Chapter 4
Environmental Consequences

4.0 ENVIRONMENTAL CONSEQUENCES

The potential environmental consequences for each of 15 resource areas are discussed in this chapter in Sections 4.1 through 4.15. The resource areas evaluated are land use and aesthetics, geology and soils, water resources (surface water and groundwater), air quality, ecological resources, cultural and paleontological resources, infrastructure, noise, waste management, human health (normal operations), human health (facility accidents), human health (transportation impacts), traffic, socioeconomics, and environmental justice. Each of the 15 resource area sections is organized to evaluate the environmental consequences of construction and facility modifications and operations of the Idaho National Laboratory (INL) and Oak Ridge National Laboratory (ORNL) Versatile Test Reactor (VTR) Alternatives. The INL and ORNL VTR Alternatives include the VTR, post-irradiation examination facilities, other support facilities, and spent nuclear fuel (SNF) management facilities. The INL and ORNL VTR Alternatives are described in more detail in Chapter 2, Sections 2.4 and 2.5, respectively. In addition, the environmental consequences for construction or facility modifications and operations of reactor fuel production options at the INL Site and the Savannah River Site (SRS) are evaluated. If the SRS Fuel Fabrication option were selected, there would be a fuel fabrication development/demonstration capability established in the Fuel Manufacturing Facility (FMF) at INL. The impacts of a 3-to-4-year INL fuel development effort would approximate those of a single year of fuel fabrication under the INL Fuel Fabrication option.

Reactor fuel production options include feedstock preparation and fuel fabrication. Reactor fuel production fabrication components could be located at the INL Site, SRS, or both. INL and SRS reactor fuel fabrication are described in more detail in Chapter 2, Sections 2.6.2 and 2.6.3, respectively. The environmental consequences of the Combined INL VTR Alternative and INL Reactor Fuel Production Options are also described. Additionally, each of the resource sections includes a summary table of the potential environmental consequences that gives an "at-a-glance" compilation of the information discussed in the sections. The information in these summary tables are the basis for the potential environmental consequences information compiled for all of the resource areas that are presented in Chapter 2. A No Action Alternative; deactivation, decommissioning, and demolition; and mitigation measures are evaluated in separate sections at the end of the chapter in Sections 4.16, 4.17, and 4.18, respectively.

4.1 Land Use and Aesthetics

Land Use

The INL Site and ORNL regions of influence (ROIs) for land use evaluation includes the land contained within both developed and undeveloped areas inside the boundaries of each location and lands immediately adjacent to their boundaries. For SRS, the ROI would be the K Area Complex (location of the K-Reactor Building) and the areas surrounding it. Facility construction, modifications, and land disturbance would occur within and adjacent to developed areas of the INL Site and largely undeveloped areas of the ORNL; only facility modifications would occur at SRS. Potential impacts of the VTR alternatives and reactor fuel production options to land use would occur if the land uses resulting from the Proposed Action were incompatible with surrounding land uses, if the Proposed Action results in a change to current land-use designation, or if a significant percentage of facility lands were disturbed for development.

Aesthetics

This section discusses the potential impacts on aesthetics (visual and scenic) of the VTR alternatives and reactor fuel production options. Aesthetics considers natural and manmade features that give a particular landscape its character and aesthetic quality. The Proposed Action would cause visual and scenic impacts if actions introduced deterioration(s) to the visual landscape(s).

The INL Site ROI is any area with a line of sight to the INL Site facilities, including the Eastern Snake River Plain, the Bitterroot, Lemhi, and Lost River mountain ranges, the Big Southern Butte, East Butte, Middle Butte, Circular Butte, Antelope Butte, Hell's Half Acre National Natural Landmark, and Hell's Half Acre Wilderness Study Area. Other areas potentially within the ROI for aesthetics would include Class I areas evaluated for visibility impacts from air emissions (i.e., Craters of the Moon National Monument).

The ORNL ROI is any area with a line of sight to the ORNL facilities, including, the East Fork Valley, Bear Creek Valley, Bethel Valley, Melton Valley, the Clinch River/Melton Hill Lake, and the bluffs on the opposite side of the Clinch River. Because of the topography of the Oak Ridge Reservation (ORR) where ORNL is located and, specifically, of the land surrounding the potential VTR site, the areas potentially affected by the ORNL VTR Alternative are limited. Other areas potentially within the ROI for aesthetics would include Class I areas evaluated for visibility impacts from air emissions (i.e., Joyce Kilmer-Slickrock Wilderness).

The SRS ROI includes the SRS (primarily the K Area Complex), and areas of the three-county area that would have line of sight visibility to the K Area Complex.

Table 4–1 presents a summary of the potential environmental consequences on land use and aesthetics for the INL and ORNL VTR Alternatives and the INL and SRS Reactor Fuel Production Options.

Table 4–1. Summary of Environmental Consequences on Land Use and Aesthetics

	VTR Alternatives	
Resource Area	***INL VTR***	***ORNL VTR***
Land Use	*Construction*: There would be minor impacts on land use from the disturbance of about 100 acres during construction activities. The VTR complex would occupy 25 acres after construction. *Operations*: There would be no impact on land use since no land would be disturbed.	*Construction*: There would be minor impacts on land use from the disturbance of about 150 acres during construction activities. The VTR complex would occupy 50 acres after construction. *Operations*: There would be no impact on land use because no land would be disturbed.
Aesthetics	*Construction*: There would be small, temporary visual impacts during construction. *Operations*: 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 in a developed area with an industrial appearance, with no change to VRM classification. Impacts on Craters of the Moon National Monument (a designated International Dark Sky Park) would not be expected by additional exterior lighting required for the VTR.	*Construction*: There would be small, temporary visual impacts during construction. *Operations*: 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.
	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Land Use	**Feedstock Preparation**	
	Construction: No impacts on land use as modifications/construction would occur in existing facilities (FCF) and not require construction of new facilities or the alteration of existing land uses at the MFC.	*Construction*: No impacts on land use as modifications/construction would occur in existing facilities (in the K Area Complex) and not require construction of new facilities or the alteration of existing land uses in K Area. Up to 3 acres of previously disturbed land would be used.

	Operations: No impacts on land use as feedstock preparation activities would occur in existing facilities and not require the alteration of existing land uses at the MFC.	*Operations*: No impacts on land use as feedstock preparation activities would occur in existing facilities and not require the alteration of existing land uses in K Area.
	Fuel Fabrication	
	Construction: No impacts on land use as modifications/construction would occur in existing facilities (FMF and ZPPR) and not require construction of new facilities or the alteration of existing land uses at the MFC. *Operations*: No impacts on land use as fuel fabrication activities would occur in existing facilities and not require the alteration of existing land uses at the MFC.	*Construction*: No impacts on land use as modifications/construction would occur in existing facilities (in the K Area Complex) and not require construction of new facilities or the alteration of existing land uses in K Area. Up to 3 acres of land disturbance, a small amount of excavation, and small quantities of geological and soil materials may be associated with constructing ancillary facilities. *Operations*: No impacts on land use as fuel fabrication activities would occur in existing facilities and not require the alteration of existing land uses in K Area.
Aesthetics	**Feedstock Preparation**	
	Construction: No impacts on aesthetics as modifications/ construction would occur in existing facilities (i.e., FCF). *Operations*: No impact on aesthetics as operations would occur in existing facilities.	*Construction*: No impacts on aesthetics as modifications/construction would occur in existing facilities (i.e., the K Area Complex). *Operations*: No impact on aesthetics as operations would occur in existing facilities.
	Fuel Fabrication	
	Construction: No impacts on aesthetics as modifications/ construction would occur in existing facilities (i.e., FMF and ZPPR). *Operations*: No impact on aesthetics as operations would occur in existing facilities.	*Construction*: No impacts on aesthetics as modifications/ construction would occur in existing facilities (i.e., the K Area Complex). *Operations*: No impact on aesthetics as operations would occur in existing facilities.
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Land Use	*Construction*: Impacts on land use would be the same as described for VTR construction, as reactor fuel options would occur in already established facilities and not require any changes to existing land use designations. *Operations*: Impacts on land use would be the same as described for VTR operations, as reactor fuel options would occur in already established facilities and not require any changes to existing land use designations.	
Aesthetics	*Construction*: Impacts on aesthetics would be the same as described for VTR construction, as reactor fuel options would occur in already established facilities and not require any changes to existing land use designations. *Operations*: Impacts on aesthetics would be the same as described for VTR operations, as reactor fuel options would occur in already established facilities and not require any changes to existing land use designations.	

FCF = Fuel Conditioning Facility; FMF = Fuel Manufacturing Facility; MFC = Materials and Fuels Complex; VRM = Visual Resource Management; VTR = Versatile Test Reactor; ZPPR = Zero Power Physics Reactor.

4.1.1 INL VTR Alternative

4.1.1.1 Construction/Facility Modification

Land Use. Construction would occur in an approximate 100-acre area adjacent to the southeastern portion of the existing Materials and Fuels Complex (MFC) area. Construction would result in land disturbance and development for permanent buildings, temporary structures, utilities, extension of the existing security perimeter fence, temporary roadways, temporary electrical lines, new electrical lines and other infrastructure needs, and other construction-related activities (e.g., gravel pit, batch plant, and additional staging areas). Areas of potential disturbance would be located within or adjacent to previously developed and active areas of the MFC. Areas within the footprint and construction staging areas would be cleared of any existing vegetation, including, but not limited to, building footprint areas, walkways, paving, and any landscaping areas.

Disturbed areas not used for building footprints or impervious surfaces (e.g., roads, walkways) would be revegetated per DOE/ID-12114, *Guidelines for Revegetation of Disturbed Sites at the Idaho National Engineering Laboratory* (DOE-ID 2019a). An area of 25 acres within the area disturbed during construction would remain permanently developed for use as facilities and infrastructure (including expanded and new sections of security perimeter fence). This represents an increase of about 0.09 percent to the amount of the total area at the INL Site presently used for facilities and supporting infrastructure.

Aesthetics. Proposed facilities would be similar to the type and visual character of structures already present on the MFC. The buildings would be of a block concrete construction and would not be taller than existing structures at the MFC. Additionally, the facilities would not substantially increase the number of structures or the footprint of the MFC. Therefore, the visual character of the MFC would not be altered. Localized and temporary visual impacts could result from construction equipment (e.g., cranes), but only in areas outside the INL Site boundary, but within line of sight of the MFC. As discussed in Section 3.1.1.2, lands within the INL Site have been designated as Class III and Class IV, indicating that management activities may attract attention but should not dominate the view of the casual observer and management activities may dominate the view and be the major focus of viewer attention, respectively. As the proposed facilities are of specifications and type similar to the existing facilities at the MFC, impacts on aesthetics related to the proposed VTR would be expected to be minimal. Impacts on visibility from air emissions during the construction of the VTR could be localized and temporary, but only in areas of the INL Site within line of sight of the MFC. Also see Section 4.4.1.1.

While exterior lighting sources at the VTR would be consistent with existing developed areas at the MFC, it would be expected that exterior lighting (e.g., buildings, parking lots, walkways) would employ technologies designed for increased energy savings, reduced maintenance costs, improved visual environment, enhanced safety measures, and reduced light pollution (DOE 2010b). This would include the prevention of projection of light above the horizon, by using light fixtures with specifically designed optics. Impacts on aesthetics in the region, including to the International Dark-Sky Association (IDA)-designated International Dark Sky Park, Craters of the Moon National Monument, would be minimal from additional exterior lighting required for the VTR.

4.1.1.2 Operations

Land Use. The operation of VTR facilities at the INL Site would occur in an area adjacent to the existing MFC. These operations would be consistent with existing land use and activities currently occurring at the MFC. The operation of the new VTR facilities would not require additional land disturbance or development. The establishment and operation of VTR facilities would not impact the opportunities available at the INL Site in its capacity as a National Environmental Research Park (NERP). As grazing is not permitted within 0.5 miles of any primary facility boundary or within 2.0 miles of any nuclear facility, the VTR would not impact livestock grazing (including on the Sagebrush-Steppe Ecosystem Reserve). Since Idaho Department of Fish and Game controlled hunts for elk and antelope occur in the northern half of the INL Site, the VTR would have no impact on these activities. Therefore, there would be no impact from land disturbance or any changes to existing land use designations during operations of the VTR.

Aesthetics. There would be minimal impact on aesthetics as newly constructed facilities would not dominate the local landscape and would be similar in design to existing facilities in a developed area with an industrial appearance, with no changes to existing Visual Resource Management (VRM) classification of Class III and Class IV. Air emissions after operations begin at the VTR would increase over the baseline demonstrated in Chapter 3, Section 3.1.4 but are much less than established threshold values and would not be considered significant enough to affect regional air quality or any Class I visual resource area. Also see Section 4.4.1.2 for more information on air quality impacts from operation of the INL VTR Alternative.

4.1.2 ORNL VTR Alternative

4.1.2.1 Construction/Facility Modification

Land Use. Construction would occur on ORR on about 150-acres about 1 mile east of the ORNL main campus, on a site previously considered for other projects (Melton Valley Site) not subject to any land use controls addressed by the Melton Valley Watershed Record of Decision (ROD) (CROET 2007; DOE 2000a). Construction would result in land disturbance and development for permanent buildings, temporary structures, utilities, extension of the existing security perimeter fence, temporary roadways, temporary electrical lines, new electrical lines and other infrastructure needs, and other construction-related activities (e.g., gravel pit, batch plant, and additional staging areas). Areas within the footprint and construction staging areas of the proposed VTR area would be cleared of any existing vegetation, including, but not limited to, building footprint areas, walkways, paving, and any landscaping areas.

After construction of VTR associated facilities, about 50 acres of the disturbed area would remain permanently developed for use as facilities and infrastructure (including expanded and new sections of security perimeter fence). This represents an increase of about 0.5 percent to the amount of the total area at the ORNL presently used for facilities and supporting infrastructure. The proposed VTR development area is located in a portion of ORNL zoned for Federal Industry and Research and designated as institutional/research and mixed research/future initiatives and would not result in a reassignment of zoning or land use designation.

