDAS and is a Hazard Category 2 nuclear facility.

After removal of unneeded equipment (current activities within these areas would be relocated), DOE would install new equipment in glovebox lines (a series of two or more related gloveboxes) to perform plutonium polishing and conversion. The number of glovebox lines required would depend upon the processes selected. As noted above, three process combinations are being considered for feedstock preparation. If the aqueous processing were to be selected, an estimated 10 glovebox[17] lines may be necessary. Glovebox lines would be constructed for feed preparation, plutonium dissolution, plutonium extraction, oxide conversion, waste processing, and acid recycling. This scenario considers the most equipment-intensive process under consideration. Other processes would be expected to require fewer gloveboxes and less operational space. All feedstock preparation equipment would be newly installed equipment (SRNL 2020).

Fuel fabrication activities in FMF would occur in a series of gloveboxes. As proposed, DOE would install gloveboxes for casting (two gloveboxes), demolding (two gloveboxes), and rod loading (one glovebox), to fabricate the fuel pins. Additional gloveboxes would be required for slug and pin inspection and scrap recovery. Two gloveboxes are proposed for scrap recovery. One would be modified from an existing glovebox, and the second would be new.

After fabrication, fuel pins would be transferred to ZPPR.[18] Bonding the sodium to the fuel (through heating) and assembling fuel pins into fuel assemblies would occur in the reactor cell room of the ZPPR. This room is sufficiently high to allow fuel pins and fuel assemblies to be vertically raised into and out of the vertical assembly device used for fuel assembly fabrication.

Fuel fabrication at the INL Site would require additional analytical chemistry capability. DOE would install new equipment in existing space at FCF as an analytical chemistry laboratory to support VTR driver fuel fabrication (INL 2019a). Driver fuel cladding would be tested in the EFF. The EFF, a less than Hazard Category 3 nuclear facility equipped with radiological fume hoods, metal-forming and machining equipment, equipment for high temperature applications (furnaces, molten salt baths, casting and annealing furnaces), and fuel experiment assembly equipment (INL 2016).

S.6.4.2 Savannah River Site Reactor Fuel Production Options

SRS is a potential site for feedstock preparation, fuel fabrication, or both. All activities would occur on the minus-20- and minus-40-foot levels (floor levels 20 and 40 feet below grade) of the K-Reactor Building[19] in the K Area Complex. To establish any new capabilities, DOE would install new gloveboxes and equipment.

Reactor fuel production capabilities could be installed in either the K-Area Complex or the similar L-Area Complex. The reactor buildings in K-Area and L-Area are of the same design, and like the K-Reactor Building, the nuclear fuel and equipment needed for reactor operations have been removed from the L-Reactor Building. This EIS specifically evaluates the potential environmental impacts of using the K-Area Complex in support of the VTR project, but the impacts would be similar if the L-Area Complex were used. The reactor buildings are only 2.5 miles apart and each is within a PIDAS. At either location, activities would largely occur indoors with small, previously disturbed locations outside being used for ancillary buildings or construction laydown areas. At L-Area, space for project activities would be available on the ground floor, as well as at the minus-20- and minus-40-foot levels. A comparative analysis shows that the offsite impacts from radiological releases would be within 3 percent of each other, with those from L-Area being slightly lower.

[17] The feedstock preparation operations design uses gloveboxes. However, the design is at a conceptual stage and subject to change. Potential changes include the use of heavily shielded or highly automated gloveboxes or even the use of hot cells. Design considerations that might affect these decisions include limiting worker dose.

[18] The reactor and auxiliary systems portion of ZPPR have been removed. The facility is now used, among other tasks, for the storage, inspection, and repackaging of transuranic elements and enriched uranium. The ZPPR facility includes a workroom, cell area, material storage vault, and the Material Control Building.

[19] Due to its use as a special nuclear material storage facility, the K-Reactor Building is a Hazard Category 1 nuclear facility. K-Reactor, constructed in the 1950s was shut down in 1996, and subsequently deactivated. Nuclear fuel and equipment needed for reactor operation were removed. The building was later modified for nuclear material storage (DNFSB 2003).

Under the SRS Feedstock Preparation Option, capabilities would be located primarily on the minus-20-foot level in the K Area Complex. The identified area would be suitable for pretreatment operations like molten salt removal of the americium from plutonium (polishing) and electrorefining and direct oxide reduction to convert fuel compounds (e.g., fuel oxides) into their metallic form. The facility floorplan has available space to install the gloveboxes required for these operations. All of the equipment for fuel processing and conversion (as described in Section S.6.4) would be newly installed (SRNS 2020).

Under the SRS Fuel Fabrication Option, the fuel fabrication capability would be located on the minus-20- and minus-40-foot levels. A portion of this area is currently occupied by excess equipment and stored drums of heavy water. The heavy water would be removed to a new onsite storage location. The disposition path for the excess equipment would be determined by characterization of the material at the time of disposal. The space in several additional pump rooms could also be used if necessary. The identified area would be suitable for the fuel fabrication glovebox processes being designed at INL (as described in Section S.6.4.1). All of the enclosures and equipment for fuel fabrication would be newly installed (SRNS 2020).

S.7 Alternatives Considered but Dismissed from Detailed Analysis

Consistent with the NEICA directive to determine the need for a versatile reactor-based, fast-neutron source and complete construction of and approve the start of operations for the user facility by December 31, 2025, to the maximum extent practicable, DOE considered several alternatives for different aspects of the VTR project. A number of reactor technologies and alternate locations for siting the VTR and VTR driver fuel production capabilities were considered, but dismissed from detailed analysis in this EIS.

S.7.1 Reactor Technology

To meet the mission need for a versatile, fast-neutron spectrum testing capability, DOE considered 18 concepts (plus the status quo). They were primarily reactor concepts, but also included some non-reactor concepts. DOE evaluated the 18 concepts (including the sodium-cooled fast test reactor concept) in the *Analysis of Alternatives, Versatile Test Reactor Project* (AoA) (DOE 2019). The 17 concepts dismissed from detailed analysis in this EIS included existing facilities, new fast test reactors, and a new accelerator-driven system. The AoA performed an initial screening of all concepts against six criteria based on the requirements of NEICA and the *Mission Need Statement for the Versatile Test Reactor (VTR) Project* (DOE 2018a). Twelve concepts failed to meet one or more of these criteria and were eliminated from further evaluation in the AoA. In particular, DOE determined that 10 concepts failed the criterion: "*Provides an intense, fast-neutron irradiation environment with prototypic spectrum to determine irradiation tolerance and chemical compatibility of reactor fuels, materials, and coolants, with the versatility to address diverse technology options and sustained and adaptable testing environments*." Six concepts failed the criterion: *The [concept] shall become operational on an accelerated schedule to regain and sustain U.S. technology leadership and to enable the competitiveness of U.S.-based industry entities in the advanced reactor markets* (DOE 2019).

Three existing facilities and two new fast test reactors (in addition to the sodium-cooled reactor) passed the initial screening criteria. The three existing facilities that passed the initial screening criteria were the Advanced Test Reactor (ATR) at the INL Site, the High Flux Isotope Reactor (HFIR) at ORNL, and FFTF at the DOE Hanford Site. The two new reactor designs that passed the screening criteria were the molten-salt-cooled fast test reactor (MSFTR) and a lead/lead-bismuth-cooled fast test reactor (LFTR).

Despite two existing operating facilities —ATR and HFIR— having favorable qualities for the VTR project (e.g., they have existing infrastructure and established fuel management), they are *primarily* thermal spectrum reactors. Even with modification, neither reactor would fully meet the test capabilities required for the VTR. They could not provide the fast-neutron flux, the neutron dose rate, or the required experimental volume. Additionally, as operating facilities, both reactors support other programs and have prior test commitments. Use of either as the VTR could interfere with the current test capabilities of the reactors and could result in conflicts between tests and experiments requiring a fast flux and those requiring a thermal flux. This would result in the loss of thermal flux test capacity at the facilities. That capacity could not be replaced using existing U.S. test capabilities, nor could it provide the full fast flux testing capability identified for the VTR. Modifying either of these reactors would create some fast flux testing capability, but could compromise the United States' ability to regain and sustain a technology leadership position. Therefore, these two reactors were dismissed from further evaluation in this EIS.

FFTF operated for many years as a fast flux test reactor and, as a result, has a demonstrated history of performing the type of testing for which VTR is proposed. Because the FFTF would be modified as part of a restart, appropriate testing capabilities could be factored into the design. However, there are uncertainties associated with modifying the design. The DOE Office of Nuclear Energy reviewed the AoA results and determined that a further examination of the "Modify and Restart FFTF Alternative" was warranted given its evaluation score, technology-related risk score, site-specific risk score, and costs relative to the sodium-cooled fast test reactor alternative. This examination included a facility walk down of FFTF conducted in October 2019 by a team composed of the VTR Program Director, DOE Richland Assistant Manager, VTR Project Manager, and industry experts. Based on the facility walk down, extensive pre- and post-tour discussions, and review of a study by the Columbia Basin Consulting Group, the team had significant concerns about the viability of restarting FFTF. These concerns include:

- FFTF was operated for 10 of its 20-year design life with a potential for an additional 10 years;
- there are an extensive number of electrical and mechanical systems that would have to be replaced since last operated in the mid-1990s;
- the Columbia Basin Consulting Group study, conducted in 2007, based its cost estimate on a 2000 restart study when the systems were in relatively good condition;
- an extensive effort would be necessary to obtain a viable cost and schedule restart estimate; and
- FFTF would require extensive design changes to accommodate testing of alternate coolant technologies (lead, salt, or gas).

There is also a concern that an extensive design and safety-basis reconstitution effort, including seismic analysis, would be costly and time consuming and has the potential to identify additional necessary upgrades. Subsequent discussions with the VTR Project Team concluded that these issues would result in a restart effort significantly longer and more costly than characterized in the AoA. The schedule and cost could increase further to accommodate upgrades to address the full suite of VTR test requirements and to respond to the current design-basis safety philosophy. Therefore, FFTF was removed from further analysis in this EIS.