Aesthetics. Proposed facilities would be similar to the type and visual character of structures already present on ORNL. The buildings would be of a block concrete construction and would not be taller than existing structures at located at ORNL. Additionally, the facilities would not substantially increase the number of structures or the footprint of the ORNL. Therefore, the visual character of the ORNL would not be altered. Localized and temporary visual impacts could result from construction equipment (e.g., cranes), but only in areas of ORNL within line of sight of the proposed VTR site. Impacts on visibility from air emissions during the construction of the VTR could be localized and temporary, but only in areas within line of sight of ORNL. Also see Section 4.4.2.1 for more information on air quality impacts from construction of the ORNL VTR Alternative.

4.1.2.2 Operations

Land Use. The operation of VTR facilities would occur about 1 mile east of the ORNL main campus, on a site previously considered for other projects. These operations would be consistent with existing land use and activities currently occurring at the ORR. The operation of the new VTR facilities would not require additional land disturbance or development. In addition, the proposed VTR development area is located in a portion of ORR zoned for Federal Industry and Research and designated as institutional/research and mixed research/future initiatives (CROET 2007). Due to these land use designations and the relatively small percentage of ORNL's overall available land that the VTR footprint would clear, the establishment and operation of VTR facilities would not impact the opportunities available at ORNL in its capacity as a NERP. The proposed area for VTR operations is partially located in an area of the Oak Ridge Wildlife Management Area designated open to all permit holders, but represents a small percentage of the overall area available to hunters. Therefore, there would be no impact from land disturbance or any changes to existing land use designations during operation of the VTR.

Aesthetics. There would be minimal impact on aesthetics as newly constructed facilities should not dominate the local landscape and would be similar in design to existing facilities in a developed area with an industrial appearance, with no changes to existing VRM classification of Class III and Class IV. Air emissions after operations begin at the VTR would increase over the baseline demonstrated in Chapter 3, Section 3.2.4 but are much less than established threshold values and would not be considered significant enough to affect regional air quality or any Class I visual resource areas. Also see Section 4.4.2.2 for more information on air quality impacts from operation of the ORNL VTR Alternative.

As discussed in Section 3.2.1, viewpoints affected by DOE facilities at ORNL are primarily associated with the public access roadways, the Clinch River/Melton Hill Lake, and the bluffs on the opposite side of the Clinch River. Hilly terrain, heavy vegetation, and hazy atmospheric conditions limits the views of the proposed VTR site from public vantage points.

4.1.3 Reactor Fuel Production Options

4.1.3.1 INL Reactor Fuel Production Options

4.1.3.1.1 INL Feedstock Preparation Option

Construction/Facility Modification

Land Use and Aesthetics. Feedstock preparation would be located in the existing Fuel Conditioning Facility (FCF) within the MFC. Construction or facility modifications would be confined to buildings within the MFC in areas already designated for such uses and would not be directly associated with new facility construction for the VTR. Localized and temporary land use and visual impacts could result from construction or facility modifications. However, visual impacts would only be in areas of the INL Site within line of sight of the MFC.

Operations

Land Use and Aesthetics. Feedstock preparation would be located in the existing FCF within the MFC in an area currently designated for industrial purposes. Activities would be contained within existing structures, with little to no visibility from areas outside the MFC. Therefore, there would be no impacts on land use or aesthetics related to operations.

4.1.3.1.2 INL Fuel Fabrication Option

Construction/Facility Modification

Land Use and Aesthetics. Fuel fabrication would be located in the existing FMF and Zero Power Physics Reactor (ZPPR) facilities within the MFC. Construction or facility modification would be confined to buildings within the MFC in areas already designated for such uses and would not be directly associated with new facility construction for the VTR. Localized and temporary land use and visual impacts could result from construction or facility modifications. However, visual impacts would only be in areas of the INL Site within line of sight of the MFC.

Operations

Land Use and Aesthetics. Fuel fabrication would be located in the existing FMF and ZPPR facilities within the MFC in an area currently designated for industrial purposes. Activities would be contained within existing structures, with little to no visibility from areas outside the MFC. Therefore, there would be no impacts on land use or aesthetics related to operations.

4.1.3.2 SRS Reactor Fuel Production Options

4.1.3.2.1 SRS Feedstock Preparation Option

Construction/Facility Modification

Land Use and Aesthetics. Modifications would be made 20 to 40 feet below ground in an existing facility (K-Reactor Building) within the K Area Complex in an area currently designated for industrial purposes. Activities would be contained within existing structures, with little to no visibility from areas outside the K Area Complex. Localized and temporary land use and visual impacts could result from construction or facility modifications. However, visual impacts would only be in areas of SRS within line of sight of the K Area Complex. Up to 3 acres of previously disturbed land would be used.

Operations

Land Use and Aesthetics. Operations would be located 20 to 40 feet below ground in an existing facility within the K Area Complex in an area currently designated for industrial purposes. Activities would be contained within existing structures, with little to no visibility from areas outside the K Area Complex. Therefore, there would be no impacts on land use or aesthetics related to operations. Up to 3 acres of land disturbance, a small amount of excavation, and small quantities of geological and soil materials maybe associated with constructing ancillary facilities.

4.1.3.2.2 SRS Fuel Fabrication Option

Construction/Facility Modification

Land Use and Aesthetics. Modifications would be made 20 to 40 feet below ground in an existing facility within the K Area Complex in an area currently designated for industrial purposes. Activities would be contained within existing structures, with little to no visibility from areas outside the K Area Complex. Localized and temporary land use and visual impacts could result from construction or facility modifications. However, visual impacts would only be in areas of SRS within line of sight of the K Area Complex. Up to 3 acres of previously disturbed land would be used.

Operations

Land Use and Aesthetics. Operations would be located 20 to 40 feet below ground in an existing facility within the K Area Complex in an area currently designated for industrial purposes. Activities would be contained within existing structures, with little to no visibility from areas outside the K Area Complex. Therefore, there would be no impacts on land use or aesthetics related to operations. Up to 3 acres of land disturbance, a small amount of excavation, and small quantities of geological and soil materials maybe associated with constructing ancillary facilities.

4.1.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

Because operational activities for feedstock preparation and reactor fuel fabrication would occur in existing MFC facilities, no changes or modification of existing land use designations at the INL Site would result. Thus, the combined impacts on land use would be the same as those described in Section 4.1.1. Similarly, impacts on aesthetics primarily would be the result of the construction and operation of VTR facilities.

4.2 Geology and Soils

This section discusses the potential environmental consequences on geology and soils that could occur during land-clearing, excavation, and grading and filling activities. This section also describes the use of geologic and soils materials (such as crushed stone, sand and gravel, and fill) during facility construction and operations. Geologic hazards can impact facility construction and operation.

As described in Chapter 3, Sections 3.1.2.2, 3.2.2.2, and 3.3.2.2, no prime or unique farmlands have been designated at the INL Site, ORNL, or SRS, respectively. As a result, the Proposed Action would have no effects on prime or unique farmland soils, and this topic is not discussed further in this section. Additionally, there are no anticipated impacts to soils from radiological releases which are very small. There were no identified mechanisms for concentration in soils. Section 4.10 discusses the potential estimated human health impacts of these releases which included evaluation of potential soils pathways. The total impacts are very small and the soils pathways are a small fraction of the total. Therefore, this topic is not discussed further in this section.

There would be no impacts on rare or valuable geologic and soil resources, including fossil fuels (e.g., oil, gas, and coal) and minerals, because as described in Chapter 3, Sections 3.1.2.3, 3.2.2.3, and 3.3.2.3, none are present at the INL Site, ORNL, or SRS, respectively. Therefore, this topic is also not discussed further in this section.

Geologic hazards (such as earthquakes, volcanoes, and slope stability) with the potential to affect facilities at the INL Site, ORNL, and SRS are described in Chapter 3, Sections 3.1.2.4, 3.2.2.4, and 3.3.2.4, respectively. All facilities would be designed, constructed, and operated in compliance with all applicable DOE orders, other Federal, State, and local requirements and standards established to protect public and worker health and safety and the environment. DOE Order 420.1B requires that nuclear and nonnuclear facilities be designed, constructed, and operated so that the public, workers, and environment are protected from adverse impacts of natural phenomena hazards, including earthquakes. The potential for geologic hazards such as earthquakes to cause accidents, and the impacts on public and worker health and safety, are discussed under accident analyses in Section 4.11.

Table 4–2 presents a summary of the potential environmental consequences on geology and soils for the INL and ORNL VTR Alternatives and the INL and SRS Reactor Fuel Production Options.

Table 4–2. Summary of Environmental Consequences on Geology and Soils

	VTR Alternatives	
	INL VTR	***ORNL VTR***
Construction	**Area disturbed:** about 100 acres **Percent of the INL Site:** 0.02 percent of 569,600 acres **Rock and soil excavated:** 135,000 cubic yards; some ripping or blasting likely **Rock/gravel needed:** 45,000 cubic yards **Backfill/soil needed:** 202,000 cubic yards	**Area disturbed:** about 150 acres **Percent of ORR:** 0.5 percent of 32,867 acres **Rock and soil excavated:** 886,000 cubic yards; some ripping or blasting likely **Rock/gravel needed:** 74,000 cubic yards **Backfill/soil needed:** 989,000 cubic yards
Operations	**Area occupied:** 25 acres No additional land disturbance, no additional excavation, and little or no use of geologic and soil materials	**Area occupied:** 50 acres No additional land disturbance, no additional excavation, and little or no use of geologic and soil materials
Discussion	BMPs would be used to limit soil erosion; total quantities of geologic and soils materials needed are unlikely to adversely impact regionally plentiful geologic and soils resources; minimal impacts are expected	

	Reactor Fuel Production Options	
	INL Feedstock Preparation and Fuel Fabrication	***SRS Feedstock Preparation and Fuel Fabrication***
Construction and Operations	No additional land disturbance, no additional excavation, and little or no use of geologic and soil materials	
Discussion	Minimal impacts on geology and soils	
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Discussion	Same as for INL VTR Alternative because little or no impacts from reactor fuel production	

BMP = best management practices; INL = Idaho National Laboratory; ORNL = Oak Ridge National Laboratory; ORR = Oak Ridge Reservation; SRS = Savannah River Site; VTR = Versatile Test Reactor.
Note: Affected environment information is from Chapter 3 of this VTR EIS.
Source: Appendix B.

4.2.1 INL VTR Alternative

As described in Chapter 3, Section 3.1.2, the ROI for geology and soils under the INL VTR Alternative, includes the INL Site and MFC.

4.2.1.1 Construction/Facility Modification

Rock and soil disturbance would be associated with site clearing, excavation, and grading conducted as part of constructing building foundations, roadways, parking areas, and laydown areas. Rock and soil disturbance would also occur during trenching and excavation work to install piping, utilities, and other conveyances between buildings and other facilities.

Site clearing required for construction would remove the vegetative cover and destroy the structure of the native soils. About 100 acres would be disturbed. There would be no additional land disturbance during modification of the post-irradiation examination and SNF conditioning facilities at the INL Site; any activities outside the buildings (e.g., construction laydown and parking) would occur on previously disturbed areas in the MFC. At the end of construction, the 75-acre temporarily disturbed area outside the VTR complex would be graded, covered with soil stockpiled from site clearing and excavation, planted with native vegetation, and returned to natural conditions.

Construction activities are estimated to result in the excavation of 135,000 cubic yards of rock and soil over the 51-month site preparation and facility construction period. As described in Chapter 3, Section 3.1.2.2, the site is relatively flat with little elevation change and the thickness of surficial soils near MFC range from 0.5 to 26.0 feet, with two locations in the MFC that have deposits of 31.5 and 46.0 feet. Some ripping or blasting of bedrock would likely be required to install building foundations and utility trenches. Levelling the site and construction of the facilities would require a total excavation volume of about 135,000 cubic yards and a fill volume of about 202,000 cubic yards. The deficit fill volume of about 67,000 cubic yards is anticipated to be obtained from onsite borrow sources, such as Rye Grass Flats.

The U.S. Environmental Protection Agency (EPA) and Idaho Department of Environmental Quality require a Stormwater Pollution Prevention Plan (SWPPP) under the National Pollutant Discharge Elimination System (NPDES) General Permit for stormwater discharges from construction activities. Although soils disturbed during construction would be temporarily subject to wind and water erosion, adherence to standard best management practices (BMPs) for soil erosion and sediment control (e.g., use of silt fencing, staked hay bales, mulching and geotextile fabrics, and revegetation) during facility construction would serve to minimize soil erosion and loss. Because the 100 acres of disturbed land would be less than 0.02 percent of the 569,600 acres of the INL Site, a limited area of soil would be actively disturbed at any one time, and BMPs would be used to limit soil erosion, minimal impacts on soils at the INL Site are expected.

Other uses for geologic and soil materials include components of concrete and asphalt, as a base under parking lots, roadways, concrete slabs, fill, grading, and revegetation of the site. Sources of construction materials would include rock and soil stockpiled during site excavation; soil from INL Site borrow sources; and crushed stone, sand, gravel, and soil supplied by offsite commercial operations. As discussed in Chapter 3, Section 3.1.2.3, a number of active borrow pits at the INL Site have been identified for borrow materials for ongoing and future activities at INL. The nearest borrow source, Rye Grass Flats, is about 11 miles southwest of MFC. 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.

4.2.1.2 Operations

4.2.1.3 The VTR and Associated Facilities Operations

The VTR and associated facilities would occupy about 25 acres during operations. The 25 acres of land within the footprint of the completed VTR complex would be occupied by facilities, covered by parking areas, walkways and roads, or revegetated. BMPs for collection and management of stormwater during operations would ensure that soil erosion within the 25-acre VTR complex would be minimized. Operation of the VTR and associated facilities would involve no ground disturbance, minimal soil erosion, and little or no use of local geologic and soil materials and, therefore, would have little additional impact on geology and soils.

4.2.2 ORNL VTR Alternative

As described in Chapter 3, Section 3.2.2, the ROI for geology and soils under the ORNL VTR Alternative, includes ORR, ORNL, and the Melton Valley Site.

4.2.2.1 Construction/Facility Modification

Rock and soil disturbance would be associated with site clearing, excavation, and grading conducted as part of constructing building foundations, roadways, parking areas, and laydown areas. Rock and soil disturbance would also occur during trenching and excavation work to install piping, utilities, and other conveyances between buildings and other facilities.

Site clearing required for construction of the VTR complex would remove the vegetative cover and destroy the structure of the native soils and would disturb about 150 acres over a 5-month period (Leidos 2020). At the end of construction, the 100-acre temporarily disturbed area outside the VTR complex would be graded, covered with soil stockpiled from site clearing and excavation, planted with native vegetation, and returned to natural conditions.

Construction activities are estimated to result in the excavation of 886,000 cubic yards of rock and soil over the 51-month site preparation and facility construction period. As described in Chapter 3, Section 3.2.2, elevations at the Melton Valley Site range from about 820 to 940 feet above mean sea level with the thickness of soils and saprolite above the bedrock, likely to average about 20 feet. Some ripping and/or blasting of bedrock would likely be required to level the site, and install building foundations and utility trenches. Because of the variation in elevation across the Melton Valley Site, the excavated rock and soil would be used to fill and level other portions of the site. Levelling the site and construction of the facilities would require a total excavation volume of about 886,000 cubic yards and a fill volume of about 989,000 cubic yards. The deficit fill volume of about 103,000 cubic yards would be obtained from onsite borrow sources such as the Copper Ridge borrow area.

EPA and Tennessee Department of Environment and Conservation (TDEC) require a SWPPP under the NPDES General Permit for stormwater discharges from construction activities. Although soils disturbed during construction would be temporarily subject to wind and water erosion, adherence to standard BMPs for soil erosion and sediment control (e.g., use of silt fencing, staked hay bales, mulching and geotextile fabrics, and revegetation) during facility construction would serve to minimize soil erosion and loss. Because the 150 acres of disturbed soils would be less than 0.5 percent of the 32,867 acres of ORR, a limited area of soils would be actively disturbed at any one time, and BMPs would be used to limit soil erosion, minimal impacts on soils at ORR are expected.

Uses of geologic and soil materials include components of concrete and asphalt, as a base course under parking lots, roadways and concrete slabs, and for fill, grading, and revegetation of the site. Sources of construction materials would include: rock and soil stockpiled during site excavation; soil from ORR borrow pits; and crushed stone, sand, gravel, and soils supplied by offsite commercial operations. As discussed in Chapter 3, Section 3.2.2.3, a number of active borrow pits at ORR have been identified for use in supplying borrow materials for ongoing and future activities at ORR. The Copper Ridge Borrow Area is about 0.5 mile southeast of the Melton Valley Site. 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.

4.2.2.2 Operations

The VTR and associated facilities would occupy about 50 acres during operations. The 50 acres within the footprint of the completed VTR complex would be occupied by facilities, covered by parking areas, walkways and roads, or revegetated. BMPs for collection and management of stormwater during operations would ensure that soil erosion within the 50-acre VTR complex would be minimized. Operation of the VTR and associated facilities would involve no ground disturbance, minimal soil erosion, and little or no use of local geologic and soil materials and, therefore, would have little additional impact on geology and soils.

4.2.3 Reactor Fuel Production Options

4.2.3.1 INL Reactor Fuel Production Options

As described in Chapter 2, Section 2.6.2, modification and operation of MFC facilities for reactor fuel production would occur within existing buildings with no additional land disturbance and little or no use of geologic and soil materials. Therefore, impacts on geology and soils from these activities would be minimal and are not discussed further in this section.

4.2.3.2 SRS Reactor Fuel Production Options

As described in Chapter 2, Section 2.6.3, modification and operation of K Area facilities for reactor fuel production would occur within existing buildings with no additional land disturbance and little or no use of geologic and soil materials. Therefore, impacts on geology and soils from these activities would be minimal and are not discussed further in this section.

4.2.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

Because there would be little or no geology and soils impacts from construction and operation of reactor fuel production, the impacts of the combined activities would be essentially the same as the impacts of the INL VTR Alternative alone as described in Section 4.2.1.

4.3 Water Resources

This section discusses the potential environmental consequences to water resources of the VTR alternatives and reactor fuel production options. The ROIs for impacts on water resources, which include surface water and groundwater within and downstream of the proposed project sites within the INL Site, ORNL, and SRS are described in Chapter 3, Sections 3.1.3, 3.2.3, and 3.3.3, respectively. There are no anticipated impacts to water resources from radiological releases which are very small. There were no identified mechanisms for concentration in water resources. Section 4.10 discusses the potential estimated human health impacts of these releases which included evaluation of potential water resources pathways. The total impacts are very small and the water resources pathways are a small fraction of the total. Therefore, this topic is not discussed further in this section. Water resources would be affected if actions associated with the alternatives increased any of the following parameters:

- Constituents in industrial wastewater or stormwater (regulated by wastewater reuse permits and NPDES permits)
- Industrial wastewater or stormwater discharge volumes (regulated by wastewater reuse permits)
- Constituents in groundwater (regulated by Federal maximum contaminant levels and State primary/secondary constituent standards)
- Groundwater use (regulated by Federal reserved water rights)

Unless wastewater reuse permit limits, NPDES permit limits, water right limits, or water system infrastructure capabilities are exceeded, impacts would be expected to be small. Impacts on water resources are assessed for two general categories: water quality and water use. Water quality is evaluated through constituents in and volume of process and sanitary wastewater discharges, constituents in and volume of stormwater discharges, and potential for discharges to eventually impact groundwater. Water use is evaluated through workforce, process, and other needs for potable and non-potable water.

Table 4–3 presents a summary of the potential environmental consequences on water resources for the INL and ORNL VTR Alternatives and the INL and SRS Reactor Fuel Production Options.

Table 4–3. Summary of Environmental Consequences on Water Resources

	VTR Alternatives	
Resource Area	***INL VTR***	***ORNL VTR***
Surface Water	*Construction*: Normal activities conducted during the construction phase for the INL VTR Alternative would discharge to surface water during stormwater discharge, batch plant operations, piping and equipment flushing, and hydrotesting. Water used during the construction phase of the INL VTR Alternative would be drawn from groundwater and discharged as surface water.	*Construction*: During the construction period of the ORNL VTR Alternative, potable water for construction workforce consumption would be drawn from the Clinch River and pumped to the water treatment plant located northeast of Y-12. The water treatment plant is owned and operated by the City of Oak Ridge. During times of peak demand, construction personnel may require a maximum of about 20 million gallons of potable water per year, or a total of about 46 million gallons over the course of the construction phase. Additional water would be required for construction activities, such as dust control and backfill. An estimated annual peak of about 52 million gallons per year would be needed or 121 million gallons over the entire construction period. The total water demand during construction of the ORNL VTR Alternative is expected to be about 172 million gallons. Normal activities conducted during the construction phase for the ORNL VTR Alternative would discharge to surface water during excavation dewatering, stormwater discharge, batch plant operations, piping and equipment flushing, and hydrotesting. Water would be discharged to surface water located adjacent to or within the proposed construction footprint.

	Operations: Process wastewater used during operations of the INL VTR Alternative would be drawn from groundwater but discharged as surface water to either the Industrial Waste Pond or active sewage lagoons. Annual wastewater totals during operations would include about 1.7 million gallons of firewater and up to 0.25 million gallons of demineralized water following treatment in the VTR liquid radioactive waste system. Altogether, this annual total of about 2 million gallons represents about 12 percent of the permitted limit of 17 million gallons per year. The estimated 2.4 million gallons of potable water to be used during operations annually would be discharged as sanitary wastewater; however, sanitary wastewater would not be discharged to the Industrial Waste Pond, and this volume would not contribute toward the permitted limit of 17 million gallons per year.	*Operations*: Process wastewater used during operations of the ORNL VTR Alternative would be drawn from the Clinch River and discharged to Bearden Creek or Melton Branch. During the operation phase of the ORNL VTR Alternative, normal operations would require and discharge an estimated 1.6 million gallons per year of potable water and 2.2 million gallons per year of firewater. Following treatment at in the VTR liquid radioactive waste system, up to 0.3 million gallons of demineralized water would also be discharged. The total annual water demand during operation of the ORNL VTR Alternative is expected to be about 4.4 million gallons.
Groundwater	*Construction:* During the construction period of the INL VTR Alternative, potable water for construction workforce consumption would be drawn from existing drinking water wells that access the Snake River Plain Aquifer and the water would be treated through the existing MFC potable water system. Up to 1,300 full-time employees may be onsite during peak times; under these conditions, construction personnel may require a maximum of about 16 million gallons of potable water per year, or a total of about 34 million gallons over the course of the construction phase. Additional water would be required for construction activities, such as dust control and backfill. An estimated annual peak of about 40 million gallons per year would be needed or 94 million gallons over the entire construction period. During times of peak need, the annual volume required during the construction phase of the INL VTR Alternative would be greater than the total of 31,055,987 gallons cited in the 2019 Water Use Report. The total water demand during construction of the INL VTR Alternative is expected to be about 128 million gallons.	*Construction*: Water used during the construction phase of the ORNL VTR Alternative would be drawn from surface water and discharged as surface water.
	Operations: The estimated 4.4 million gallons per year of water used during the operation phase of the INL VTR Alternative would be drawn from groundwater but discharged as surface water to the Industrial Waste Pond or active sewage lagoons.	*Operations*: Water used during the operation phase of the ORNL VTR Alternative would be drawn from surface water and discharged as surface water.
	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Surface Water	**Feedstock Preparation**	
	Construction: The 5,000 gallons of water required for cleaning and the estimated 230,000 gallons of potable water required by construction workers would be drawn from groundwater but discharged as surface water.	*Construction*: The 6 million gallons of water needed during the construction phase would be drawn from groundwater but discharged as surface water.
	Operations: About 1.4 million gallons of water would be drawn annually from groundwater. Sanitary waste would be discharged as surface	*Operations*: About 1.4 million gallons of water would be drawn annually from groundwater but discharged as surface water.

	water. Process waters would be transported off site for treatment and disposal.	
	Fuel Fabrication	
	Construction: The 5,000 gallons of water required for cleaning and the estimated 230,000 gallons of potable water required by construction workers would be drawn from groundwater but discharged as surface water.	*Construction*: The 6 million gallons of water needed during the construction phase would be drawn from groundwater but discharged as surface water.
	Operations: About 880,000 gallons of water would be drawn annually from groundwater and discharged as surface water.	*Operations*: About 1.4 million gallons of water would be drawn annually from groundwater but discharged as surface water.
Groundwater	**Feedstock Preparation**	
	Construction: An estimated maximum of 5,000 gallons would be required during the construction phase, primarily for cleaning construction areas and equipment. A total of about 230,000 gallons of potable water would be required to serve the 18 construction workers anticipated over the entire construction phase.	*Construction*: An estimated 120 full-time employees would increase potable water use by about 20 gallons per minute or require a total about 3 million gallons over the course of the construction phase. The additional volume of non-potable water required during construction is expected to total about 6 million gallons.
	Operations: Operations and the addition of 300 new full-time employees would require about 1.4 million gallons of water per year.	*Operations*: Operations and the addition of 300 new full-time employees would require about 1.4 million gallons of water per year.
	Fuel Fabrication	
	Construction: An estimated maximum of 5,000 gallons would be required during the construction phase, primarily for cleaning construction areas and equipment. A total of about 230,000 gallons of potable water would be required to serve the 18 construction workers anticipated over the entire construction phase.	*Construction*: An estimated 120 full-time employees would increase potable water use by about 20 gallons per minute or require a total about 3 million gallons over the course of the construction phase. The additional volume of non-potable water required during construction is expected to total about 6 million gallons.
	Operations: The addition of 70 new full-time employees would increase potable water use by about 880,000 gallons per year. In addition, about 20 gallons of water would be required per week (1,000 gallons per year) for mopping and cleaning.	*Operations*: Operations and the addition of 300 new full-time employees would require about 1.4 million gallons of water per year.
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Surface Water	*Construction*: Water used during construction of the reactor fuel production options would be discharged to the same surface waters as discussed above for in the INL VTR Alternative but much lower in volume. As such, impacts on surface water would be generally as discussed for the INL VTR Alternative.	
	Operations: Feedstock preparation and fuel fabrication operations would require an additional 2.4 million gallons of water over VTR operations for a combined total of about 6.8 million gallons discharged as surface water.	
Groundwater	*Construction*: The anticipated water usage under the reactor fuel production options would represent a small percentage of the anticipated water required by the INL VTR Alternative. As such, construction impacts on groundwater would be generally as discussed above for the INL VTR Alternative.	
	Operations: Feedstock preparation and fuel fabrication operations would require an additional 2.4 million gallons of water over VTR operations for a combined total of about 6.8 million gallons drawn from groundwater sources.	

INL = Idaho National Laboratory; MFC = Materials and Fuels Complex; ORNL = Oak Ridge National Laboratory; SRS = Savannah River Site; VTR = Versatile Test Reactor.

4.3.1 Surface Water

4.3.1.1 INL VTR Alternative

Construction/Facility Modification

It is anticipated that construction activities would require about 51 months following the completion of the project's design phase. The impacts on water resources from construction activities are presented below in terms of increases over the baseline described in Section 3.1.3. Impacts on surface water resources are expected to vary over the construction period depending on the activity.

Normal activities conducted during the construction phase for the INL VTR Alternative would discharge to surface water during stormwater discharge, batch plant operations, piping and equipment flushing, and hydrotesting. Specific stormwater drainage plans for construction would be finalized in later stages of design. Low-impact techniques would be used to prevent groundwater pollution and keep stormwater runoff on the construction site. For example, the construction area would be graded, and local infiltration at the construction site would be used for stormwater management prior to establishment of paved areas or roofs. Silt and debris in stormwater runoff from construction areas could be captured by silt fencing. Water could be collected in infiltration basins down gradient of the exposed areas to minimize erosion and sedimentation on the surrounding environment once paved or roof areas are established. Stormwater in infiltration basins would evaporate or infiltrate the ground surface. Established BMPs would continue to be used to minimize sediment and chemical constituents in stormwater runoff. No activities are expected to add to or change the constituents in the stormwater discharge during construction. Therefore, the construction period would have no impact on stormwater quality.