The most significant factor for the two new reactor designs (MSFTR and LFTR) is the current level of development and technical maturity for these reactor concepts. In an assessment of the technical readiness level of various reactor concepts, the *Advanced Demonstration and Test Reactor Options Study* concluded that salt-cooled (it evaluated a fluoride-cooled high-temperature reactor) and lead-cooled fast reactors are less mature than sodium-cooled fast reactors and require additional research and development (INL 2017a). There is considerably less knowledge base for these designs than for the sodium-cooled fast test reactor concept. Only one molten-salt reactor has been built and it was not a fast reactor. Experience with building and operating lead-cooled reactors is limited, not readily available, and related to submarine propulsion. For both reactor concepts, a demonstration reactor might be necessary, which would result in greater costs and unacceptable schedule delays for the construction and operation of the VTR. These reactor technologies were dismissed from further evaluation in this EIS because of the technical and schedule risk associated with their technical maturity.

S.7.2 Site Selection

In addition to the two sites proposed for locating the VTR and its associated post-irradiation examination facilities, DOE considered two additional sites. DOE used a variety of factors in narrowing down the potential VTR reactor and support sites for assessment in this EIS. Chief among the factors is the realistic and pragmatic assessment of whether the site had an adequate location and the technical infrastructure necessary to support the key VTR activities. Most importantly, the site needed to have the technical infrastructure to support construction and operation of a test reactor; to operate hot cells for post-irradiation examination of test items; and to use hot cells for the disassembly of spent fuel and processing it to a form suitable for long-term disposal.

DOE recognized that choosing a site that has the human resources with the requisite experience to build and operate a test reactor like the VTR is essential to the success of the VTR mission. An equally important site selection consideration is that VTR support activities include operation of hot cells for two critical purposes: post-irradiation examination and spent fuel treatment. These critical VTR support activities require a substantial technical staff with direct experience in use of hot cells. While at one time, DOE had hot cell facilities at multiple sites, most of those hot cells have been shut down. Hot cell operation is a highly specialized field and it requires years to train new staff and gain the experience necessary to conduct the operations.

The AoA performed a preliminary assessment of candidate sites for the location of VTR technology. Four DOE sites were considered. Three sites have test reactors: ATR and the Transient Reactor Test Facility (TREAT) at the INL Site, HFIR at ORNL, and the deactivated FFTF at Hanford. The AoA selected the fourth site, SRS to represent a generic DOE site without a test reactor. Additionally, a generic non-government site was evaluated. Sites were assessed to the degree to which they have the capability to meet the preliminary assessment criteria.

Hanford, with FFTF and the Pacific Northwest National Laboratory (PNNL), was considered because of existing capabilities and past experience. PNNL has a full range of supporting infrastructure for transportation, construction and operation, safety, security, nuclear material management, and regulatory compliance. Substantial support capabilities exist at PNNL, including hot cells (the Shielded Analytical Laboratory) for post-irradiation examination and laboratories (the Radiochemical Processing Laboratory) for chemistry, materials, and instrumentation. In spite of these capabilities, Hanford was dismissed from detailed analysis in this EIS. The FFTF has not operated since 1992 and is currently in a long-term surveillance and maintenance condition. This means that the organizational infrastructure needed to support operation of a test reactor no longer exists at Hanford. After nearly 30 years, experienced test reactor operational staff would not be available. Additionally, compared to INL and ORNL, PNNL has more limited capability to support experiment fabrication and fuel and experiment disassembly and inspection. INL and ORNL currently perform these activities in association with their onsite reactors.

SRS and Savannah River National Laboratory (SRNL) have extensive history in nuclear reactor operation and offer a full range of supporting infrastructure for transportation, construction and operation, safety, security, nuclear material management, and regulatory compliance. There are also substantial support capabilities currently available at SRNL, including hot cells and laboratories for chemistry, materials, and instrumentation. SRNL has bench-scale hot cell capability. These hot cells, however, are currently used to support DOE's Office of Environmental Management missions at SRS. In spite of its technical capabilities, Savannah River Site was dismissed from detailed analysis as a location for the VTR. SRS has no test reactor experience and the last of the onsite operating reactors shut down in 1992. This means that the organizational infrastructure needed to support operation of a test reactor does not exist at SRS. Compared to INL and ORNL, SRS also has more limited capability (primarily located at SRNL) to support experiment fabrication and fuel and experiment disassembly and inspection. INL and ORNL currently performs these activities in association with operation of their onsite test reactors.

No specific non-government sites were identified for the location of the VTR in the AoA (DOE 2019); the AoA assessed a generic non-government site. It was considered unlikely that a site could be identified with available infrastructure, staff experienced in preparation of test assemblies, test reactor operation, and post-irradiation examination, spent fuel management experience, and the security required for the VTR facilities. Additionally, any non-government site would fall under the regulatory authority of the U.S. Nuclear Regulatory Commission (NRC). Many licensing related activities would have to be completed before beginning construction and do not have a fixed duration, adding programmatic risk to the project schedule. Given the existence of DOE sites that have demonstrated capabilities to support the VTR and given the potential schedule impact of the added licensing activities, locating the VTR at a non-government site was not considered a viable alternative and was dismissed from detailed analysis.

VTR fuel production, including feedstock preparation and fuel fabrication, requires several key factors. Because of the quantities of plutonium handled each year, a site must be able to support DOE's security requirements. DOE has only a few facilities with available space and capacity that can securely handle the quantities of plutonium necessary to support the VTR's fuel needs. These facilities are principally at the K Area Complex at SRS and at the MFC at the INL Site. Equally important for fuel manufacturing success is the technical staff to support feedstock preparation and fuel fabrication. These activities are very specialized, and most of the past DOE activities of this nature have been closed. As such, the DOE talent and expertise in these areas is limited to a few sites. The principal remaining facilities and expertise in plutonium fuels and processing are at INL, SRS, PNNL, LANL, and Lawrence Livermore National Laboratory (LLNL). Realistically, other missions fully use the remaining facilities and engage the expertise at PNNL, LANL, and LLNL, thereby precluding these sites from detailed analysis.

S.8 Preferred Alternative

DOE's Preferred Alternative is the INL VTR Alternative. DOE would build and operate the VTR at the INL Site adjacent to the existing MFC. Existing facilities within the MFC would be modified and used for post-irradiation examination of test assemblies. Post-irradiation examination would be performed in HFEF, IMCL, and other MFC facilities. Spent VTR driver fuel would be treated to remove the sodium-bonded material at FCF. Modifications to FCF may be required to carry out this process. The intent of this treatment is to condition and transform the spent nuclear fuel into a form that would meet the acceptance criteria for a future permanent repository. This treated fuel would be temporarily stored at a new VTR spent fuel pad at MFC.

DOE has no preferred options at this time for where it would perform reactor fuel production (feedstock preparation or driver fuel fabrication) for the VTR. This EIS evaluates options for both processes at the INL Site and at SRS. DOE could choose to use either site or a combination of both sites to implement either option. DOE will state its preferred options for feedstock preparation and fuel fabrication in the Final VTR EIS, if preferred options are identified before issuance.

S.9 Summary of Environmental Consequences

S.9.1 Comparison of Alternatives and Options

Table S–1 summarizes and allows side-by-side comparison of the potential environmental impacts of the INL VTR Alternative and the ORNL VTR Alternative. Impacts are presented for the construction of the VTR at the INL Site and the VTR and a hot cell facility at ORNL. The impacts, as presented, include the operation of the VTR, post-irradiation examination activities, and spent driver fuel management. **Table S–2** summarizes and allows comparison of the impacts from establishing the capabilities for and performing feedstock preparation and fuel fabrication at the INL Site or SRS.

Under the No Action Alternative, DOE would make use of the limited capabilities available at existing facilities, both domestic and foreign, for testing in the fast-neutron-flux spectrum. DOE would not construct or modify any facilities or effect any substantial change in the level of operations for post-irradiation examination. There would be no need for new VTR driver fuel production and no VTR spent nuclear fuel would be generated. Whereas the impacts presented in Tables S–1 and S–2 represent potential incremental increases, under the No Action Alternative there would be no increase in environmental impacts at the INL Site, ORNL, and SRS above those described in Chapter 3, Affected Environment.

S.9.2 Summary of Combined Idaho National Laboratory Impacts

Potential environmental impacts were evaluated for three possible actions at the INL Site: 1) construction and operation of the VTR along with modification and operation of associated facilities needed for post-irradiation examination of test articles and management of spent fuel; 2) facility modifications and operation to prepare fuel feedstock material for use in VTR driver fuel; and 3) facility modifications and operation for fabrication of VTR driver fuel. Impacts were evaluated separately for each of these actions. **Table S–3** summarizes the potential environmental consequences that could occur if DOE were to decide to perform all three actions at the INL Site.

Table S–1. Summary of Versatile Test Reactor Alternative Environmental Consequences

Resource Area	Alternatives: INL VTR	Alternatives: ORNL VTR
Land Use and Aesthetics (Chapter 4, Section 4.1)		
Land Use	*Construction*: There would be minor impacts on land use from the disturbance of approximately 100 acres during construction activities.	*Construction*: There would be minor impacts on land use from the disturbance of approximately 150 acres during construction activities.
	Operations: Land use would be consistent with existing land use and activities currently occurring at each location. Approximately 25 acres of previously unused area would be converted permanently for industrial use at the INL Site. Approximately 50 acres of vegetated area at ORNL would be cleared and converted permanently for industrial use.	
Aesthetics	*Construction*: There would be minimal impacts on aesthetics as newly constructed facilities would not dominate the local landscape and would be similar in design to existing facilities. Though not visible from offsite areas, approximately 150 acres of vegetated/forested area at ORNL would be cleared during construction.	
	Operations: There would be minimal impacts on aesthetics from operation of the newly constructed facilities that would be similar in design to existing facilities, but only from areas within line of sight of the new facilities. Impacts on International Dark Sky Park, Craters of the Moon National Monument would not be expected from additional exterior lighting required for the VTR at the INL Site.	
Geology and Soils (Chapter 4, Section 4.2)		
	Construction: Area disturbed would be 100 acres. Volume of excavated materials would be 135,000 cubic yards; backfill/soil needed would be 202,000 cubic yards; deficit fill volume of 67,000 cubic yards would be obtained from onsite borrow sources such as Rye Grass Flats. Rock/gravel needed would be 45,000 cubic yards. The total quantities of geologic and soil materials needed during construction would represent small percentages of regionally plentiful resources and are unlikely to adversely impact geology and soil resources.	*Construction*: Area disturbed would be 150 acres. Volume of excavated material would be 886,000 cubic yards; backfill/soil needed would be 989,000 cubic yards; deficit fill volume of 103,000 cubic yards would be obtained from onsite borrow sources such as the Copper Ridge borrow area. Rock/gravel needed would be 74,000 cubic yards. The total quantities of geologic and soil materials needed during construction would represent small percentages of regionally plentiful resources and are unlikely to adversely impact geology and soil resources.
	Operations: Area occupied would be 25 acres. No additional land disturbance, no additional excavation, and little or no use of geologic and soil materials.	*Operations*: Area occupied would be 50 acres. No additional land disturbance, no additional excavation, and little or no use of geologic and soil materials.
Water Resources (Chapter 4, Section 4.3)		
	Construction: All water required during the construction process would be drawn from existing wells that access the Snake River Plain Aquifer. Potable water would be treated through the existing Materials and Fuels Complex system. The total water demand is estimated to be about 128 million gallons, including about 34 million gallons of potable water and about 94 million gallons for other construction activities. Water would be discharged to surface water (which could include the Materials and Fuels Complex sewage lagoons or other surface discharges such as swales).	*Construction*: All water required during the construction process would be drawn from the Clinch River. Potable water would be treated at a water treatment plant that is owned and operated by the City of Oak Ridge and located northeast of the Y-12 National Security Complex. The total water demand is estimated to be about 170 million gallons during the entire construction period, including about 46 million gallons of potable water and about 121 million gallons for construction activities. Water would be discharged to adjacent surface waters.