Equipment washing would generate routine wastewater throughout the construction phase. Construction equipment could either be taken to the Central Facilities Area to be washed in an established maintenance area or washed in a temporary wash area that would prevent greases, oils, or material residues from contacting the ground surface and migrating to the subsurface.

Wastewater and stormwater discharges to unlined infiltration basins or the ground, or uncontrolled spills of chemicals or petroleum products, are potential pathways of groundwater contamination. Spills prevention and cleanup programs, the wastewater discharge management plan, and waste management programs control contaminants in these pathways. These plans and programs conform to applicable Federal and State requirements and some are subject to Federal and State compliance inspections. Examples of BMPs used to protect groundwater include reducing soil erosion and stormwater runoff by using silt fencing, hay bales, or rills that catch sediment or confining runoff to designated areas (e.g., infiltration basins). Using the minimum, effective quantity of chemicals and considering the use of "greener" alternatives when available, and applying practicable and careful management of hazardous materials and wastes are also BMPs.

Sanitary wastewater from the construction workforce would be handled by portable systems and hauled off site for disposal in accordance with regulations. Sanitary wastewater discharges during the construction period would not introduce novel constituents not already present on site under baseline conditions. Constituents and constituent concentrations in active sewage lagoons are not regulated by permit; however, all design, testing, and operations requirements in Idaho Administrative Procedure Act code (IDAPA) 58.01.16 are met and approved by the State. The active sewage lagoons are lined to contain constituents. Therefore, the construction period would not impact constituent concentrations in effluent. As portable sanitary systems would be used, sanitary discharge volumes to the active sewage lagoons would not increase.

Because construction workers would use portable sanitary systems and other construction-related water would be drawn from groundwater, no changes to surface water use would be expected during implementation of the INL VTR Alternative.

Operations

Process wastewater used during operations of the INL VTR Alternative would be drawn from groundwater but discharged as surface water to either the Industrial Waste Pond or active sewage lagoons. During the operation phase of the INL VTR Alternative, normal operations would discharge about 1.7 million gallons per year of fire water and up to 0.25 million gallons per year of demineralized water following treatment in the VTR liquid radioactive waste system (following such treatment, the discharged demineralized water would only exhibit negligible levels of radioactivity and would not represent an increased risk over existing operations). Altogether, this total of about 2 million gallons represents about 12 percent of the permitted limit of 17 million gallons per year stipulated in the State of Idaho Industrial Wastewater Reuse Permit for the INL Site's MFC Industrial Waste Pond. In addition, an estimated 2.4 million gallons per year of potable water would be required during operations and discharged as sanitary wastewater. However, sanitary wastewater would not be discharged to the Industrial Waste Pond and would not contribute toward the permitted limit of 17 million gallons per year.

4.3.1.2 ORNL VTR Alternative

Construction/Facility Modification

It is anticipated that construction activities would require about 51 months following the completion of the project's design phase. The impacts on water resources from construction activities are presented below in terms of increases to the baseline described in Section 3.2.3. Impacts on surface water resources are expected to vary over the construction period depending on the activity.

Normal activities conducted during the construction phase for the ORNL VTR Alternative would discharge to surface water during excavation dewatering, stormwater discharge, batch plant operations, piping and equipment flushing, and hydrotesting. Water would be discharged to surface water located adjacent to or within the proposed construction footprint (e.g., tributaries to Bearden Creek to the north and southeast or Melton Branch to the west and southwest).

Excavation activities associated with the construction phase of the ORNL VTR Alternative are expected to encounter groundwater. The groundwater table exists about 50 to 175 feet below grade across the ORNL, and the proposed project would require VTR components to be installed at depths of up to 93 feet below grade. As such, dewatering efforts would discharge water through outfalls to a creek. It is possible that outfalls needed for such efforts would require new or modified permits. The TDEC requires a NPDES Stormwater Construction permit for "…construction sites involving clearing, grading or excavation that result in an area of disturbance of one or more acres".

Specific stormwater drainage plans for construction would be finalized in later stages of design. Low-impact development techniques would be used to prevent groundwater pollution and keep stormwater runoff on the construction site. For example, the construction area would be graded, and local infiltration at the construction site would be used for stormwater management prior to establishment of paved areas or roofs. Silt and debris in stormwater runoff from construction areas could be captured by silt fencing. Water could be collected in infiltration basins down gradient of the exposed areas to minimize erosion and sedimentation on the surrounding environment once paved or roof areas are established. Stormwater in infiltration basins would evaporate or infiltrate the ground surface. Established BMPs would continue to be used to minimize sediment and chemical constituents in stormwater runoff. The TDEC's Erosion and Prevention Control Handbook provides guidance regarding erosion prevention and sediment control BMPs and for the development and implementation of SWPPPs, as required for

Tennessee General NPDES Permits for Discharges Associated with Construction Activities and individual NPDES permits. No activities are expected to add to or change the constituents in the stormwater discharge during construction. Therefore, the construction period would have no impact on stormwater quality.

Equipment washing would generate routine wastewater throughout the construction phase. Construction equipment could either be taken to an established maintenance area or washed in a temporary wash area that would prevent greases, oils, or material residues from contacting the ground surface and migrating to the subsurface. Due to BMPs, sedimentation and erosion in existing surface water drainage ways are not expected to increase during the construction period.

Wastewater and stormwater discharges to sediment basins or the ground, or uncontrolled spills of chemicals or petroleum products, are potential pathways of groundwater contamination. Spill prevention and clean-up programs, the wastewater discharge management plan, and waste management programs control contaminants in these pathways. These plans and programs conform to applicable Federal and State requirements, and some are subject to Federal and State compliance inspections. Examples of BMPs used to protect groundwater include reducing soil erosion and stormwater runoff by using silt fencing, hay bales, or rills that catch sediment, or confine runoff to designated areas (e.g., infiltration basins); minimizing use of chemicals; and careful management of hazardous materials and wastes.

Sanitary wastewater from the construction workforce would be handled by portable systems and hauled off site for disposal in accordance with regulations. Sanitary wastewater discharges during the construction period would not introduce novel constituents not already present on site under baseline conditions.

Construction workers would use portable sanitary systems, but industrial and other construction-related water would be drawn from surface water. During the construction period of the ORNL VTR Alternative, potable water for construction workforce consumption would be drawn from the Clinch River and pumped to the water treatment plant located northeast of Y-12. The water treatment plant is owned and operated by the City of Oak Ridge. This water would be used for both sanitation purposes and construction activities. Up to 1,300 full-time employees may be onsite during peak times and may utilize up to 20 million gallons per year; a total of about 46 million gallons of potable water are expected to be required during the construction phase of the ORNL VTR Alternative. Additional water would be required for construction activities, such as dust control and backfill. An estimated total of about 121 million gallons would be needed over the entire construction period, with annual volumes ranging from an average of about 29 million gallons to a peak of about 52 million gallons. The total water needs for construction of the ORNL VTR Alternative are expected to be about 172 million gallons. The existing ORNL water treatment system can accommodate an annual rate of 2.55 billion gallons per year, so the existing treatment and supply system has the capacity to serve the ORNL VTR Alternative.

Intermittent tributaries to Bearden Creek form the north and southeast boundaries of the construction footprint for the ORNL VTR Alternative; intermittent tributaries to Melton Branch form the west and southwest boundaries. In addition, intermittent waterways extend into the proposed permanent footprint of the VTR complex at ORNL. Wetlands associated with these surface waters occupy about 4.7 acres of the temporary construction area. The TDEC requires an Aquatic Resource Alteration Permit or a Section 401 Water Quality Certification for projects that result in "physical alterations to properties of waters of the state". Construction activities associated with the ORNL VTR Alternative could release discharged water or sediment to these resources. However, any impacts on wetlands would occur in compliance with all Federal, State, and permit requirements to reduce or avoid impacts on onsite wetlands.

Operations

Process wastewater used during operations of the ORNL VTR Alternative would be drawn from the Clinch River and discharged to Bearden Creek or Melton Branch. During the operation phase of the ORNL VTR Alternative, normal operations would discharge about 1.6 million gallons of sanitary wastewater and about 2.2 million gallons of fire water. Following treatment in the VTR liquid radioactive waste system, up to 0.3 million gallons of demineralized water would also be discharged. Following such treatment, the discharged demineralized water would only exhibit negligible levels of radioactivity and would not represent an increased risk over existing operations. These wastewater discharges would flow through new outfalls to Bearden Creek or Melton Branch; these outlets may require a new or modified permit prior to use.

About 1.8 acres of palustrine, forested wetlands exist within the operational footprint of the ORNL VTR Alternative. These wetlands, associated with the tributaries to Bearden Creek and Melton Branch would be permanently affected by the proposed project, but activities would be conducted in compliance with the terms of an Aquatic Resource Alteration Permit or a Section 401 Water Quality Certification obtained from the TDEC, if required. As such, potential impacts on wetland structure or quality would be reduced and maintained at less-than-significant levels or avoided altogether.

4.3.1.3 INL and SRS Reactor Fuel Production Options

Because groundwater serves as the primary water sources at both the INL Site and SRS, no changes to surface water use would be expected during implementation of the reactor fuel production options. The water required by construction of the INL Fuel Fabrication Reactor Fuel Production Options would be discharged to the same sources as described in Section 4.3.1.1, but in much smaller volumes. As such, anticipated impacts on surface water quality would be similar to, but less intense than, the impacts discussed in Section 4.3.1.1. Operation of the INL Fuel Fabrication Reactor Fuel Production Options would require about 2.4 million gallons of water, almost all of which would be potable. This water would be discharged as sanitary wastewater and, therefore, would not affect the site's permitted limit of 17 million gallons per year for the Industrial Waste Pond. Operation of the feedstock preparation option at INL would require about 50,000 gallons for steam, aqueous processing, and waste treatment. The 50,000 gallons of treated wastewater would be discharged to the MFC's Industrial Waste Pond or as surface water depending on the characteristics following evaporative and chemical treatment or sent off site for treatment and disposal. This volume would represent a 0.3 percent contribution toward the permitted limit of 17 million gallons.

Sanitary wastewater from construction and operation of the SRS Fuel Fabrication Reactor Fuel Production Options would be discharged to the sanitary treatment plant, located within K Area, and then discharged through K-12 Outfall. This outfall comingles with the river at the water discharge of K-18 Outfall. Depending on the characteristics following evaporation and chemical treatment, about 50,000 gallons of treated wastewater generated by aqueous processing and waste treatment during operation of the feedstock preparation option may be suitable for onsite discharge to surface water or sent off site for treatment and disposal. The additional wastewater anticipated through construction and operation of the SRS Fuel Fabrication Reactor Fuel Production Options are not expected to affect permit thresholds.

4.3.1.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

This section presents the total impacts that would occur if the VTR and the fuel fabrication capability were both established at the INL Site. Water used during construction of the reactor fuel production options would be discharged to the same surface waters as discussed above for in the INL VTR Alternative but much lower in volume. As such, the combined construction impacts would be as described in Section 4.3.1.1 for the INL VTR Alternative and the INL Options. Operation of the INL VTR Alternative, feedstock preparation, and fuel fabrication all at the INL Site would require a combined total of about 6.8 million gallons of water per year. This volume would be drawn from groundwater but discharged as surface water to the Industrial Waste Pond and active sewage lagoons, as discussed in Section 4.3.1.1. However, all but about 51,000 gallons of the estimated 2.4 million gallons required for operation of the reactor fuel options would be discharged as sanitary wastewater and therefore, not counted toward the Industrial Waste Pond's permitted limit of 17 million gallons. As such, the combined impacts from all three of these components would still be generally as described in Section 4.3.1.1.

4.3.2 Groundwater

4.3.2.1 INL VTR Alternative

Construction/Facility Modification

During the construction period of the INL VTR Alternative, potable water for construction workforce consumption would be drawn from existing drinking water wells that access the Snake River Plain Aquifer (SRPA) and the water would be treated through the existing MFC potable water system. Up to 1,300 full-time employees may be onsite during peak times; during such times, about 16 million gallons of potable water could be required per year. Anticipated potable water needs during the entire construction phase total about 34 million gallons. Additional water would be required for construction activities, such as dust control and backfill. An estimated total of about 94 million gallons would be needed over the entire construction period, with annual volumes ranging from an average of about 22 million gallons to a peak of about 40 million gallons. Altogether, the total water demand during the construction phase is anticipated to be about 128 million gallons. During times of peak need, the annual volume required during the construction phase of the INL VTR Alternative would be greater than the total of 31,055,987 gallons cited in the 2019 Water Use Report.

Construction of the VTR would involve excavation activities at depths of up to 93 feet below grade. However, the water table exists about 649 to 662 feet below grade at the MFC, located adjacent to the proposed project site. Therefore, construction activities are not expected to encounter groundwater during excavation.

Constituent concentrations in onsite groundwater are expected to remain similar to existing baseline conditions during the construction period. Therefore, activities during the construction period for this alternative would not impact groundwater quality compared to baseline conditions described in Section 3.3. The drinking water monitoring program has shown that constituents in drinking water wells are below regulatory limits. Activities during the construction period of the INL VTR Alternative would not impact the wellhead protection areas compared to baseline conditions described in Section 3.3.

Operations

Water used during the operation phase of the INL VTR Alternative would be drawn from groundwater but discharged as surface water to the Industrial Waste Pond or active sewage lagoons. The total volume of water required during operations is discussed in Section 4.3.1.1.

4.3.2.2 ORNL VTR Alternative

Construction/Facility Modification

Water used during the construction phase of the ORNL VTR Alternative would be drawn from surface water and discharged as surface water. The total volume of water required during operations are discussed in Section 4.3.1.2. Groundwater is expected to be encountered during excavation activities, as discussed in Section 4.3.1.2, but groundwater withdrawn during dewatering activities would be discharged as surface water.

Operations

Water used during the operation phase of the ORNL VTR Alternative would be drawn from surface water and discharged as surface water. The total volume of water required during operations is discussed in Section 4.3.1.2.

4.3.2.3 Reactor Fuel Production Options

4.3.2.3.1 INL Option – Feedstock Preparation

Construction/Facility Modification

Under this scenario, the only construction activities would be to modify existing space in the FCF's operating floor/high bay, mockup area, and workshop and convert it for use in feedstock preparation. An estimated maximum of 5,000 gallons of water would be required during the 3-year construction phase, primarily for cleaning construction areas and equipment. A total of about 230,000 gallons of potable water would be required to serve the 18 construction workers anticipated over the entire construction phase.

Operations

Under this scenario, feedstock preparation capabilities would occur within the modified FCF. A series of glovebox lines would be installed for feedstock polishing and conversion. Water usage would be well within the existing capacities of the individual facilities and the MFC. Operations would require about 50,000 gallons of water for steam, aqueous processing, and waste treatment. Together with the addition of 300 full-time employees, operation of the feedstock preparation option would increase potable water use by about 1.4 million gallons per year. This volume would be drawn from groundwater but discharged as surface water.

4.3.2.3.2 INL Option – Fuel Fabrication

Construction/Facility Modification

Under this scenario, the VTR fuel fabrication process at the INL Site would be located in existing facilities at MFC (FCF, FMF, and ZPPR). The only construction activities, occurring over a 2-year period, would be the build out of the equipment locations in the FMF, ZPPR, and FCF. An estimated maximum of 5,000 gallons would be required during the construction phase, primarily for cleaning construction areas and equipment. A total of about 230,000 gallons of potable water would be required to serve the 18 construction workers anticipated over the entire construction phase.

Operations

Under this scenario, the VTR fuel fabrication process at the INL Site would be located in existing facilities at MFC (FCF, FMF, and ZPPR). Volumes of water used during operations would be well within the existing capacities of the individual facilities and the MFC. The addition of 70 new full-time employees would increase potable water use by about 880,000 gallons per year. In addition, about 20 gallons of water would be required per week (1,000 gallons per year) for mopping and cleaning.

4.3.2.3.3 SRS Option – Feedstock Preparation

Construction/Facility Modification

Under this scenario, no new facilities would be constructed at SRS. The capability would be located adjacent to the location for the fuel fabrication capability, in the K Area Complex, primarily at the minus-20-foot level (20 feet below grade). An estimated 120 full-time employees would increase potable water use by about 20 gallons per minute or require a total about 3 million gallons over the course of the construction phase. The additional volume of non-potable water required during construction is expected to total about 6 million gallons.

Operations

The feedstock processing capability at SRS would be located adjacent to the location for the fuel fabrication capability, which is in the K Area Complex, and the process equipment would be located at the minus-20-foot level at the minus-40-foot level (20 and 40 feet below grade). Operations and the addition of 300 new full-time employees would require about 1.4 million gallons of water per year.

4.3.2.3.4 SRS Option – Fuel Fabrication

Construction/Facility Modification

Under this scenario, no new facilities would be constructed at SRS. The only construction activities would be the build-out of the equipment locations within an existing facility in the K Area Complex and the removal of existing equipment. Construction is assumed to require 3 years. The fuel fabrication facility would be located on the minus-20- and minus-40-foot levels (20 and 40 feet below grade) of the Building 105-K. An estimated 120 full-time employees would increase potable water use by about 20 gallons per minute or require a total about 3 million gallons over the course of the construction phase. The additional volume of non-potable water required during construction is expected to total about 6 million gallons.

Operations

The fuel fabrication facility would be located on the minus-20-and minus-40-foot levels (20 and 40 feet below grade) of the Building 105-K. Although the VTR modifications have not been designed, based on similar K Area upgrade projects, the space needed for support facilities for the needed HVAC, fire suppression, etc., are expected to be substantial. At least one and possibly two of the adjacent 108-K Buildings could be needed for these support operations. Operations and the addition of 300 new full-time employees would require about 1.4 million gallons of water per year for potable use and cleaning.

4.3.2.4 INL VTR, Feedstock Preparation, and Fuel Fabrication Combined Impacts

This section presents the total potential groundwater impacts that would occur if the VTR and the reactor fuel production capability were both established at the INL Site. The anticipated water usage under construction of the reactor fuel options would represent a small percentage of the anticipated water required by construction of the INL VTR Alternative. Operations would require about 4.4 million gallons for the VTR alternative, 1.4 million gallons for feedstock preparation, and 880,000 gallons for fuel fabrication per year for a total of about 6.8 million gallons. Of the volume required for operation of the Reactor Fuel Production Options, almost all would be potable water and therefore discharged as sanitary wastewater. Sanitary wastewater would not be discharged to the Industrial Waste Pond and would not contribute against the permitted limit of 17 million gallons. About 50,000 gallons required for aqueous processing and waste treatment would be discharged to the Industrial Waste Pond or as surface water depending on the characteristics following evaporation and chemical treatment or sent off site for treatment and disposal. This volume would represent about 0.3 percent of the permitted limit of 17 million gallons. Because of this, and since all water used during construction and operation would be drawn from groundwater sources and discharged to surface water, impacts would be generally as discussed in Section 4.3.1.1.

4.4 Air Quality

Construction and operations activities under the proposed project alternatives would result in air emissions of criteria pollutants, hazardous air pollutants (HAPs), and greenhouse gases (GHGs). The following analysis evaluates projected emissions relative to air quality conditions within several project regions and their applicable Federal, State, and local air pollution standards and regulations. For criteria pollutants that would occur within a region that attains a National Ambient Air Quality Standard (NAAQS), the analysis compares estimates of annual emissions from a project alternative to the EPA prevention of significant deterioration- (PSD) permitting threshold of 250 tons per year. The comparison would then be used to make an initial determination of the significance of potential impacts on air quality. The PSD-permitting threshold represents the level of potential new emissions below which a new stationary source can emit without triggering the requirement to obtain a PSD permit. For criteria pollutants that would occur within a region that does not attain a NAAQS, the analysis compares the increase in annual emissions to the applicable pollutant conformity de minimis threshold. If the intensity of annual emissions increases for a project alternative are below a PSD or applicable conformity threshold, the indication is that air quality impacts would be insignificant for that pollutant.

If emissions from a project alternative would exceed one of the indicator thresholds mentioned above, further analysis was conducted to predict whether impacts would be significant. In such cases, if emissions would (1) not contribute to an exceedance of an ambient air quality standard or (2) conform to the approved State Implementation Plan, then impacts would not be significant.

Air quality impacts of nonradiological HAPs from construction and operation activities at each site are evaluated in terms of whether they would produce adverse impacts on the public. Additionally, the analysis predicts GHG and radiological air emissions for each project alternative for purposes of making reasoned choices among the alternatives. Sections 4.10 through 4.12 (Human Health) present estimates of the health effects from potential radiological air emissions.

Table 4–4 presents a summary of the potential environmental consequences on air quality for the INL and ORNL VTR Alternatives and the INL and SRS Reactor Fuel Production Options.

Table 4–4. Summary of Environmental Consequences on Air Quality

	VTR Alternatives	
	INL VTR	***ORNL VTR***
Construction	Annual nonradiological emissions from construction of the VTR facilities would be well below the annual indicator thresholds. HAPs 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 construction of the VTR facilities would be below the annual indicator thresholds. HAPs emissions generated by 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 well below the annual indicator thresholds. Operations activities would generate radiological air emissions.	Annual nonradiological emissions from operation of the VTR facilities would be well below the annual indicator thresholds. Operations activities would generate radiological air emissions. Each source of radiological air emissions would operate under a Construction Permit and existing Title V operating permit. An Air Permitting and Applicability Determination (APAD) would be performed to ensure compliance with NESHAP, Subpart H.
Discussion	DOE would implement protective measures to minimize the generation of fugitive dust during construction. Construction and operation of the VTR Alternative at either location would not result in adverse impacts from nonradiological air emissions. Impacts of radiological air emissions are evaluated in EIS Sections 4.10 through 4.12 (Human Health).	

	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Construction and Operations	Construction and operations of the Reactor Fuel Production Options at either location would result in minor amounts of nonradiological emissions that would be well below the annual indicator thresholds. These actions at both locations also would produce minimal amounts of HAPs. Construction activities at INL/SRS would not generate radiological air emissions. Operations activities at both sites would generate radiological air emissions.	
Discussion	Construction and operation of the Reactor Fuel Production Options at either location would not result in adverse impacts from nonradiological air emissions. Impacts of radiological air emissions are evaluated in EIS Sections 4.10 through 4.12 (Human Health).	
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Discussion	Same as for INL VTR Alternative because of minimal impacts from fuel fabrication.	

Note: Affected environment information is from Chapter 3 of this VTR EIS.
Sources: INL 2020f; ORNL 2020c.

4.4.1 INL VTR Alternative

The air quality analysis estimates air emissions that would result from the construction and operation of the INL VTR Alternative. The counties that encompass the INL Site currently attain all of the NAAQS. Therefore, the analysis used the PSD-permitting threshold of 250 tons per year for criteria pollutants as indicators of the significance of projected air quality impacts within the INL Site project region.

4.4.1.1 Construction/Facility Modification

The INL VTR Alternative would require construction of new facilities and modifications to existing facilities at the INL Site. Air quality impacts from projected construction activities would result from (1) combustive emissions due to the use of fossil-fuel-powered equipment, trucks, and worker commuter vehicles and (2) fugitive dust emissions (PM_{10}/$PM_{2.5}$) due to the operation of equipment on exposed soil. Construction activity data developed by INL staff were used to estimate projected construction equipment usages and associated combustive and fugitive dust emissions (INL 2020f). Construction activities for the alternative would take about 4 years to complete (INL 2020f).

Factors needed to derive construction source emission rates were obtained from EPA's Motor Vehicle Emission Simulator (MOVES) MOVES2014b model for non-road construction equipment and on-road vehicles (EPA 2018a) and Western Regional Air Partnership's Fugitive Dust Handbook (Countess Environmental 2006). The analysis assumes that DOE would implement protective measures to minimize the generation of fugitive dust during construction and to comply with Sections 650 and 651 (Rules for Control of Fugitive Dust) of the IDAPA Rules for the Control of Air Pollution in Idaho. Implementation of these measures would reduce fugitive dust emissions from active disturbed areas by up to 74 percent compared to uncontrolled levels (Countess Environmental 2006). Chapter 6, Section 6.1, of this EIS includes details of the air quality protective measures assessed in this EIS.

Table 4–5 presents estimates of calendar year emissions that would occur from construction of new facilities and modifications to existing facilities under the INL VTR Alternative. The data in Table 4–5 show that the combined annual emissions from construction of the VTR facilities would be well below the annual indicator thresholds. Therefore, annual emissions from construction of the combined facilities under the alternative would not result in adverse air quality impacts.

Combustion of fossil fuels in construction equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Combined HAPs from diesel-powered internal combustion engines compose about 15 and 3 percent, respectively, of total volatile organic compounds and PM_{10} emissions (California Air Resources Board 2018). The analysis estimates that onsite HAPs emissions from construction of the INL VTR Alternative would peak in year 2023 at 0.14 tons per year. The mobile and intermittent operation of construction emission sources would result in dispersed concentrations of these HAPs adjacent to construction activities. The substantial transport distance of construction emissions from MFC to the nearest locations of the INL Site boundary (about 3 miles) would produce further dispersion and inconsequential concentrations of HAPs beyond the INL Site boundary. In addition, the intermittent operation of construction trucks and worker commuter vehicles on public roads would result in low concentrations of HAPs at these offsite locations. As a result, HAPs concentrations generated by construction activities would not result in adverse air quality impacts on the public.

Table 4–5. Calendar Year Nonradiological Construction Emissions – INL VTR Alternative

Calendar Year/Source Type	*Air Pollutant Emissions (tons per year)*						
	VOC	*CO*	*NO_x*	*SO_2*	*PM_{10}*	*$PM_{2.5}$*	*CO_2e (metric tons)*
Year 2022							
Onsite On-road Sources	0.05	1.00	0.48	0.002	0.06	0.02	261
Onsite Non-road Sources	0.35	2.47	4.66	0.01	0.27	0.27	1,614
Fugitive Dust					56.78	5.68	
Offsite On-road Sources	0.08	5.12	1.00	0.006	0.20	0.05	761
Total Annual Emissions	**0.48**	**8.59**	**6.13**	**0.02**	**57.31**	**6.01**	**2,637**
Year 2023							
Onsite On-road Sources	0.08	1.46	0.78	0.004	0.09	0.04	445
Onsite Non-road Sources	0.73	4.61	8.59	0.02	0.47	0.45	2,755
Fugitive Dust					102.21	10.22	
Offsite On-road Sources	0.36	24.37	4.28	0.03	0.95	0.22	3,666
Total Annual Emissions	**1.16**	**30.44**	**13.64**	**0.05**	**103.72**	**10.93**	**6,866**
Year 2024							
Onsite On-road Sources	0.06	1.27	0.61	0.003	0.08	0.03	393
Onsite Non-road Sources	0.68	4.16	8.50	0.02	0.43	0.41	2,773
Fugitive Dust					68.14	6.81	
Offsite On-road Sources	0.32	24.32	3.91	0.03	0.98	0.22	3,763
Total Annual Emissions	**1.06**	**29.75**	**13.03**	**0.05**	**69.62**	**7.47**	**6,929**
Year 2025							
Onsite On-road Sources	0.02	0.73	0.22	0.002	0.04	0.01	182
Onsite Non-road Sources	0.21	1.50	2.50	0.01	0.13	0.13	1,051
Fugitive Dust					34.07	3.41	
Offsite On-road Sources	0.03	1.09	0.50	0.00	0.10	0.02	336
Total Annual Emissions	**0.26**	**3.32**	**3.21**	**0.01**	**34.33**	**3.57**	**1,569**
Annual Indicator Thresholds	**250**	**250**	**250**	**250**	**250**	**250**	**NA**
Exceed Threshold?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; NA = not applicable; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

Note: Due to rounding, sums and products may not equal those calculated from table entries.

Construction activities from the INL VTR Alternative would not generate radiological air emissions. Construction of new facilities that occur in nonradiological areas and facility modifications within radiological areas would not be expected to increase existing radiological air emissions.