Resource Area	***Alternatives***	
	INL VTR	***ORNL VTR***
	Operations: Water would be drawn from the Snake River Plain Aquifer and discharged as surface water to either the Industrial Waste Pond or active sewage lagoons. The total annual volume of water that would be discharged is estimated to be about 4.4 million gallons, which includes the volume required for personnel use and sanitation, firewater, and demineralized water. No water would be required for operation of the reactor itself.	*Operations*: Water used during operations would be drawn from the Clinch River and discharged to Bearden Creek or Melton Branch. The total annual volume of water that would be discharged is estimated to be about 4.4 million gallons, which includes the volume required for personnel use and sanitation, firewater, and demineralized water. No water would be required for operation of the reactor itself.
Air Quality (Chapter 4, Section 4.4)		
	Construction: Counties that encompass the INL Site currently are in attainment for all national ambient air quality standards (NAAQS) (i.e., for criteria pollutants). Annual nonradiological emissions estimated for construction of the VTR facilities would be well below the EPA prevention of significant deterioration (PSD) permitting threshold of 250 tons per year for a criteria pollutant. Construction at the INL Site would generate more fugitive dust compared to the effort at ORNL, as the INL Site has a more arid climate. Hazardous air pollutant (HAP) emissions from construction activities would not result in adverse air quality impacts on the public. Construction activities would not generate radiological air emissions.	*Construction*: Counties that encompass ORNL currently are in attainment for all NAAQS. Annual nonradiological emissions estimated for construction of the VTR facilities would be well below the EPA PSD permitting threshold of 250 tons per year for a criteria pollutant. Construction at ORNL would result in higher emissions of most pollutants (compared to the INL Site), due to the larger area and more effort needed to clear and grade the project site. HAPs emissions from construction activities would not result in adverse air quality impacts on the public. Construction activities would not generate radiological air emissions.
	Operations: Annual nonradiological emissions from operation of the VTR facilities would be similar and well below the annual indicator thresholds. Impacts from radiological air emissions are addressed under Human Health – Normal Operations.	
Ecological Resources (Chapter 4, Section 4.5)		
	Construction: Area disturbed: about 100 acres. Construction would result in a loss of sagebrush habitat. Losses to sagebrush habitat would be compensated for in accordance to the DOE's 'no net loss of sagebrush habitat' policy on the INL Site under the Candidate Conservation Agreement (CCA) for the sage-grouse. Nesting bird surveys would occur prior to any ground disturbance or vegetation removal to confirm the absence of Migratory Bird Treaty Act-protected species, as well as sage-grouse, in the proposed project area. A 300-foot buffer would be established around active pygmy rabbit burrow systems to prevent direct impacts. Operational and administrative controls would be evaluated and implemented, if warranted, to reduce the potential for adverse effects on wildlife species and human-wildlife interactions.	*Construction:* Area disturbed: about 150 acres. Construction would result in a loss of forested habitat, including up to thirty-seven hemlock trees, with potential for impacts on federally and state-listed species and aquatic resources. If the ORNL VTR alternative were selected, additional species-specific surveys would occur. Aquatic features (e.g., channels, tributaries, drainages, catchments, seeps, springs or wetlands) would be impacted. Potential impacts to aquatic resources would require wetland delineations, stream evaluations, and hydrologic determinations of currently unclassified channels and wet weather conveyances. Any potential Exceptional Tennessee Waterways would require additional assessment using the Tennessee Rapid Assessment Method. In compliance with Section 404 of the Clean Water Act, a permit from U.S. Army Corps of Engineers would be obtained prior to any construction work within jurisdictional features and compensatory mitigation would be required for unavoidable impacts.

Resource Area	Alternatives: INL VTR	Alternatives: ORNL VTR
	Operations: Area occupied by new structures would be about 25 acres. Operations would take place in new and existing facilities. No additional land disturbance would occur, and therefore no additional impacts would occur on ecological resources.	*Operations*: Area occupied by new structures would be about 50 acres. Operations would take place in new and existing facilities. No additional land disturbance would occur, and therefore no additional impacts would occur on ecological resources.
Cultural and Paleontological Resources (Chapter 4, Section 4.6)		
	Construction: No impacts on significant cultural and paleontological resources would occur from facility construction and land disturbance.	
	Operations: No impacts on cultural and paleontological resources would occur from facility operations.	
Infrastructure (Chapter 4, Section 4.7)		
	Construction: Construction electricity usage would average 1,000 megawatt-hours per year with a peak annual use of 2,000 megawatt-hours. Diesel fuel usage would total 2.3 million gallons. Total water usage would be 128 million gallons.	*Construction:* Construction electricity usage would average 1,300 megawatt-hours per year with a peak annual use of 2,600 megawatt-hours. Diesel fuel usage would total 3.3 million gallons. Total water usage would be 170 million gallons.
	Operations: Operations at VTR would use 150,000 megawatt-hours per year of electricity, 4.7 million cubic feet of propane per year, and 4.4 million gallons of water per year.	*Operations*: Operations at VTR would use 180,000 megawatt-hours per year of electricity, 4.7 million cubic feet of propane per year, and 4.4 million gallons of water per year.
	Discussion: For construction, more resources would be used at ORNL because a new hot cell facility would be constructed in addition to the VTR. For operations, estimates for electrical usage differ because INL would primarily utilize two existing facilities for post-irradiation examination and spent fuel treatment and ORNL would use a new facility for most of these activities.	
Noise and Vibration (Chapter 4, Section 4.8)		
Noise	*Construction:* Due to the distance, estimated noise levels at the INL Site boundary (2.9 miles) and closest receptor (5.0 miles) would not be perceptible and would be consistent with ambient levels.	*Construction:* Estimated noise levels at the closest receptor (6,750 feet) would be approximately 47 dBA, which given the distance, would be minimal and remain below the noise standards at the closest receptor.
	Operations: Due to the distance, noise levels at the INL Site boundary (2.9 miles) and closest receptor (5.0 miles) would not be perceptible and would be consistent with ambient levels.	*Operations*: Noise levels would be similar to other existing equipment at ORNL and would not impact offsite receptors.
Vibration	*Construction:* Ground-borne vibration due to typical construction activities are expected to be below the threshold of human perception at offsite locations.	
	Operations: Ground-borne vibration due to typical operational activities are expected to be below the threshold of human perception at offsite locations.	

<table>
<tr><th rowspan="2">Resource Area</th><th colspan="2">Alternatives</th></tr>
<tr><th>INL VTR</th><th>ORNL VTR</th></tr>
<tr><td colspan="3">Waste Management and Spent Nuclear Fuel Management (Chapter 4, Section 4.9)</td></tr>
<tr><td rowspan="2"></td><td>Construction:
About 9,900 cubic meters of construction waste would be generated during construction activities.</td><td>Construction:
About 13,000 cubic meters of construction waste would be generated during construction activities.</td></tr>
<tr><td colspan="2">Operations (annual impacts):
During operations, 540 cubic meters of LLW, 38 cubic meters of MLLW, 0.89 cubic meters of TRU waste, and 7.2 cubic meters of hazardous and TSCA wastes would be generated. The characteristics of these wastes would be similar to wastes currently generated by existing activities. All wastes would be packaged for shipment off site. Treatment and disposal of these wastes are well within the current capacities of existing offsite facilities.</td></tr>
<tr><td rowspan="2">Spent Nuclear Fuel</td><td colspan="2">Construction: No spent fuel is generated during construction.</td></tr>
<tr><td colspan="2">Operations:
The heavy metal from 45 spent driver fuel assemblies produced annually (66 for the final core at the end of the VTR's operational life) would be treated and packaged as spent nuclear fuel and placed on the VTR spent fuel pad pending offsite shipment. The total number of spent fuel assemblies over the lifetime of the project represent about 110 metric tons of heavy metal.</td></tr>
<tr><td colspan="3">Human Health – Normal Operations (Chapter 4, Section 4.10)</td></tr>
<tr><td rowspan="2"></td><td>Construction:
Offsite population
No impacts on the public; there would be no radiological releases during construction.
Worker population – workers would receive exposures from installing equipment in existing facilities.
Dose: 10 person-rem
LCFs: 0 (calculated: 6×10^{-3})
Industrial accidents: 79 injuries with no fatalities expected.</td><td>Construction:
Offsite population
Same as INL Alternative
Worker population
No radiological impacts; all work would be performed in area of the site with no known radioactive contamination.
Industrial accidents: 120 injuries with no fatalities expected.</td></tr>
<tr><td>Operations (annual impacts):
Offsite population
Dose: 0.044 person-rem
LCFs: 0 (calculated: 3×10^{-5})
Maximally exposed individual
Dose: 0.0068 millirem
LCF risk: 4×10^{-9}
Worker population
Dose: 53 person-rem
LCFs: 0 (calculated: 3×10^{-2})
Industrial accidents: 9 injuries with no fatalities expected.</td><td>Operations (annual impacts):
Offsite population
Dose: 0.58 person-rem
LCFs: 0 (calculated: 3×10^{-4})
Maximally exposed individual
Dose: 0.031 millirem
LCF risk: 2×10^{-8}
Worker population
Dose: 44 person-rem
LCFs: 0 (calculated: 3×10^{-2})
Industrial accidents: 9 injuries with no expected fatalities</td></tr>
</table>