Air emissions from construction of the INL VTR Alternative would have the potential to affect the Craters of the Moon National Monument PSD Class I area, whose nearest border is about 45 miles southwest of the MFC. As stated above for potential HAPs impacts from proposed construction, the mobile and intermittent operation of construction emission sources would result in dispersed concentrations of air pollutants at locations outside of the INL Site. The substantial transport distance of these emissions to the nearest boundary of the Craters of the Moon National Monument (about 45 miles) would produce substantial dispersion and would result in negligible concentrations of air pollutants within this pristine Class I area. Therefore, construction of the INL VTR Alternative would negligibly affect air quality values within the Craters of the Moon National Monument pristine Class I area.

4.4.1.2 Operations

Air quality impacts from the operation of the INL VTR Alternative would occur from (1) intermittent use of two diesel-powered backup electrical generators rated at one megawatt each, (2) intermittent use of propane-fired heaters for the VTR sodium heat exchanger system during maintenance activities, (3) diesel-powered trucks that deliver material and haul off wastes, and (4) worker commuter vehicles. Vehicle trips and associated trip lengths used in the analysis are consistent with metrics developed for proposed VTR activities at the INL Site (INL 2020f).

Factors needed to derive on-road vehicle emission rates were obtained from the EPA MOVES2014b model. To estimate emissions from the proposed backup generators, the analysis assumes that these units would operate at EPA non-road Tier 4 standard levels (EPA 2018b). The backup generators would operate for about four days per year (INL 2020a). At this level of annual operation (less than 500 hours per year) with use of diesel fuel, these units would not require a permit to construct, as outlined in Section 58.01.01.222.01.d of the IDAPA Rules for the Control of Air Pollution in Idaho. Factors needed to estimate emissions for the propane-fired heaters were obtained from the EPA AP-42 document (EPA 2008).

Table 4–6 presents estimates of annual nonradiological emissions that would occur due to operation of the INL VTR Alternative. The data in Table 4–6 show that annual emissions from operations of the INL VTR Alternative would be well below the annual indicator thresholds.

Table 4–6. Annual Nonradiological Operations Emissions – INL VTR Alternative

	Air Pollutant Emissions (tons per year)						
Source-Facility	***VOC***	***CO***	***NO_x***	***SO_2***	***PM_{10}***	***$PM_{2.5}$***	***CO_2e (metric tons)***
Back-up Generators – VTR	0.03	0.50	0.10	0.001	0.004	0.004	93
Sodium Heaters – Normal Operations	0.000	0.002	0.003	0.000	0.000	0.000	3
Haul Trucks	0.03	0.15	0.55	0.003	0.08	0.02	277
Worker Commuter Vehicles	0.02	2.85	0.18	0.003	0.08	0.02	347
Total – Normal Operations	**0.09**	**3.50**	**0.84**	**0.01**	**0.17**	**0.04**	**720**
Sodium Heaters – Large Component Replacement [a]	0.02	0.16	0.27	0.00	0.01	0.01	**239**
Annual Emissions during LCR Cycle [b]	**0.11**	**3.66**	**1.11**	**0.01**	**0.18**	**0.06**	**956**
Annual Indicator Thresholds	**250**	**250**	**250**	**250**	**250**	**250**	**NA**
Exceed Threshold?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; LCR = large component replacement; NA = not applicable; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

[a] LCR would occur every 15 years.

[b] Equal to normal operations plus sodium heaters – LCR.

Note: Due to rounding, sums and products may not equal those calculated from table entries.

Combustion of fossil fuels in operations equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Operation of the diesel-powered backup generators at the VTR Facility would produce about 0.005 tons per year of combined HAPs emissions (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). The substantial transport distance of these HAPs emissions from the MFC to the nearest locations of the INL Site boundary (about 3 miles) would produce HAPs impacts that would not exceed an ambient concentration of concern beyond the INL Site boundary. In addition, the intermittent operation of delivery and haul trucks and worker commuter vehicles on public roads would result in low concentrations of HAPs at these offsite locations. As a result, HAPs concentrations generated by operations activities would not result in adverse air quality impacts on the public.

Operation of the INL VTR Alternative would generate radiological air emissions from processes in the VTR, Test Assembly Examination, and Spent Fuel Storage and Treatment Facilities. INL would develop an Air Permitting and Applicability Determination (APAD) for each applicable source of radiological air emissions to ensure compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H. All radionuclide sources within these facilities would vent to stacks that would operate with continuous emission monitoring (CEM) systems and high-efficiency particulate air (HEPA) filters or a series of HEPA filters that have a control efficiency of at least 99.9 percent. Section 4.10.1 of this EIS presents estimates of annual radiological emissions that would occur from the operation of the INL VTR Alternative.

Air emissions from operation of the INL VTR Alternative would have the potential to affect the Craters of the Moon National Monument PSD Class I area. The substantial transport distance of minor amounts of operations emissions to the nearest boundary of the Craters of the Moon National Monument (about 45 miles) would produce substantial dispersion and would result in negligible concentrations of air pollutants within this pristine PSD Class I area. Therefore, operation of the INL VTR Alternative would negligibly affect air quality values within the Craters of the Moon National Monument pristine PSD Class I area.

4.4.2 ORNL VTR Alternative

The air quality analysis estimates air emissions that would result from the construction and operation of the ORNL VTR Alternative. Roane and Anderson Counties that encompass ORNL currently attain all of the NAAQS. Therefore, the analysis used the PSD-permitting threshold of 250 tons per year for criteria pollutants as indicators of the significance of projected air quality impacts within the ORNL project region.

4.4.2.1 Construction/Facility Modification

The ORNL VTR Alternative would require construction of new facilities for the VTR, Test Assembly Examination, and Spent Fuel Treatment and Storage facilities. Air quality impacts from projected construction activities would result from (1) combustive emissions due to the use of fossil-fuel-powered equipment, trucks, and worker's commuter vehicles and (2) fugitive dust emissions due to the operation of equipment on exposed soil.

Activity data needed for the estimation of construction emissions were based on the effort needed to construct the VTR complex at INL, plus site-specific activity data developed for site clearing, site excavation, and construction of the hot cell and spent fuel storage facilities at ORNL (Leidos 2020). Factors needed to derive construction source emission rates were obtained from the EPA MOVES2014b model for non-road construction equipment and on-road vehicles (EPA 2018a), the Western Regional Air Partnership's Fugitive Dust Handbook (Countess Environmental 2006) for fugitive dust, and the First Order Fire Effects Model (FOFEM) for slash burning (USFS 2020). The analysis assumes that DOE would implement protective measures to minimize the generation of fugitive dust during construction and to comply with Chapter 1200-3-8 (Fugitive Dust) of the Tennessee Air Pollution Control Regulations.

Implementation of these measures would reduce fugitive dust emissions from active disturbed areas by up to 74 percent compared to uncontrolled levels. DOE also would comply with Chapter 1200-3-4 (Open Burning) of the Tennessee Air Pollution Control Regulations to minimize emissions from proposed site clearing activities. Chapter 6, Section 6.1, of this EIS includes details of the air quality protective measures assessed in this EIS.

Table 4–7 presents estimates of calendar year emissions that would occur from construction of the VTR alternative at ORNL. The data in Table 4–7 show that construction of the VTR facilities would result in emissions that would be below the annual indicator thresholds. Therefore, annual emissions from construction of the combined facilities under the Alternative would not result in adverse air quality impacts.

Table 4–7. Calendar Year Nonradiological Construction Emissions – ORNL VTR Alternative

Calendar Year/Source Type	*Air Pollutant Emissions (tons per year)*						
	VOC	*CO*	*NO_x*	*SO_2*	*PM_{10}*	*$PM_{2.5}$*	*CO_2e (metric tons)*
Year 2022							
Onsite On-road Sources	0.01	0.14	0.15	0.00	0.02	0.01	72
Onsite Non-road Sources	0.33	1.80	0.99	0.00	0.08	0.08	272
Fugitive Dust					6.95	0.69	
Offsite On-road Sources	0.03	0.32	0.54	0.00	0.07	0.02	236
Slash Burning	28.88	136.80	3.06	1.91	26.64	22.64	2,787
Total Annual Emissions	**29.26**	**139.06**	**4.75**	**1.91**	**33.76**	**23.45**	**3,367**
Year 2023							
Onsite On-road Sources	0.08	2.99	0.62	0.00	0.10	0.03	552
Onsite Non-road Sources	0.68	4.27	8.45	0.02	0.42	0.41	2,571
Fugitive Dust					43.21	4.32	
Offsite On-road Sources	0.11	6.93	1.20	0.01	0.27	0.06	1,055
Total Annual Emissions	**0.87**	**14.19**	**10.27**	**0.03**	**44.02**	**4.82**	**4,178**
Year 2024							
Onsite On-road Sources	0.18	7.90	1.41	0.01	0.27	0.07	1,437
Onsite Non-road Sources	1.05	6.18	12.66	0.03	0.62	0.60	3,630
Fugitive Dust					13.00	1.30	
Offsite On-road Sources	0.28	19.58	3.23	0.02	0.82	0.18	3,117
Total Annual Emissions	**1.51**	**33.67**	**17.30**	**0.07**	**14.70**	**2.15**	**8,184**
Year 2025							
Onsite On-road Sources	0.13	5.55	1.14	0.01	0.22	0.06	1,157
Onsite Non-road Sources	1.00	5.64	12.35	0.03	0.58	0.56	3,912
Fugitive Dust					7.32	1.08	
Offsite On-road Sources	0.18	13.45	2.15	0.02	0.60	0.12	2,257
Total Annual Emissions	**1.31**	**24.64**	**15.64**	**0.06**	**8.72**	**1.83**	**7,326**
Annual Indicator Thresholds	**250**	**250**	**250**	**250**	**250**	**250**	**NA**
Exceed Threshold?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; NA = not applicable; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

Note: Due to rounding, sums and products may not equal those calculated from table entries.

Slash burning and the combustion of fossil fuels in construction equipment, trucks, and worker commuter vehicles would emit nonradiological HAPs. Onsite HAPs emissions from construction of the ORNL VTR Alternative would peak in year 2022 at 1.15 tons per year (equal to 15 and 3 percent, respectively, of combustive volatile organic compound (VOC) and PM_{10} emissions from diesel equipment plus 1 and 3 percent, respectively, of VOC and PM_{10} emissions from slash burning). The overwhelming majority of these emissions would occur from slash burning (equal to one and three percent, respectively, of VOC and PM_{10} emissions from this source). The intermittent emissivity of slash burning and the substantial transport distance of these emissions from the proposed location of the VTR facilities to the nearest locations of the ORNL facility boundary (about 2 miles) would produce substantial dispersion and inconsequential concentrations of HAPs beyond the ORNL property boundary. In addition, the intermittent operation of construction trucks and worker commuter vehicles on public roads would result in low concentrations of HAPs at these offsite locations. As a result, HAPs concentrations generated by construction activities would not result in adverse air quality impacts on the public.

Construction of the ORNL VTR Alternative would not generate radiological air emissions, as proposed construction activities would occur in nonradiological areas.

Air emissions from construction of the ORNL VTR Alternative would have the potential to affect the Joyce Kilmer-Slickrock Wilderness Area PSD Class I area, whose nearest border is about 38 miles south-southeast of the ORNL. As stated above for potential HAPs impacts from proposed construction, the intermittent operation of construction emission sources would result in dispersed concentrations of air pollutants at locations offsite ORNL. The substantial transport distance of these emissions to the nearest boundary of the Joyce Kilmer-Slickrock Wilderness Area (about 38 miles) would produce substantial dispersion and would result in negligible concentrations of air pollutants within this pristine Class I area. Therefore, construction of the ORNL VTR Alternative would negligibly affect air quality values within the Joyce Kilmer-Slickrock Wilderness Area pristine Class I area.

4.4.2.2 Operations

Air quality impacts from the operation of the ORNL VTR Alternative would occur from (1) intermittent use of diesel-powered backup electrical generators, (2) intermittent use of propane-fired heaters for the VTR sodium secondary heat transport system during maintenance activities, (3) diesel-powered trucks that deliver material and haul off wastes, and (4) worker commuter vehicles. Generator and heater operations, vehicle trips, and vehicle trip lengths used in the analysis are consistent with metrics developed for proposed VTR activities at ORNL (ORNL 2020c; Leidos 2020).

Factors needed to derive on-road vehicle emission rates were obtained from the EPA MOVES2014b model. To estimate emissions from the proposed backup generators, the analysis assumes that these units would operate at EPA non-road Tier 4 standard levels (EPA 2018a). The backup generators would operate for about four days per year (INL 2020a) within the VTR and hot cell facilities. If used exclusively for emergency replacement or standby service and at this proposed level of annual operation, these generator units would not require a construction or operating permit, as outlined in Chapter 1200-3-9-.04 (Construction and Operating Permits) of the Tennessee Air Pollution Control Regulations. In addition, the potential to emit for the generator units based on 500 hours of operation would produce insignificant emissions (less than 5 tons per year for criteria pollutants and less than 1,000 pounds per year for an individual HAP), as defined in Chapter 1200-03-09 of the Tennessee Air Pollution Control Regulations. Factors needed to estimate emissions for the propane-fired heaters were obtained from the EPA AP-42 document (EPA 2008).

Table 4–8 presents estimates of annual nonradiological emissions that would occur due to operation of the ORNL VTR Alternative. The data in Table 4–8 show that operation of the VTR facilities would result in minimal emissions that would be well below the annual indicator thresholds.

Table 4–8. Annual Nonradiological Operations Emissions – ORNL VTR Alternative

Source-Facility	*Air Pollutant Emissions (tons per year)*						
	VOC	*CO*	*NO_x*	*SO_2*	*PM_{10}*	*$PM_{2.5}$*	*CO_2e (metric tons)*
Back-up Generators	0.05	0.66	0.13	0.001	0.01	0.005	121
Sodium Heaters – Normal Operations	0.000	0.002	0.003	0.000	0.000	0.000	3
Haul Trucks	0.03	0.13	0.45	0.002	0.07	0.02	246
Worker Commuter Vehicles	0.06	7.21	0.39	0.006	0.19	0.03	852
Total– Normal Operations	**0.13**	**8.00**	**0.97**	**0.01**	**0.27**	**0.06**	**1,222**
Sodium Heaters - Large Component Replacement [a]	0.02	0.16	0.27	0.00	0.01	0.01	239
Annual Emissions during LCR Cycle [b]	**0.15**	**8.16**	**1.24**	**0.01**	**0.28**	**0.07**	**1,460**
Annual Indicator Thresholds	**250**	**250**	**250**	**250**	**250**	**250**	**NA**
Exceed Threshold?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; LCR = large component replacement; NA = not applicable; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

[a] LCR would occur every 15 years.

[b] Equal to normal operations plus sodium heaters – LCR.

Note: Due to rounding, sums and products may not equal those calculated from table entries.

Combustion of fossil fuels in operations equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Operation of these sources by the VTR Facility would produce about 0.03 tons per year of combined HAPs emissions (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). The substantial transport distance of these HAPs emissions from the proposed location of the VTR facilities to the nearest locations of the ORNL facility boundary (about 2 miles) would produce HAPs impacts that would not exceed an ambient concentration of concern beyond the ORNL property boundary. In addition, the intermittent operation of delivery and haul trucks and worker commuter vehicles on public roads would result in low concentrations of HAPs at these offsite locations. As a result, HAPs concentrations generated by operations activities would not result in adverse air quality impacts on the public.

Operation of the ORNL VTR Alternative would generate radiological air emissions from processes in the VTR, Test Assembly Examination, and Spent Fuel Storage and Treatment Facilities. All radionuclide sources within these facilities would vent to stacks that would operate with CEM systems and HEPA filters or a series of HEPA filters that have a control efficiency of at least 99.9 percent. Each source of radiological air emissions would operate under a Construction Permit and existing Title V operating permit. An APAD would be performed to ensure compliance with NESHAP, Subpart H. Section 4.10.2 of this EIS presents levels of radiological emissions that would occur from operation of the VTR facilities at ORNL.

Air emissions from operation of the ORNL VTR Alternative would have the potential to affect the Joyce Kilmer-Slickrock Wilderness Area PSD Class I area. The substantial transport distance of minor amounts of operations emissions to the nearest boundary of the Joyce Kilmer-Slickrock Wilderness Area (about 38 miles) would produce substantial dispersion and would result in negligible concentrations of air pollutants within this pristine Class I area. Therefore, operation of the ORNL VTR Alternative would negligibly affect air quality values within the Joyce Kilmer-Slickrock Wilderness Area pristine Class I area.

4.4.3 Reactor Fuel Production Options

4.4.3.1 INL Reactor Fuel Production Options

4.4.3.1.1 INL Feedstock Preparation Option

Construction/Facility Modification

The feedstock preparation option would not require construction of new facilities at the INL Site. The only construction activities would be the build-out of equipment within the FMF, ZPPR, and FCF. Construction activity data developed by INL staff were used to estimate projected construction equipment usages and associated combustive emissions (INL 2020f).

Table 4–9 presents estimates of calendar year nonradiological emissions for construction of the feedstock preparation at the INL site. The analysis assumed that all modifications would occur in calendar years 2024 and 2025. The data in Table 4–9 show that construction under this option would result in minimal emissions that would be well below the annual indicator thresholds.

Combustion of fossil fuels in construction equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Onsite HAPs emissions from construction of the feedstock preparation option at the INL Site would be less than 0.001 tons per year (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). This minimal amount of HAPs emissions from construction would not result in adverse air quality impacts on the public.

Construction activities from the feedstock preparation at the INL site would not generate radiological air emissions.

Table 4–9. Calendar Year Nonradiological Emissions – Construction of Feedstock Preparation Facilities at INL

Calendar Year/Source Type	*Air Pollutant Emissions (tons per year)*						
	VOC	*CO*	*NO_x*	*SO_2*	*PM_{10}*	*$PM_{2.5}$*	*CO_2e (metric tons)*
Year 2024							
Onsite On-road Sources	0.000	0.02	0.002	0.000	0.000	0.000	53
Onsite Non-road Sources	0.000	0.001	0.002	0.000	0.000	0.000	2
Offsite On-road Sources	0.001	0.13	0.01	0.000	0.004	0.001	16
Total Annual Emissions	**0.002**	**0.15**	**0.02**	**0.000**	**0.005**	**0.001**	**20**
Year 2025							
Onsite On-road Sources	0.000	0.02	0.001	0.000	0.000	0.000	3
Offsite On-road Sources	0.001	0.12	0.01	0.000	0.004	0.001	16
Total Annual Emissions	**0.001**	**0.13**	**0.01**	**0.000**	**0.004**	**0.001**	**18**
Annual Indicator Thresholds	**250**	**250**	**250**	**250**	**250**	**250**	**NA**
Exceed Threshold?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; NA = not applicable; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

Note: Due to rounding, sums and products may not equal those calculated from table entries.

Operations

Air quality impacts from the operation of the feedstock preparation facilities at the INL Site would occur from (1) diesel-powered trucks that deliver material and haul off wastes and (2) worker's commuter vehicles. Operation of the INL Site feedstock preparation facilities would not produce any nonradiological emissions from stationary sources. Vehicle trips and associated trip lengths used in the analysis are consistent with the metrics developed for proposed activities at the INL Site.

Table 4–10 presents estimates of annual nonradiological emissions that would occur due to operation of the feedstock preparation at the INL Site. These data show that annual emissions from this scenario would be well below the annual indicator thresholds.

Table 4–10. Annual Nonradiological Operations Emissions from Feedstock Preparation Facilities at the INL Site

Facility	*Air Pollutant Emissions (tons per year)*						
	VOC	*CO*	*NO_x*	*SO_2*	*PM_{10}*	*$PM_{2.5}$*	*CO_2e (metric tons)*
Haul Trucks	0.000	0.000	0.001	0.000	0.000	0.000	1
Worker Commuter Vehicles	0.003	0.39	0.03	0.000	0.01	0.002	248
Total Annual Emissions	**0.003**	**0.39**	**0.03**	**0.000**	**0.01**	**0.002**	**49**
Annual Indicator Thresholds	**250**	**250**	**250**	**250**	**250**	**250**	**NA**
Exceed Threshold?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; NA = not applicable; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

Note: Due to rounding, sums and products may not equal those calculated from table entries.

Combustion of fossil fuels in trucks and worker commuter vehicles also would emit nonradiological HAPs. Onsite HAPs emissions from operation of the feedstock preparation facilities at the INL Site would be less than 0.001 tons per year (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). This minimal amount of HAPs emissions from operations would not result in adverse air quality impacts on the public.

Operation of the feedstock preparation facilities at the INL Site would generate radiological air emissions. INL would develop an APAD for each applicable source of radiological air emissions to ensure compliance with NESHAP, Subpart H. All radionuclide sources within these facilities would vent to stacks that would operate with CEM systems and HEPA filters or a series of HEPA filters that have a control efficiency of at least 99.9 percent. Section 4.10.3.1 of this EIS presents estimates of annual radiological emissions that would occur from the operation of the feedstock preparation at the INL Site.

4.4.3.1.2 INL Fuel Fabrication Option

Construction/Facility Modification

Construction activities for the fuel fabrication would be nearly identical to those associated with the feedstock preparation option. Therefore, emissions estimated for construction of the feedstock preparation, as presented in Table 4–9, would approximate those for construction of the fuel fabrication. As a result, construction of the fuel fabrication at the INL Site would result in minimal emissions that would be well below the annual indicator thresholds.

Combustion of fossil fuels in construction equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Onsite HAPs emissions from construction of the fuel fabrication option at the INL Site would be less than 0.001 tons per year (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). This minimal amount of HAPs emissions from construction would not result in adverse air quality impacts on the public.

Construction activities from the fuel fabrication option at the INL Site would not generate radiological air emissions.

Operations

Operations for the fuel fabrication option at the INL Site would be nearly identical to those associated with feedstock preparation, except that they would include a truck trip to dispose of waste. Therefore, nonradiological emissions estimated for operation of the feedstock preparation option, as presented in Table 4–10, would approximate those for operation of the fuel fabrication option. As a result, operation of the fuel fabrication option at the INL Site would result in minimal nonradiological emissions that would be well below the annual indicator thresholds.

Combustion of fossil fuels in trucks and worker commuter vehicles also would emit nonradiological HAPs. Onsite HAPs emissions from operation of the fuel fabrication at the INL Site would be less than 0.001 tons per year (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). This minimal amount of HAPs emissions from operations would not result in adverse air quality impacts on the public.

Operation of the fuel fabrication at the INL Site would generate radiological air emissions. INL would develop an APAD for each applicable source of radiological air emissions to ensure compliance with NESHAP, Subpart H. All radionuclide sources within these facilities would vent to stacks that would operate with CEM systems and HEPA filters or a series of HEPA filters that have a control efficiency of at least 99.9 percent. Section 4.10.3.1 of this EIS presents estimates of annual radiological emissions that would occur from the operation of the fuel fabrication option at the INL Site.

4.4.3.2 SRS Reactor Fuel Production Options

The air quality analysis estimates air emissions that would result from the construction and operation of the reactor fuel production options at SRS. Aiken and Barnwell Counties that encompasses SRS currently attain all of the NAAQS. Therefore, the analysis used the PSD permitting threshold of 250 tons per year for criteria pollutants as indicators of the significance of projected air quality impacts within the SRS project region.

4.4.3.2.1 SRS Feedstock Preparation Option

Construction/Facility Modification

The feedstock preparation option would not require construction of new facilities at SRS. Construction activities would include the build-out of the equipment locations within an existing facility in the K Area Complex and removal of existing equipment. Construction equipment fuel usages developed by SRS staff were used to estimate projected construction equipment combustive emissions (SRNS 2020). Vehicle trips and associated trip lengths used in the analysis are consistent with the metrics developed for proposed activities at SRS. Construction activities under this option would take about 3 years to complete.

Table 4–11 presents estimates of total emissions for construction of the feedstock preparation capability at SRS. The data in Table 4–11 show that construction of the option would result in total emissions that would be well below the annual indicator thresholds. Therefore, annual emissions from construction of the Scenario would not result in adverse air quality impacts.

Combustion of fossil fuels in construction equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Total onsite HAPs emissions from construction of the feedstock preparation option at SRS would be about 0.01 tons (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). The substantial transport distance of construction emissions from the K Area Complex to the nearest locations of the SRS facility boundary (about 5.5 miles) would result in inconsequential concentrations of HAPs beyond the SRS property boundary. Therefore, the minimal amount of HAPs emissions from construction would not result in adverse air quality impacts on the public.

Table 4–11. Annual Nonradiological Emissions – Construction of Feedstock Preparation Capability at SRS

Source	Air Pollutant Emissions (tons per year)						
	VOC	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$	CO_2e (metric tons)
Onsite On-road Sources	0.02	1.62	0.20	0.00	0.05	0.01	201
Onsite Non-road Sources	0.04	0.85	0.24	0.00	0.02	0.01	57
Offsite On-road Sources	0.05	3.24	0.44	0.00	0.10	0.02	416
Total Annual Emissions	0.11	5.71	0.88	0.01	0.17	0.05	**674**
Annual Indicator Thresholds	**250**	**250**	**250**	**250**	**250**	**250**	**NA**
Exceed Threshold?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; NA = not applicable; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

Note: Due to rounding, sums and products may not equal those calculated from table entries.

It is anticipated that asbestos would be encountered during demolition and renovation (D&R) activities. An inspection would be conducted by a licensed inspector prior to initiation of D&R activities and as needed during D&R to identify asbestos containing materials. D&R activities would comply with NESHAP Subpart M - National Emission Standard for Asbestos, as cited in South Carolina Department of Health and Environmental Control (SCDHEC) Air Pollution Control Regulations and Standards Regulation 61-62.61.

The majority of the material and equipment to be removed are expected to be radiologically clean, with the exception of heavy water tanks and their contents. Construction activities from the feedstock preparation at SRS would not generate radiological air emissions.

Operations

Air quality impacts from the operation of the feedstock preparation option at SRS would occur from (1) intermittent use of a diesel-powered backup electrical generator, (2) diesel-powered trucks that deliver and haul off materials, and (3) worker's commuter vehicles. Generator operations, vehicle trips, and vehicle trip lengths used in the analysis are consistent with metrics developed for proposed activities at SRS (SRNS 2020).

Table 4–12 presents estimates of annual nonradiological emissions that would occur due to operation of the feedstock preparation option at SRS. These data show that annual emissions from operations under this option would be well below the annual indicator thresholds.

Combustion of fossil fuels in operations equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Operation of the feedstock preparation and fuel fabrication option at SRS would generate onsite HAPs emissions of about 0.01 tons per year (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). The substantial transport distance of operations emissions from the K Area Complex to the nearest locations of the SRS facility boundary (about 5.5 miles) would result in inconsequential concentrations of HAPs beyond the SRS property boundary. Therefore, the minimal amount of HAPs emissions from operations would not result in adverse air quality impacts on the public.

Operation of the SRS feedstock preparation facilities would generate radiological air emissions that would approximate those estimated for the INL Site feedstock preparation facilities and are presented in Section 4.10.3.2 of this EIS. All radionuclide sources within these facilities would vent to stacks that would operate with CEM systems and HEPA filters or a series of HEPA filters that have a control efficiency of at least 99.9 percent.

Table 4–12. Annual Nonradiological Operations Emissions for Feedstock Preparation - SRS

	Air Pollutant Emissions (tons per year)						
Source - Facility	***VOC***	***CO***	***NO_x***	***SO_2***	***PM_{10}***	***$PM_{2.5}$***	***CO_2e (metric tons)***
Back-up Generators - VTR	0.02	0.23	0.03	0.0003	0.001	0.00	42
Haul Trucks	0.00	0.01	0.05	0.00	0.01	0.00	29
Worker's Commuter Vehicles	0.07	7.58	0.39	0.01	0.19	0.04	909
Total Annual Emissions	**0.08**	**7.83**	**0.47**	**0.01**	**0.20**	**0.04**	**980**
Annual Indicator Thresholds	**250**	**250**	**250**	**250**	**250**	**250**	**NA**
Exceed Threshold?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; NA = not applicable; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter less than 2.5 microns in diameter; PM_{10} = particulate matter less than 10 microns in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

Note: Due to rounding, sums and products may not equal those calculated from table entries.