<table>
<tr><th rowspan="2">Resource Area</th><th colspan="2">Alternatives</th></tr>
<tr><th>INL VTR</th><th>ORNL VTR</th></tr>
<tr><td></td><td colspan="2">Discussion:
For construction, a larger number of injuries is expected at ORNL due to the construction of a new hot cell facility in addition to the VTR. For operations, a lower worker population dose is expected at ORNL than INL because at INL additional Materials and Fuels Complex staff could be tasked to support VTR personnel. That same additional support was not assumed for ORNL as the post-irradiation examination and spent fuel treatment staff at ORNL would be new and dedicated to VTR operations only.</td></tr>
<tr><td colspan="3">Human Health – Facility Accidents (Chapter 4, Section 4.11)</td></tr>
<tr><td rowspan="3"></td><td colspan="2">Construction:
No impacts on the offsite public, maximally exposed individual, or noninvolved worker. No construction accidents are expected to release radiological or hazardous materials.</td></tr>
<tr><td>Operations (annual impacts):
Offsite population
Accident probability: less than one in 10,000 per year
Dose: 38 person-rem
LCFs: 0 (0.02)
Maximally exposed individual
Accident probability: less than one in 10,000 per year
Dose: 0.25 rem
LCF risk: 0.0001
Noninvolved worker
Accident probability: less than one in 10,000 per year
Dose: 160 rem
LCF risk: 0.2</td><td>Operations (annual impacts):
Offsite population
Accident probability: less than one in 10,000 per year
Dose: 1,400 person-rem
LCFs: 1
Maximally exposed individual
Accident probability: less than one in 10,000 per year
Dose: 14 rem
LCF risk: 0.009
Noninvolved worker
Accident probability: less than one in 10,000 per year
Dose: 400 rem
LCF risk: 0.5</td></tr>
<tr><td colspan="2">Discussion:
The risks to the maximally exposed individual and the general population from accidents at the INL Site and ORNL are very small, taking into account the very, very low probabilities (less than one in 10,000 per year) and consequences of the accidents. A fire involving VTR spent driver fuel subassemblies in the VTR Experiment Hall is the bounding operational accident at the VTR. Offsite impacts on the maximally exposed individual and general population from an accident at ORNL would be greater than impacts at the INL Site because of the proximity of the proposed VTR site to areas of public access and because the population near ORNL is larger and closer to the VTR. A hypothetical, beyond-design-basis event with an estimated frequency much less than 1 in 10 million is evaluated and discussed in Chapter 4, Section 4.11 and Appendix D.</td></tr>
</table>

<table>
<tr><th rowspan="2">Resource Area</th><th colspan="2">Alternatives</th></tr>
<tr><th>INL VTR</th><th>ORNL VTR</th></tr>
<tr><td colspan="3">Human Health – Transportation Impacts (Chapter 4, Section 4.12)</td></tr>
<tr><td></td><td>Construction:
Shipments: 18,460, with 1 potential traffic accident fatality based on accident statistics.</td><td>Construction:
Shipments: 23,790, with 1 potential traffic accident fatality, based on accident statistics.</td></tr>
<tr><td></td><td>Operations (annual impacts):
Radioactive waste shipments: 130
Population:
Maximum dose: 8 person-rem with no LCFs. Individual doses from transportation would be well below DOE and regulatory limits.
Worker population:
Maximum dose: 7 person-rem with no LCFs. Individual worker doses from transportation would be limited to meet DOE administrative worker dose limits.
Accidents:
LCFs: None
Nonradiological traffic fatalities: 1 potential traffic fatality over the 60-year life of the project</td><td>Operations (annual impacts):
Radioactive waste shipments: 130
Population:
Maximum dose: 12 person-rem with no LCFs. Individual doses from transportation would be well below DOE and regulatory limits.
Worker population:
Maximum dose: 10 person-rem with no LCFs. Individual worker doses from transportation would be limited to meet DOE administrative worker dose limits.
Accidents:
LCFs: None
Nonradiological traffic fatalities: 1 potential traffic fatality over the 60-year life of the of the project</td></tr>
<tr><td></td><td colspan="2">Discussion:
Radioactive wastes include contact-handled and remote-handled LLW, MLLW, TRU waste, and mixed TRU waste.
For incident-free operations, the affected population includes individuals living within 0.5 miles of each side of the road. For accident conditions, the affected population includes individuals living within 50 miles of the accident.</td></tr>
<tr><td colspan="3">Traffic (Chapter 4, Section 4.13)</td></tr>
<tr><td></td><td colspan="2">Construction:
The average increases in daily traffic during construction are not expected to exceed existing level of service of offsite roads and no upgrades or improvements to onsite roads are anticipated.</td></tr>
<tr><td></td><td colspan="2">Operations:
Operations at each facility are expected to result in an increase in traffic from new employees. The changes would represent a minor increase in traffic at each facility (about 5 percent). Operations traffic is not expected to cause a change in the existing level of service of offsite roads and no upgrades or improvements to onsite roads are anticipated.</td></tr>
</table>

Resource Area	Alternatives	
	INL VTR	**ORNL VTR**
Socioeconomics (Chapter 4, Section 4.14)		
	Construction: The increase in jobs and income from construction would have a short-term beneficial impact on the local and regional economy. The population influx associated with an in-migrating workforce and their families is considered relatively small and would have no major adverse impacts on the region in terms of population, employment, income levels, housing, or community services.	
	Operations: The increase of 218 jobs would have a beneficial impact on the local and regional economy. The population influx associated with an in-migrating workforce and their families is considered relatively small and would have no major adverse impacts on the region in terms of population, housing, or community services.	*Operations*: The increase of 300 jobs would have a beneficial impact on the local and regional economy. The population influx associated with an in-migrating workforce and their families is considered relatively small and would have no major adverse impacts on the region in terms of population, housing, or community services.
Environmental Justice (Chapter 4, Section 4.15)		
	Construction and Operations: No disproportionately high and adverse impacts on minority or low-income populations are expected. Increased health risks to minority or low-income individuals or populations exposed to radiation would be negligible.	

dBA = decibels, A-weighted; EPA = U.S. Environmental Protection Agency; INL = Idaho National Laboratory; LCF = latent cancer fatality; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; ORNL = Oak Ridge National Laboratory; TRU = transuranic; TSCA = Toxic Substances Control Act.
Note: Sums and products presented in the table may differ from those calculated from individual entries due to rounding.

Table S–2. Summary of Environmental Consequences for Reactor Fuel Production Options

Resource Area	***Options***			
	INL Feedstock Preparation	***INL Fuel Fabrication***	***SRS Feedstock Preparation***	***SRS Fuel Fabrication*** [a]
Land Use and Aesthetics (Chapter 4, Section 4.1)				
Land Use	*Construction and Operations*: No impacts on land use as modifications/construction and operations would occur in existing facilities and not require construction of new facilities or additional land use.		*Construction and Operations*: No impacts on land use as modifications/construction and operations would occur in existing facilities or adjacent to those facilities. Up to 3 acres of previously disturbed land would be used.	
Aesthetics	*Construction and Operations*: No impacts on aesthetics as modifications/construction would occur in existing facilities.		*Construction and Operations*: No impacts on aesthetics as modifications/construction would occur in or adjacent to existing facilities and be compatible with the current industrial setting.	
Geology and Soils (Chapter 4, Section 4.2)				
	Construction and Operations: No additional land disturbance, no additional excavation, and little or no use of geologic and soil materials because modifications/construction and operations would occur in existing buildings.		*Construction and Operations*: Most modifications/construction and operations would occur in existing buildings. Up to 3 acres of land disturbance, a small amount of excavation, and small quantities of geologic and soil materials maybe associated with constructing ancillary facilities.	
Water Resources (Chapter 4, Section 4.3)				
	Construction: An estimated 230,000 gallons of potable water would be required by construction personnel and 5,000 gallons of water would be needed for cleaning. The water would be drawn from groundwater and discharged as surface water (which could include the Materials and Fuels Complex sewage lagoons or other surface discharges such as swales).		*Construction*: An estimated 3 million gallons of potable water would be needed. An additional volume of non-potable water required during construction is expected to total about 6 million gallons.	
	Operations: The addition of 300 new full-time employees would require about 1.4 million gallons of water per year. An additional 50,000 gallons would be needed for process operations. Water would be drawn from groundwater. Sanitary waste would be discharged as surface water. Process waters would be transported off site for treatment and disposal.	*Operations*: The addition of 70 new full-time employees would increase potable water use by about 880,000 gallons per year. In addition, about 1,000 gallons per year would be needed for mopping and cleaning. This water would be drawn from groundwater and discharged as surface water.	*Operations*: The addition of 300 new full-time employees would increase water use by about 1.4 million gallons of water per year. An additional 50,000 gallons would be needed for process operations. Water would be drawn from groundwater and discharged as surface water.	*Operations*: The addition of 300 new full-time employees would increase water use by about 1.4 million gallons of water per year. This water would be drawn from groundwater and discharged as surface water.
	Discussion: The higher estimate of water use for construction of the feedstock preparation capability at SRS is because a greater level of effort is expected to make the facility modifications. More interior modifications (removing and constructing walls) are expected at SRS than at INL. Under the Fuel Fabrication Options, all new staff would be required at SRS, whereas at INL, a portion of the staff is existing and would be augmented with new hires.			

<table>
<tr><th rowspan="2">Resource Area</th><th colspan="4">Options</th></tr>
<tr><th>INL Feedstock Preparation</th><th>INL Fuel Fabrication</th><th>SRS Feedstock Preparation</th><th>SRS Fuel Fabrication [a]</th></tr>
<tr><td colspan="5">Air Quality (Chapter 4, Section 4.4)</td></tr>
<tr><td></td><td colspan="4">Construction and Operation:
The counties that encompass the INL Site and SRS currently are in attainment for all NAAQS. Annual nonradiological emissions from construction and operation would be well below the EPA prevention of significant deterioration (PSD) permitting threshold of 250 tons per year for a criteria pollutant. Construction and operation of the options SRS would result in slightly higher emissions compared to activities at the INL Site. Construction activities would not generate radiological air emissions at the INL Site and would generate radiological emissions at SRS. Operations would generate small quantities of radiological air emissions. See Human Health – Normal Operations below for the estimated impacts from these emissions.</td></tr>
<tr><td colspan="5">Ecological Resources (Chapter 4, Section 4.5)</td></tr>
<tr><td></td><td colspan="4">Construction and Operations:
There would be no impacts on ecological resources as modifications/construction would occur in existing facilities or adjacent to those facilities on previously disturbed land. Operations would occur in existing or new facilities.</td></tr>
<tr><td colspan="5">Cultural and Paleontological Resources (Chapter 4, Section 4.6)</td></tr>
<tr><td></td><td colspan="2">Construction and Operations:
No impacts on significant cultural resources as changes to the internal configuration of active laboratories or other experimental or testing properties to accommodate new experiments or tests are exempt activities per the INL Cultural Resources Management Plan (INL 2016). With proposed operations conducted within existing facilities, there would be no impacts to paleontological resources.</td><td colspan="2">Construction and Operations:
No impacts on cultural or paleontological resources as modifications or construction would occur in K Area Complex facilities or adjacent to those facilities on previously disturbed land.</td></tr>
<tr><td colspan="5">Infrastructure (Chapter 4, Section 4.7)</td></tr>
<tr><td rowspan="2"></td><td colspan="4">Construction:
Use of existing infrastructure would be at levels well below existing capacities.</td></tr>
<tr><td>Operations:
Use of existing infrastructure within the Fuel Conditioning Facility would be well below existing capacities. Electric demand would be 6,700 megawatt-hours per year and water usage would be 1.5 million gallons per year.</td><td>Operations:
Use of existing infrastructure within FCF, the Fuel Manufacturing Facility and Zero Power Physics Reactor would be well below existing capacities. Electric demand would be 8,300 to 13,300 megawatt-hours per year and water usage would be 0.88 million gallons per year.</td><td>Operations:
Use of existing infrastructure within the K-Reactor building would be well below existing capacities. Electric demand would be 6,700 megawatt-hours per year and water usage would be 1.5 million gallons per year.</td><td>Operations:
Use of existing infrastructure within K-Reactor building would be well below existing capacities. Electric demand would be 8,300 to 13,300 megawatt-hours per year and water usage would be 1.4 million gallons per year.</td></tr>
<tr><td colspan="5">Noise and Vibration (Chapter 4, Section 4.8)</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Construction:
Due to the distance, estimated noise and vibration levels at the INL Site boundary (2.9 miles) and closest receptor (5.0 miles) would not be perceptible and would be consistent with ambient levels.</td><td colspan="2">Construction:
Due to the large distance from the site and receptors, estimated noise and vibration levels at the SRS boundary (5.5 miles) would not be perceptible and would be consistent with ambient levels.</td></tr>
<tr><td colspan="4">Operations:
Operational noise and vibration would be contained within the building and not be perceptible at the boundary.</td></tr>
</table>

Resource Area	***Options***			
	INL Feedstock Preparation	***INL Fuel Fabrication***	***SRS Feedstock Preparation***	***SRS Fuel Fabrication*** [a]
Waste Management and Spent Nuclear Fuel Management (Chapter 4, Section 4.9)				
	Construction: Existing facilities would be modified and existing equipment reallocated, as necessary, to support both feedstock preparation and fuel fabrication activities. Equipment currently in this space would be relocated for use in other facilities. Small volumes of construction waste, LLW, MLLW, and hazardous and TSCA wastes would generated during the modifications of facilities and the relocation of existing equipment and the installation of the new equipment.			
	Operations (annual impacts): During operations, 170 to 340 cubic meters of LLW, 2 to 4 cubic meters of MLLW, and 1 to 2 cubic meters of hazardous and TSCA wastes would be generated. The characteristics of these wastes would be similar to wastes currently generated by existing activities. These wastes would be managed within the current waste management system and sent offsite for disposal. The proposed action would provide preparation and packaging capabilities for the 200 to 400 cubic meters of TRU waste that would be generated from fuel production; TRU waste would be shipped to the Waste Isolation Pilot Plant for disposal.			
Human Health – Normal Operations (Chapter 4, Section 4.10)				
	Construction: Offsite population No impacts on the public; no radiological releases expected during construction. Worker population Work would occur in a clean area of an existing facility so there would be no worker dose. Due to the short duration and small number of workers, less than 1 industrial injury is calculated.	*Construction*: Offsite population No impacts on the public; no radiological releases expected during construction. Worker population Dose: 21 person-rem LCFs: 0 (calculated: 1×10^{-2}) Due to the short duration and small number of workers, less than 1 industrial injury is calculated.	*Construction*: Offsite population Same as INL Feedstock Preparation. Worker population Dose: 1.3 person-rem LCFs: 0 (calculated: 8×10^{-4}) Industrial accidents: 10 injuries with no fatalities expected.	*Construction*: Offsite population Same as INL Fuel Fabrication Worker population Dose: 0.8 person-rem LCFs: 0 (calculated: 5×10^{-4}) Industrial accidents: 10 injuries with no fatalities expected.
	Operations (annual impacts): Offsite population Dose: 0.012 person-rem LCFs: 0 (calculated: 7×10^{-6}) Maximally exposed individual Dose: 0.0012 millirem LCF risk: 7×10^{-10} Worker population Dose: 51 person-rem LCFs: 0 (calculated: 3×10^{-2}) Industrial accidents: 9 injuries with no fatalities expected.	*Operations (annual impacts):* Offsite population Dose: 0.0053 person-rem LCFs: 0 (calculated: 3×10^{-6}) Maximally exposed individual Dose: 0.0016 millirem LCF risk: 1×10^{-9} Worker population Dose: 51 person-rem LCFs: 0 (calculated: 3×10^{-2}) Industrial accidents: 9 injuries with no fatalities expected	*Operations (annual impacts)*: Offsite population Dose: 0.042 person-rem LCFs: 0 (calculated: 2×10^{-5}) Maximally exposed individual Dose: 0.0015 millirem LCF risk: 9×10^{-10} Worker population Dose: 51 person-rem LCFs: 0 (calculated: 3×10^{-2}) Industrial accidents: 9 injuries with no fatalities expected.	*Operations (annual impacts)*: Offsite population Dose: 0.020 person-rem LCFs: 0 (calculated: 1×10^{-5}) Maximally exposed individual Dose: 0.00071 millirem LCF risk: 4×10^{-10} Worker population Dose: 51 person-rem LCFs: 0 (calculated: 3×10^{-2}) Industrial accidents: 9 injuries with no fatalities expected.

<table>
<tr><th rowspan="2">Resource Area</th><th colspan="4">Options</th></tr>
<tr><th>INL Feedstock Preparation</th><th>INL Fuel Fabrication</th><th>SRS Feedstock Preparation</th><th>SRS Fuel Fabrication [a]</th></tr>
<tr><td colspan="5">Human Health – Facility Accidents (Chapter 4, Section 4.11)</td></tr>
<tr><td rowspan="3"></td><td colspan="4">Construction:
No impacts on the offsite public, maximally exposed individual, or noninvolved worker. No construction accidents are expected to release radiological or hazardous materials.</td></tr>
<tr>
<td>Operations (annual impacts):
Offsite population
Probability less than 0.0001/year
Dose: 0.034 person-rem
LCF risk: 2×10^{-5}
Maximally exposed individual
Probability less than 0.0001/year
Dose: 0.0002 rem
LCF risk: 1×10^{-7}
Noninvolved worker
Probability less than 0.0001/year
Dose: 0.00052 rem
LCF risk: 3×10^{-7}</td>
<td>Operations (annual impacts):
Offsite population
Probability less than 0.0001/year
Dose: 0.13 person-rem
LCF risk: 8×10^{-5}
Maximally exposed individual
Probability less than 0.0001/year
Dose: 0.0036 rem
LCF risk: 2×10^{-6}
Noninvolved worker
Probability less than 0.0001/year
Dose: 0.048 rem
LCF risk: 3×10^{-5}</td>
<td>Operations (annual impacts):
Offsite population
Probability less than 0.0001/year
Dose: 0.22 person-rem
LCF risk: 1×10^{-4}
Maximally exposed individual
Probability less than 0.0001/year
Dose: 7.9×10^{-5} rem
LCF risk: 5×10^{-8}
Noninvolved worker
Probability less than 0.0001/year
Dose: 0.015 rem
LCF risk: 9×10^{-6}</td>
<td>Operations (annual impacts):
Offsite population
Probability less than 0.0001/year
Dose: 0.81 person-rem
LCF risk: 5×10^{-4}
Maximally exposed individual
Probability less than 0.0001/year
Dose: 0.0016 rem
LCF risk: 9×10^{-7}
Noninvolved worker
Probability less than 0.0001/year
Dose: 0.18 rem
LCF risk: 1×10^{-4}</td>
</tr>
<tr><td colspan="4">Discussion:
The risks to the maximally exposed individual and the general population from accidents at the INL Site and SRS are very small, taking into account the very, very low probabilities (less than one in 10,000 per year) and consequences of the accidents. A criticality while melting plutonium metal and adding uranium and zirconium is the bounding operational accident during fuel fabrication; an aqueous/electrorefining accident is bounding during feedstock preparation. Offsite impacts on the public from an accident at SRS are up to six times greater than impacts at the INL Site because the population near SRS is larger and closer to the reactor fuel production facility.</td></tr>
<tr><td colspan="5">Human Health – Transportation Impacts (Chapter 4, Section 4.12)</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Construction:
Shipments: None
Accidents: None</td><td colspan="2">Construction:
Shipments: 2,454 with no radiological impacts
Accidents: None</td></tr>
<tr><td colspan="2">Operations (annual impacts):
All transportation impacts associated with reactor fuel production are included. No distinction is made between impacts from feedstock preparation and those from fuel fabrication.
Radioactive waste shipments: 57 to 285 estimated shipments. Additionally, this option would include 15 VTR fuel shipments annually to ORNL for the ORNL VTR Alternative.</td><td colspan="2">Operations (annual impacts):
All transportation impacts associated with reactor fuel production are included. No distinction is made between impacts from feedstock preparation and those from fuel fabrication.
Radioactive waste shipments: There would be 57 to 278 estimated shipments. Additionally, this option would include 15 VTR fuel shipments annually to the INL Site or ORNL, for the INL VTR or the ORNL VTR Alternative, respectively.</td></tr>
</table>

Resource Area	Options			
	INL Feedstock Preparation	***INL Fuel Fabrication***	***SRS Feedstock Preparation***	***SRS Fuel Fabrication*** [a]
	Population: Maximum dose: 20 person-rem with no LCFs. Individual doses from operations would be well below DOE and regulatory limits. Worker Population: Maximum dose: 23 person-rem with no LCFs. Individual worker doses from operations would be limited to meet DOE administrative worker dose limits.		Population: Maximum dose: 32 person-rem with no LCFs. Individual doses from operations would be well below DOE and regulatory limits. Worker Population: Maximum dose: 34 person-rem with no LCFs. Individual worker doses from operations would be limited to meet DOE administrative worker dose limits.	
	Accidents: LCFs: None Nonradiological traffic fatalities: Two potential traffic accident fatalities over the life of the project		Accidents: LCFs: None Nonradiological traffic fatalities: Three potential traffic accident fatalities over the life of the project	
Traffic (Chapter 4, Section 4.13)				
	Construction and Operations: The increase in traffic from both material shipments and workers are not expected to cause a change in existing level of service of offsite roads and no upgrades or improvements to onsite roads are anticipated.			
Socioeconomics (Chapter 4, Section 4.14)				
	Construction: Negligible adverse impact; small and beneficial short-term economic impact associated with construction activities.			
	Operations: The increase in jobs and income would be considered a potential beneficial impact on the local and regional economy. The population influx associated with an in-migrating workforce and their families is considered relatively small and would have no major adverse impacts on the regional in terms of population, employment, income levels, housing, or community services.			
	300 new employees for operations	70 new employees for operations	300 new employees for operations	300 new employees for operations
Environmental Justice (Chapter 4, Section 4.15)				
	Construction and Operation: No disproportionately high and adverse impacts on minority or low-income populations are expected. Increased health risks to minority or low-income individuals or populations exposed to radiation would be negligible.			

EPA = U.S. Environmental Protection Agency; INL = Idaho National Laboratory; LCF = latent cancer fatality; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; NAAQS = National Ambient Air Quality Standards; SRS = Savannah River Site; TRU = transuranic; TSCA = Toxic Substances Control Act.

[a] If the SRS Fuel Fabrication Option were selected, there would be a fuel fabrication development/demonstration capability established in the Fuel Manufacturing Facility at INL. The impacts of 3-to-4 years INL fuel development effort would approximate those of a single year of fuel fabrication under the INL Fuel Fabrication Option.

Note: Sums and products presented in the table may differ from those calculated from individual entries due to rounding.

Table S–3. Summary of Combined Environmental Consequences for the Versatile Test Reactor, Feedstock Preparation, and Fuel Fabrication at Idaho National Laboratory

Resource Area	*Construction*	*Operations*
Land Use and Aesthetics (Chapter 4, Section 4.1)		
Land Use	Same as Table S–1, INL VTR Alternative: There would be minor impacts on land use from the disturbance of approximately 100 acres during construction activities. The VTR complex would occupy approximately 25 acres after construction.	There would be no impact on land use since no additional land would be disturbed.
Aesthetics	Same as Table S–1, INL VTR Alternative: There would be minimal impacts on aesthetics as newly constructed facilities would not dominate the local landscape and would be similar in design to existing facilities.	Same as Table S–1, INL VTR Alternative: There would be minimal impacts on aesthetics from operation of the newly constructed facilities that would be similar in design to existing facilities.
Geology and Soils (Chapter 4, Section 4.2)		
	Same as Table S–1, INL VTR Alternative: Area disturbed would be 100 acres. The total quantities of geologic and soil materials needed during construction would represent small percentages of regionally plentiful resources and are unlikely to adversely impact geology and soil resources.	Same as Table S–1, INL VTR Alternative: Area occupied would be 25 acres. No additional land disturbance, no additional excavation, and little or no use of geologic and soil materials. Minimal impacts.
Water Resources (Chapter 4, Section 4.3)		
	Water would be drawn from existing wells that access the Snake River Plain Aquifer and treated through the existing Materials and Fuels Complex (MFC) potable water system. The total water estimated to be used is 128 million gallons. Discharges would be made to surface water (which could include the MFC sewage lagoons or other surface discharges such as swales).	Water use is estimated to be 6.8 million gallons per year. Water would be drawn from groundwater and most would be discharged as surface water to the Industrial Waste Pond or active sewage lagoons. About 50,000 gallons of potentially contaminated process water would be sent off site for treatment and disposal.
Air Quality (Chapter 4, Section 4.4)		
	Annual nonradiological emissions from construction of the VTR facilities would be well below the EPA prevention of significant deterioration (PSD) permitting threshold of 250 tons per year for a criteria pollutant. Hazardous air pollutant emissions generated by construction activities would not result in adverse air quality impacts on the public. Construction activities would not generate radiological air emissions.	Annual nonradiological emissions from operation of the VTR facilities would be well below the annual PSD indicator thresholds. Operations activities would generate small quantities of radiological air emissions. See Human Health – Normal Operations below for the estimated impacts from these emissions.

Resource Area	*Construction*	*Operations*
Ecological Resources (Chapter 4, Section 4.5)		
	Same as Table S–1, INL VTR Alternative: Area disturbed: is about 100 acres. Construction would result in a loss of sagebrush habitat. Losses to sagebrush habitat would be compensated for in accordance to the DOE's 'no net loss of sagebrush habitat' policy on the INL Site under the Candidate Conservation Agreement (CCA) for the sage-grouse. Nesting bird surveys, as indicated in the MBTA permit, would occur prior to any ground disturbance or vegetation removal to confirm the absence of MBTA protected species, as well as sage-grouse, from the proposed project area. A 300-foot buffer would be established around active pygmy rabbit burrow systems to prevent direct impacts. Operational and administrative controls will be evaluated and implemented, if warranted, to reduce the potential for adverse effects to wildlife species and human-wildlife interactions.	Same as Table S–1, INL VTR Alternative: Area occupied is about 25 acres. Operations would take place in new and existing facilities. No additional land disturbance would occur so there would be no impacts on ecological resources.
Cultural and Paleontological Resources (Chapter 4, Section 4.6)		
	No impacts on significant cultural and paleontological resources would occur from facility construction, land disturbance, and operations.	
Infrastructure (Chapter 4, Section 4.7)		
	Construction electricity usage would be 1,000 megawatt-hours average annual value with annual peak value of 2,000 megawatt-hours. Diesel fuel usage would total 2.3 million gallons. Total water usage would be 128 million gallons.	VTR operations and driver fuel production would use 170,000 megawatt-hours per year of electricity, 4.7 million cubic feet of propane per year, and 6.8 million gallons of water per year.
Noise & Vibration (Chapter 4, Section 4.8)		
Noise	Due to the distance, estimated construction and operations noise levels at the INL Site boundary (2.9 miles) and closest receptor (5.0 miles) would not be perceptible and would be consistent with ambient levels.	
Vibration	Ground borne vibration due to typical construction and operation activities are expected to be below the threshold of human perception.	
Waste Management and Spent Nuclear Fuel Management (Chapter 4, Section 4.9)		
Waste Management	About 9,900 cubic meters of construction waste would be generated during VTR construction activities. For the Reactor Fuel Production, existing facilities would be modified and existing equipment reallocated, as necessary, to support feedstock preparation and fuel fabrication activities. Equipment currently in this space would be relocated for use in other facilities. Small volumes of construction waste, LLW, MLLW, and hazardous and TSCA wastes would be generated during the modifications of facilities and the relocation of existing equipment and the installation of the new equipment would be minimal.	Annually, about 710 to 880 cubic meters of LLW, 40 to 42 cubic meters of MLLW, 200 to 400 cubic meters of TRU waste, and 8.2 to 9.2 cubic meters of hazardous and TSCA wastes would be generated The characteristics of most of these wastes would be similar to wastes currently generated from existing activities and would be managed within the current waste management system. The project would provide preparation and packaging capabilities for the 200 to 400 cubic meters of TRU waste that would be generated from fuel production. All wastes would be shipped off site for treatment and/or disposal. Treatment and disposal of these wastes are well within the current capacities of existing offsite facilities.

Resource Area	Construction	Operations
Spent Nuclear Fuel	*Construction:* No spent nuclear fuel would be generated during construction.	*Operations:* The heavy metal from 45 spent driver fuel assemblies produced annually (66 for the final core offload at the end of the VTR's operational lifetime) would be treated and packaged as spent nuclear fuel and placed on the VTR spent fuel pad pending offsite shipment. The total number of spent fuel assemblies over the lifetime of the project represent about 110 metric tons of heavy metal.
Human Health – Normal Operations (Chapter 4, Section 4.10)		
	Offsite population No population impacts. Maximally exposed individual No maximally exposed individual impacts. Worker population Dose: 32 person-rem LCFs: 0 (calculated: 2×10^{-2}) Industrial accidents: 80 injuries with no fatalities expected.	*Annual impacts:* Offsite population Dose: 0.06 person-rem LCFs: 0 (calculated: 4×10^{-5}) Maximally exposed individual Dose: 0.0096 millirem LCF risk: 6×10^{-9} Worker population Dose: 160 person-rem LCFs: 0 (calculated: 9×10^{-2}) Industrial accidents: 26 injuries with no fatalities expected.
Human Health – Facility Accidents (Chapter 4, Section 4.11)		
	Offsite population No impacts on the offsite public. There are no radiological or hazardous material accident scenarios during construction. Maximally exposed individual No impacts on the maximally exposed individual. There are no radiological or hazardous material accident scenarios during construction. Noninvolved worker No impacts on the noninvolved worker. There are no radiological or hazardous material accident scenarios during construction.	*Annual impacts*: Offsite population Accident probability: less than one in 10,000 per year Dose: 1,400 person-rem LCFs: 1 Maximally exposed individual Accident probability: less than one in 10,000 per year Dose: 0.25 rem LCF risk: 0.0001 Noninvolved worker Accident probability: less than one in 10,000 per year Dose: 160 rem LCF risk: 0.2

Resource Area	***Construction***	***Operations***
Human Health – Transportation Impacts (Chapter 4, Section 4.12)		
	Radioactive waste shipments: 18,460 total shipments with no radiological impacts Accidents: One potential traffic accident fatality.	Radioactive waste shipments: 187 to 415 shipments annually. Offsite Population: Maximum dose: 28 person-rem with no LCFs. Individual doses from operations would be well below DOE and regulatory limits. Worker Population: Maximum dose: 30 person-rem with no LCFs. Individual doses from operations would be well below DOE and regulatory limits. Accidents: LCFs: None Nonradiological traffic fatalities: Three potential traffic accident fatalities over the 60-year life of the project
Traffic (Chapter 4, Section 4.13)		
	The average increases in daily traffic during construction are not expected to exceed existing level of service of offsite roads, and no upgrades or improvements to onsite roads are anticipated.	Operations at each facility are expected to result in an increase of about 400 employees. This represents a negligible increase in traffic at each facility (about 5 percent). Operation traffic not expected to exceed existing level of service of offsite roads and no upgrades or improvements to onsite roads are anticipated.
Socioeconomics (Chapter 4, Section 4.14)		
	The increase in jobs and income would have a short-term beneficial impact on the local and regional economy. The population influx associated with an in-migrating workforce and their families is considered relatively small and would have no major adverse impacts on the regional area of influence in terms of population, employment, income levels, housing, or community services.	The increase in 588 jobs would have a beneficial impact on the local and regional economy. The population influx associated with an in-migrating workforce and their families is considered relatively small and would have no major adverse impacts on the regional area of influence in terms of population, housing, or community services.
Environmental Justice (Chapter 4, Section 4.15)		
	No disproportionately high and adverse impacts on minority or low-income populations are expected. Increased risks of minority or low-income individuals or populations exposed to radiation would be negligible.	

EPA = U.S. Environmental Protection Agency; INL = Idaho National Laboratory; LCF = latent cancer fatality; LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; TRU = transuranic; TSCA = Toxic Substances Control Act.
Note: Sums and products presented in the table may differ from those calculated from individual entries due to rounding.

S.9.3 Cumulative Impacts

CEQ regulations define cumulative impacts as effects on the environment that result from implementing any of the alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such actions (40 CFR 1508.7). Cumulative impacts were assessed by combining the effects of activities at the INL Site, ORNL, and SRS for each of the alternatives and options assessed in this VTR EIS with the effects of other past, present, and reasonably foreseeable future actions. Many of these actions occur at different times and locations and may not be truly additive. However, the effects were combined irrespective of the time and location of the impact, to encompass any uncertainties in the projected activities and their effects. This approach produces a conservative estimate of cumulative impacts for the activities considered. **Table S–4**, presents a summary and comparison of cumulative impacts at the INL Site, ORNL, and SRS. Cumulative impacts for issues of national and global concern (i.e., transportation, ozone depletion, and climate change) are presented below.

Transportation – The assessment of cumulative transportation impacts for past, present, and reasonably foreseeable future actions concentrates on offsite transportation throughout the nation that would result in potential radiation exposure to the transportation workers and the general population. Cumulative radiological impacts from transportation are estimated using the dose to the workers and the general population, because dose can be directly related to latent cancer fatalities (LCFs) using a cancer risk coefficient.

When combined with past, present, and reasonably foreseeable future nation-wide transportation, the cumulative transportation worker dose was estimated to be about 430,000 person-rem (258 LCFs). The cumulative general population dose was estimated to be about 441,000 person-rem (265 LCFs). For the INL VTR and the ORNL VTR Alternatives evaluated in this EIS, doses to transportation workers and the general population would be less than 2,120 and 2,025 person-rem, respectively. Therefore, transportation worker and population doses from the proposed action would be less than 0.5 percent of the cumulative worker and population doses, and would not substantially contribute to cumulative transportation impacts.

Ozone Depletion – The proposed action is not expected to use substantial quantities of ozone-depleting substances as regulated under 40 CFR Part 82, "Protection of Stratospheric Ozone." Emissions of ozone-depleting substances would be very small and would represent a negligible contribution to the destruction of the Earth's protective ozone layer.

Climate Change – Greenhouse gas (GHG) emissions from construction and operations at the INL Site, ORNL, and SRS of 65,000, 97,000, and 59,000 metric tons of carbon dioxide equivalents, respectively, would occur over a period of up to 65 years. These emissions would imperceptibly add to U.S. and global GHG emissions, which were estimated to be 6.7 billion metric tons and 36.6 billion metric tons of carbon dioxide equivalents, respectively, in 2018. Therefore, GHGs emitted from the proposed actions at the INL Site, ORNL, and SRS would be a negligible percentage of U.S. and global GHG emissions and would not substantially contribute to future climate change.

Table S–4. Summary and Comparison of Cumulative Impacts

Resource Area	*INL VTR Alternative (including Reactor Fuel Production Option)*	*ORNL VTR Alternative*	*SRS Reactor Fuel Production Option*
Land Use and Aesthetics	Activities evaluated under the proposed action would disturb 100 acres, or approximately 0.2 percent of the 45,400 acres of currently developed land at the INL Site and approximately 0.02 percent of the 569,600 acres of land available at the INL Site, and would not substantially contribute to cumulative land use impacts. Because construction would disturb only 100 acres, would be located adjacent to industrial area at MFC, and would be geographically separated from most of the other activities at the INL Site, the proposed action would not substantially contribute to cumulative aesthetics impacts.	Activities evaluated under the proposed action would disturb 150 acres, or approximately 1.2 percent of the 12,250 to 12,450 acres of developed land at ORR and approximately 0.5 percent of the 32,867 acres of land available at ORR, and would not substantially contribute to cumulative land use impacts. Because construction would disturb only 150 acres and would be geographically and topographically separated from most of the other activities at ORR, the proposed action would not substantially contribute to cumulative aesthetics impacts.	Modification and operation activities would occur primarily within existing buildings with minimal additional land disturbance. Therefore, impacts of the proposed action on land use and aesthetics would be minimal and would not contribute substantially to cumulative impacts.
Geology and Soils	Based on the information presented above for Land Use, the amount of soil disturbed by the proposed action would be a small percentage of the total soil disturbed at the INL Site and would not substantially contribute to cumulative impacts. The amount of geologic and soils materials used by the proposed action would be 112,000 cubic yards or about 9 percent of the 1,230,000 cubic yards used by other activities at the INL Site.	Based on the information presented above for Land Use, the amount of soil disturbed by the proposed action would be a small percentage of the total soil disturbed at ORR and would not substantially contribute to cumulative impacts. The amount of geologic and soils materials used by the proposed action would be 187,000 cubic yards or approximately 13 percent of the 1,460,000 cubic yards used by other activities at ORR.	Modification and operation activities would occur primarily within existing buildings with minimal additional land disturbance. Therefore, impacts of the proposed action on geology and soils would be minimal and would not contribute substantially to cumulative impacts.
Water Resources	Under the proposed action, no effluent would be discharged directly to natural surface water bodies, and no surface water would be used. Therefore, the proposed action would not contribute to cumulative impacts on surface water. No effluent would be discharged directly to groundwater, therefore, the proposed action would not contribute to cumulative impacts on groundwater quality. Groundwater withdrawal for the proposed action, would be less than 1 percent of the 872 million gallons per year cumulative groundwater use at the INL Site, and therefore, would not substantially contribute to cumulative impacts. The other past, present, and reasonably foreseeable future actions would be located across	Under the proposed action, no effluent would be discharged directly to groundwater, and no groundwater would be withdrawn, except shallow groundwater withdrawn during dewatering. Dewatering would be of short duration and localized extent. Therefore, the proposed action would not substantially contribute to cumulative groundwater impacts. Water use would be less than 0.1 percent of the 4.27 billion gallons per year cumulative surface water use at ORR, and would not substantially contribute to cumulative impacts on surface water availability. No contaminated effluent would be discharged directly to surface water during operation, therefore, the proposed action	Under the proposed action, modification and operation activities would occur within existing buildings with no additional land disturbance and no effluent discharged directly to surface water or groundwater. Therefore, impacts on surface water and groundwater quality would be minimal and would not contribute to cumulative impacts. No surface water would be used, therefore, the proposed action would not contribute to cumulative impacts from surface water use. Groundwater withdrawal for the proposed action would be less than 1 percent of the 538 to 623 million gallons per year cumulative groundwater

Resource Area	INL VTR Alternative (including Reactor Fuel Production Option)	ORNL VTR Alternative	SRS Reactor Fuel Production Option
	the INL Site and would discharge wastewater to different discharge points. Therefore, there would be little or no cumulative impact of these discharges.	would not contribute to cumulative impacts on surface water quality.	use at SRS, and therefore, would not substantially contribute to cumulative impacts.
Air Quality	The minor increase in offsite air pollutant concentrations produced from construction and operation, in combination with emissions from other past, present, and reasonably foreseeable future actions, would result in air pollutant concentrations that would not exceed the State and national ambient air quality standards. Emissions from construction and operations activities would not substantially contribute to cumulative air quality impacts.		
Ecological Resources	Cumulative impacts on ecological resources would not be substantial because ground disturbance and land clearing for the proposed action and other past, present, and reasonably foreseeable future actions would occur at different locations and times, and appropriate best management practices (such as sagebrush replacement and invasive species management) would be enforced.	The proposed action and other past, present, and reasonably foreseeable future actions would occur at different locations and times, and appropriate best management practices (such as wetland protection) would be enforced. The loss of habitat associated with the proposed action would account for less than 1 percent of the 24,000 acres of forested-hardwood habitat and less than 1 percent of the 4,100 acres of interior forest available at ORR. Even though these impacts to vegetation would generally be considered minor due to the availability of forested-hardwood habitats within ORNL and intermountain regions of Appalachia, ongoing assessments of the ORNL's ecological resources suggest that in-kind mitigation (i.e., protection or enhancement of ecologically-similar resources) could be required due to impacts to vegetation and may entail greater acreage than available elsewhere on ORNL (ORNL 2020).	Under the proposed action, modification and operation activities would occur primarily within existing buildings with minimal additional land disturbance. Therefore, impacts of the proposed action on ecological resources would be minimal and would not contribute substantially to cumulative impacts.
Cultural and Paleontological Resources	Cumulative impacts on cultural and paleontological resources within the regional area of influence would be negligible because no historic properties or paleontological resources were identified within the area of proposed new construction. The proposed new construction is consistent with the historic industrial character of the area and would not diminish the integrity of setting of any existing historic property within the Materials and Fuels Complex.	Cumulative impacts on cultural and paleontological resources within the regional area of influence would be negligible because of the lack of significant resources within the area of potential effect and due to the necessity of following the NHPA Section 106 process for all activities.	Under the proposed action, modification and operation activities would occur primarily within existing buildings with minimal additional land disturbance. Therefore, impacts of the proposed action on cultural and paleontological resources would be minimal and would not contribute substantially to cumulative impacts.

Resource Area	INL VTR Alternative (including Reactor Fuel Production Option)	ORNL VTR Alternative	SRS Reactor Fuel Production Option
Infrastructure	Projected cumulative site activities would annually require 468,000 to 471,000 megawatt-hours of electricity which is below the site capacity of 481,800 megawatt-hours. Annual electricity use for the proposed action would be approximately 170,000 megawatt-hours of electricity, which represents about one third of the 481,800 megawatt-hours of site capacity. Operation of the proposed action would annually use about 6.8 million gallons of water, which represents a fraction of the 872 million gallons cumulative infrastructure use and an even smaller fraction of the 11.4 billion gallons total site capacity. Therefore, operation activities would not substantially contribute to cumulative water use impacts.	Projected cumulative site activities would annually require about 1,440,000 to 1,520,000 megawatt-hours of electricity, which is well within the total site-wide capacity of 13,880,000 megawatt-hours. Cumulative annual water usage would be about 4,270 million gallons, which is well within the site-wide capacity of 11,715 million gallons. Operation of the proposed action would annually use about 180,000 megawatt-hours of electricity and about 4.4 million gallons of water, which represents a fraction of cumulative infrastructure use and an even smaller fraction of total site capacity. Therefore, operation activities would not substantially contribute to cumulative infrastructure impacts.	Projected cumulative site activities would annually require about 851,000 to 1,000,000 megawatt-hours of electricity, which is well within the total site-wide capacity of 4,400,000 megawatt-hours. Cumulative annual water usage would range from about 538 million to 624 million gallons of water, which is well within the site-wide capacity of 2,950 million gallons. Operation of the proposed action activities would annually use about 13,300 megawatt-hours of electricity and 3.6 million gallons of water, which represents a fraction of the cumulative infrastructure use and an even smaller fraction of total site capacity. Therefore, operation activities would not substantially contribute to cumulative infrastructure impacts.
Noise	The closest offsite receptor is a home/farm site that is approximately 5.0 miles away. Given the large distance, cumulative noise from construction or operation of projects at MFC and other locations within the INL Site would be indistinguishable from background at the closest offsite noise-sensitive receptor.	The closest offsite receptors include residential homes more than 1.25 miles to the east and across the Clinch River. Given the large distance, cumulative noise from construction or operation of projects at ORNL would be indistinguishable from background at the closest offsite noise-sensitive receptors.	Under the proposed action, modification and operation activities would occur within existing buildings with no additional land disturbance. Therefore, impacts of the proposed action on noise would be minimal and would not contribute to cumulative impacts.
Waste Management	The waste management infrastructures at the INL Site, ORNL, and SRS were developed such that they would be able to accommodate the quantities of waste generated by the proposed action. Therefore, cumulative waste generation would be within site capacities. There are existing offsite DOE and commercial waste management facilities with sufficient capacities for the treatment and disposal needs associated with the relatively small volumes of LLW and MLLW wastes that would be generated by the proposed action. Therefore, substantial cumulative impacts on offsite LLW and MLLW treatment and disposal facilities would not be expected. The Waste Isolation Pilot Plant (WIPP) is currently the only disposal option for TRU waste. WIPP's Land Withdrawal Act total TRU waste volume limit is 175,564 cubic meters. As of the reporting date for the 2019 *Annual Transuranic Waste Inventory Report* (ATWIR), 67,400 cubic meters of TRU waste were disposed of at the WIPP facility. The alternatives and options evaluated in this EIS would generate an estimated 24,000 cubic meters of TRU waste. TRU waste volume estimates such as those provided in NEPA documents, cannot be used to determine compliance with the WIPP Land Withdrawal Act TRU waste volume capacity limit. These wastes and waste from other actions will be incorporated, as appropriate, into future ATWIR TRU waste inventory estimates. Any GTCC-like waste (e.g., non-defense TRU waste not eligible for disposal at WIPP) generated from the proposed action would be stored at the generator site in accordance with applicable requirements until a disposal capability is available.		

Resource Area	INL VTR Alternative (including Reactor Fuel Production Option)	ORNL VTR Alternative	SRS Reactor Fuel Production Option
Human Health – Normal Operations	The cumulative offsite population dose would be 0.13 person-rem per year with no expected LCFs (calculated value of 8×10^{-5}). Operation of the proposed action would result in a total population dose of 0.061 person-rem per year with no expected LCFs (calculated value of 4×10^{-5}). The proposed action would be 45 percent of the cumulative dose and LCFs. While the proposed action is a significant portion of the cumulative impact, the absolute value is low and therefore, would not substantially contribute to human health impacts. The cumulative MEI dose would be 1.8 millirem per year with an associated LCF risk of 1×10^{-6}. Operation of the proposed action would result in a total MEI dose of 0.0096 millirem per year with an associated LCF risk of 6×10^{-9}. The proposed action would be 0.05 percent of the cumulative MEI dose and LCFs and therefore, would not substantially contribute to cumulative human health impacts. The cumulative worker dose would be 220 person-rem per year with no expected LCFs (calculated value of 0.1). Operation of the proposed action would result in a total worker dose of 110 person-rem per year with no expected LCFs (calculated value of 0.07). The proposed action would be 51 percent of the cumulative dose and LCFs. The proposed action could result in 4 worker LCFs from 60 years of VTR operation. Some of the worker dose estimate is the result of using conservative dose estimates for some fuel fabrication workers. Additional worker protection could be incorporated into the final design to reduce potential worker doses.	The cumulative offsite population dose would be 94 person-rem per year with no expected LCFs (calculated value of 0.06). Operation of the proposed action would result in a total population dose of 0.58 person-rem per year with no expected LCFs (calculated value of 0.0004). The proposed action would be less than one percent of the cumulative dose and LCFs and therefore, would not substantially contribute to cumulative human health impacts. The cumulative MEI dose for ORR activities would be 3.8 millirem per year with an associated LCF risk of 2×10^{-6}. Operation of the proposed action would result in a total MEI dose of 0.031 millirem per year with an associated LCF risk of 2×10^{-8}. The proposed action would be about one percent of the cumulative MEI dose and LCFs and therefore, would not substantially contribute to cumulative human health impacts. The cumulative worker dose would be 110 person-rem per year with no expected LCFs (calculated value of 0.08). Operation of the proposed action would result in a total worker dose of 44 person-rem per year with no expected LCFs (calculated value of 0.03). The proposed action would be 39 percent of the cumulative dose and LCFs. This could result in 2 worker LCFs from 60 years of VTR operation. Additional worker protection could be incorporated into the final design potentially reducing worker doses.	The cumulative offsite population dose would be 35 person-rem per year with no expected LCFs (calculated value of 0.02). Operation of the proposed action would result in a total population dose of 0.062 person-rem per year with no expected LCFs (calculated value of 4×10^{-5}). The proposed action would be 0.2 percent of the cumulative dose and LCFs and therefore, would not substantially contribute to cumulative human health impacts. The cumulative MEI dose from SRS activities would be 0.82 millirem per year with an associated LCF risk of 5×10^{-7}. Operation of the proposed action would result in a total MEI dose of 0.0022 millirem per year with an associated LCF risk of 1×10^{-9}. The proposed action would be about 0.03 percent of the cumulative MEI dose and LCFs and therefore, would not substantially contribute to cumulative human health impacts. The cumulative worker dose would be about 1,000 person-rem per year with 1 expected LCFs (calculated value of 0.6). Operation of the proposed action would result in a total worker dose of 102 person-rem per year with no expected LCFs (calculated value of 0.06). The proposed action would be 10 percent of the cumulative dose and LCFs and therefore, would not substantially contribute to cumulative human health impacts. This could result in 4 worker LCFs from 60 years of VTR operation. Additional worker protection could be incorporated into the final design potentially reducing worker doses.

Resource Area	***INL VTR Alternative (including Reactor Fuel Production Option)***	***ORNL VTR Alternative***	***SRS Reactor Fuel Production Option***
Traffic	The impacts on traffic from construction and operation activities are anticipated to be negligible to minor. As such, they would not substantially contribute to cumulative traffic impacts.		
Socioeconomics	Cumulative employment at INL from present and reasonably foreseeable future actions could reach a peak of about 7,990 persons; this is about 5.1 percent of the 157,400 people employed in the INL Site region in 2018. Activities under the proposed action could produce direct employment of up to a peak of about 1,350 construction workers during the 51-month construction period, nearly 32 percent of the 4,120 cumulative workforce related to construction activities. The 588 operations staff (new workers) under the proposed action would be about 7.4 percent of the 7,990 cumulative workforce related to annual operations and a very small percentage of the about 157,400 people employed in the INL Site region in 2018. Note: That the total operations workforce under the proposed action would actually be close to 820, however, 230 of these workers would be pulled from the existing on-site workforce. The overall contribution to cumulative socioeconomic impacts (e.g., housing, schools, and community services) from the proposed action on the regional area of influence is expected to be small.	Cumulative employment at ORR from past, present, and reasonably foreseeable future actions could reach a peak of about 15,200 persons; this is about 4.7 percent of the 320,327 people employed in the ORR regional area of influence, including ORNL, in 2019. Activities under the proposed action could produce direct employment of up to a peak of 1,598 construction workers during the 51-month construction period, or 30 percent of the 5,380 cumulative workforce (peak) related to construction activities. The 300 operations staff under the proposed action would be about 2 percent of the 15,200 cumulative workforce related to operations and a very small percentage of the about 320,327 people employed in the ORR region in 2019. The overall contribution to cumulative socioeconomic impacts (e.g., housing, schools, and community services) from the proposed action on the regional area of influence is expected to be small.	Cumulative employment at SRS from past, present, and reasonably foreseeable future actions could reach a peak of about 15,600 persons; this is about 6.4 percent of the 243,863 people employed in the SRS regional area of influence in 2019. Activities under the proposed action could produce direct employment of up to a peak of 240 construction workers during the three-year construction period, or 3.2 percent of the 7,430 cumulative workforce (peak) related to construction activities. The 600 operations staff under the proposed action would be about 3.7 percent of the 16,410 cumulative workforce related to operations and a very small percentage of the about 243,863 people employed in the SRS region in 2019. The overall contribution to cumulative socioeconomic impacts (e.g., housing, schools, and community services) from the proposed action on the regional area of influence is expected to be small.
Environmental Justice	Because the doses from the proposed action would be small and there would be no disproportionate high and adverse impacts on minority and low-income populations, the proposed action would not substantially contribute to cumulative environmental justice impacts.		

LCF = latent cancer fatality; MEI = maximally exposed individual; MFC = Materials and Fuels Complex; ORR = Oak Ridge Reservation.

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