4.4.3.2.2 SRS Fuel Fabrication Option

Construction/Facility Modification

Construction activities for the fuel fabrication at SRS would be nearly identical to those associated with the feedstock preparation option. Therefore, emissions estimated for construction of the feedstock preparation, as presented in Table 4–11, would approximate those for construction of the fuel fabrication. As a result, construction of the fuel fabrication at SRS would result in minimal emissions that would be well below the annual indicator thresholds.

Combustion of fossil fuels in construction equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Total onsite HAPs emissions from construction of the fuel fabrication at SRS would be about 0.01 tons (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). This minimal amount of HAPs emissions from construction would not result in adverse air quality impacts on the public.

It is anticipated that asbestos would be encountered during D&R activities. An inspection would be conducted by a licensed inspector prior to initiation of D&R activities and as needed during D&R to identify asbestos containing materials. D&R activities would comply with NESHAP Subpart M - National Emission Standard for Asbestos, as cited in SCDHEC Air Pollution Control Regulations and Standards Regulation 61-62.61.

The majority of the material and equipment to be removed is expected to be radiologically clean, with the exception of heavy water tanks and their contents. Construction activities from the fuel fabrication at SRS would not generate radiological air emissions.

Operations

Operations for the fuel fabrication option at SRS would be nearly identical to those associated with the feedstock preparation options Therefore, nonradiological emissions estimated for operation of the feedstock preparation, as presented in Table 4–12, would approximate those for operation of the fuel fabrication option. As a result, operation of the fuel fabrication at SRS would result in minimal nonradiological emissions that would be well below the annual indicator thresholds.

Combustion of fossil fuels in operations equipment, trucks, and worker commuter vehicles also would emit nonradiological HAPs. Operation of the fuel fabrication at SRS would generate onsite HAPs emissions of about 0.003 tons per year (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). This minimal amount of HAPs emissions from operations would not result in adverse air quality impacts on the public.

Operation of the fuel fabrication at SRS would generate radiological air emissions that would approximate those estimated for operation of the fuel fabrication at the INL Site and presented in Section 4.10.3.2 of this EIS. All radionuclide sources within these facilities would vent to stacks that would operate with CEM systems and HEPA filters or a series of HEPA filters that have a control efficiency of at least 99.9 percent.

4.4.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

4.4.4.1 Construction/Facility Modification

Tables 4–5 and 4–9 present estimates of annual nonradiological emissions that would occur from the construction of the VTR alternative and reactor fuel production options at the INL Site. Summing the data in Tables 4–5 and 4–9 would result in annual construction emissions from the combined activities that would equate to no more than 41 percent of an annual emission indicator threshold for any pollutant. As a result, nonradiological emissions generated by the combined construction activities would not result in adverse air quality impacts.

Onsite HAPs emissions generated from construction of the combined VTR alternative and reactor fuel options at the INL Site would peak in year 2023 at 0.14 tons per year (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). The mobile and intermittent operation of construction emission sources would result in dispersed concentrations of these HAPs adjacent to construction activities. The substantial transport distance of construction emissions from MFC to the nearest locations of the INL Site boundary (about 3 miles) would produce further dispersion and inconsequential concentrations of HAPs beyond the INL Site boundary. In addition, the intermittent operation of construction trucks and worker commuter vehicles on public roads would result in low concentrations of HAPs at these offsite locations. As a result, HAPs concentrations generated by the combined construction activities would not result in adverse air quality impacts on the public.

Construction activities from the INL VTR Alternative would not generate radiological air emissions, as facility modifications within radiological areas would not be expected to increase existing radiological air emissions. Construction activities from the reactor fuel production options at the INL Site would not generate radiological air emissions.

4.4.4.2 Operations

Tables 4–6 and 4–10 present estimates of annual nonradiological emissions that would occur from the operation of the VTR alternative and reactor fuel production options at the INL site. Summing the data in Tables 4–6 and 4–10 would result in annual operations emissions from the combined activities that would equate to no more than 1.6 percent of an annual emission indicator threshold for any pollutant. As a result, nonradiological emissions generated by the combined operations activities would not result in adverse air quality impacts.

Emissions from the combined onsite operations of the VTR alternative and reactor fuel production options at the INL Site would produce about 0.01 tons per year of HAPs emissions (equal to 15 and 3 percent, respectively, of combustive VOC and PM_{10} emissions from diesel equipment). The substantial transport distance of these HAPs emissions from the MFC to the nearest locations of the INL Site boundary (about 3 miles) would produce HAPs impacts that would not exceed an ambient concentration of concern beyond the INL Site boundary. In addition, the intermittent operation of delivery and haul trucks and worker's commuter vehicles on public roads would result in low concentrations of HAPs at these offsite locations. As a result, HAPs concentrations generated by combined operations activities would not result in adverse air quality impacts on the public.

Operation of the VTR alternative and reactor fuel options at the INL Site would generate radiological air emissions from facility processes. INL would develop an APAD for each applicable source of radiological air emissions to ensure compliance with NESHAP, Subpart H. All radionuclide sources within these facilities would be vented to stacks that would operate with CEM systems and HEPA filters or a series of HEPA filters that have a control efficiency of at least 99.9 percent. Section 4.10.4 of this EIS presents estimates of annual radiological emissions that would occur from the operation of the INL VTR Alternative and maximum emissions from the reactor fuel fabrication option (specifically, feedstock preparation) at the INL Site.

Air emissions from operation of the combined VTR alternative and fuel production at the INL Site would have the potential to affect the Craters of the Moon National Monument PSD Class I area. The substantial transport distance of minor amounts of operations emissions to the nearest boundary of the Craters of the Moon National Monument (about 45 miles) would produce substantial dispersion and would result in negligible concentrations of air pollutants within this pristine Class I area. Therefore, operation of the Combined VTR Alternative and INL Reactor Fuel Production Options would negligibly affect air quality values within the Craters of the Moon National Monument pristine Class I area.

4.5 Ecological Resources

Vegetation, wildlife wetlands and aquatic habitat, and rare, threatened, endangered, or sensitive species are the ecological resources at the INL Site and ORNL. Under the Proposed Action, potential impacts on ecological resources could include temporary and permanent disturbance, degradation, or loss of habitat from land clearing activities or disturbance or displacement of wildlife due to an increase in noise and human activity associated with construction. Impacts could also include fragmentation of remaining habitats resulting from project developments and increase in human-wildlife interactions (such as encounters and collisions between wildlife and motor vehicles). Multiple hazards (e.g., accidental spill or disaster) pose a risk for potential deleterious effects on vegetation and wildlife such as decline in species diversity, mortality, growth rate, vigor, and genetic mutations. For the VTR at the INL Site or ORNL, operational accidents are all managed so that no fuel melts and results in negligible releases. A fire involving VTR spent fuel subassemblies in the VTR Experiment Hall is considered extremely unlikely (see Section 4.1.1, Human Health Facility Accidents). Radiological exposure has different effects on ecological resources where some species are more sensitive than others. For the Proposed Action, radiological impacts on human health was used as a measure to determine the need to address the potential impacts on ecological resources. Radiological exposure from the Proposed Action does not differ significantly from current levels, and radiological impacts on human health was determined to be insignificant; therefore, impacts on ecological resources were considered to be minor and were not analyzed in detail. Furthermore, the project design provides additional structures, spill prevention, and management plans (e.g., wastewater discharge, waste management) that would contain and control any spills. Thus, any potential impacts on ecological resources caused from chemical spills are considered minor.

Impact significance for ecological resources is assessed based on intensity of the impact (how severely the resources is affected) and context (what proportion of the resource is affected). Context takes into account the importance of the resources, which is related to such factors as function, condition, and relative scarcity. Significant impacts are considered to occur if activities (e.g., construction) were to take place within important habitat use areas during critical seasons or if permanent habitat disturbance would exceed 1 percent of available similar habitat within the site and surrounding area. Likewise, if construction or operation of the Proposed Action were to cause population-level effects to any species from direct mortality or diminished survivorship, it would be considered significantly impactful. This analysis focuses on wildlife or vegetation types that are important to the function of the ecosystem or are protected under Federal or State law or statute.

Table 4–13 presents a summary of the potential environmental consequences on ecological resources for the INL and ORNL VTR Alternatives and the INL and SRS Reactor Fuel Production Options.

Table 4–13. Summary of Environmental Consequences on Ecological Resources

	VTR Alternatives	
	INL VTR	***ORNL VTR***
Construction	**Area disturbed:** about 100 acres	**Area disturbed:** about 150 acres
Operations	**Area occupied:** about 25 acres Operations would take place in the newly constructed facilities. No additional land disturbance, no additional excavation, therefore no impacts on ecological resources.	**Area occupied:** about 50 acres Operations would take place in the newly constructed facilities. No additional land disturbance, no additional excavation, therefore no impacts on ecological resources.
Discussion	*Vegetation*: Construction would result in a loss of sagebrush habitat. In compliance with the CCA, pre- and post-construction surveys must be completed to establish the amounts of sagebrush restoration and other native revegetation efforts needed to rehabilitate disturbed areas as determined by DOE's ESER contractor. To comply with DOE's policy, the loss of sagebrush from the Proposed Action requires monitoring sagebrush disturbance and planting amounts equal to that disturbed in areas beneficial to sage-grouse. Revegetation of temporary disturbance areas would occur in accordance with annual INL Site Revegetation Assessment program practices (INL/EXT-19-56726). Invasive species management will continue to be implemented at the INL Site. *Wildlife*: Operational and administrative controls would be evaluated and implemented, if warranted, to reduce the potential for adverse effects to wildlife species and human-wildlife interactions. These controls include (but are not limited to) seasonal timing of project activities, enforcing low speed limits, ultrasonic warning whistles to flush wildlife, hazing animals from the road, and preemptive awareness programs for construction crews. Administrative controls would include the posting of speed limit signs, and roping off sensitive areas (such as snake hibernacula and the pygmy rabbit burrow area). Wildlife habitat fragmentation could occur. Land clearing would cause disturbances in the landscape resulting in new habitat edges, potentially disrupting wildlife ecosystem processes and habitats. Infrastructure and traffic could impose dispersal barriers to most non-flying terrestrial animals. *Special status species*: In addition to the operational and administrative controls listed above, construction/land clearing activities that include vegetation removal, occurring from April 1 to October 1 would be controlled to preclude damage to active nests of all MBTA-protected species including waterfowl, corvids (ravens), owls, hawks, eagles, and passerines. 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-	*Vegetation:* Construction would result in a loss of forested habitat, including up to 37 hemlock trees. A forester (as administered by the ORNL Natural Resource Manager) would survey the site to assess the age and value of hemlock trees subject to permanent disturbance, as well as inspect for non-native insect pests prior to construction and/or site clearing activities. Additionally, invasive species management would continue to be implemented through the Invasive Plant Management Program at ORNL. *Wildlife*: 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. These controls include (but are not limited to) seasonal timing of project activities, reduced speed limits, ultrasonic warning whistles, hazing animals from the road, and preemptive awareness programs for construction crews. ONRL would time tree removal to occur outside of times of increased migratory bird activity. Increased activity typically occurs from late March through early August. Wildlife habitat fragmentation could occur. Land clearing would cause disturbances in the landscape resulting in new habitat edges, potentially disrupting wildlife ecosystem processes and habitats. For less mobile species, such as amphibians and insects, there is the potential for impacts on local populations. *Special status species:* If the ORNL VTR Alternative were selected, additional species-specific surveys will need to occur to adequately determine the severity of effects to federally and State-listed special status species from the Proposed Action. Mitigation for federally and State-listed species, aquatic features and sensitive habitats may also be required. Tree removal and other activities would avoid certain times of the year to minimize impacts on species, such as federally and State listed bats and migratory birds. Construction/land clearing activities, including vegetation removal, that occur from April 1 through October 1 would be controlled to preclude damage to active nests of passerines. Work during the migratory bird nesting season (April 1 through October 1) requires a migratory bird nesting survey 72 hours

	grouse, from the proposed project area. A 300-foot buffer would be established around active pygmy rabbit burrow systems to prevent direct impacts. Temporary staging of VTR components, construction equipment, and worker parking would occur outside of this area. Although habitat fragmentation could occur from the loss of sagebrush due to land clearing, sagebrush habitats would be restored elsewhere onsite under the CCA. *Aquatic Resources*: There are no aquatic resources within the proposed project area. Therefore, no impacts on aquatic resources would occur under the INL VTR Alternative.	prior to vegetation disturbance in an area. Any tree removal from April 1 to November 15 may impact roosting sites for federally and State-listed bats. DOE would be required to consult with USFWS and the TWRA and/or TDEC prior to construction and/or site clearing activities. *Aquatic Resources*: Vegetation within the proposed project area is comprised primarily of forested wetland habitats. About 10.5 acres (4.25 hectares) of wetlands, 15,637 feet (4,766 meters) of streams, conveyances and/or channels, and 30 seeps and spring could be impacted. Compliance with all Federal and State (e.g., Exceptional Tennessee Waters) and regulations will occur. A Section 404 wetland permit from USACE must be obtained prior to any construction work within jurisdictional features and compensatory mitigation would be required for any unavoidable impacts.
	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Construction and Operations	No additional land disturbance, no additional excavation, therefore no impacts on ecological resources would occur.	
Discussion	Activities associated with constructing/modifying and operating facilities would occur in existing facilities or adjacent to those facilities on previously developed or disturbed areas. Therefore, no impacts on ecological resources.	
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Discussion	Same as for INL VTR Alternative because minimal or no impacts from fuel fabrication.	

CCA = Candidate Conservation Agreement; ESER = Environmental Science, Education and Research Program; MBTA = Migratory Bird Treaty Act.

4.5.1 INL VTR Alternative

As described in Chapter 3, Section 3.1.5, the ROI for ecological resources under the INL VTR Alternative, includes the MFC facility and surrounding area within the INL Site.

4.5.1.1 Construction/Facility Modification

Vegetation

Under the INL VTR Alternative, potential temporary and permanent impacts on sagebrush steppe habitats would occur as a result of site clearing, excavation, and grading conducted as part of constructing building foundations, roadways, parking areas, and laydown areas. **Table 4–14** presents the permanent and temporary impacts on vegetation communities as a result of the INL VTR Alternative.

Table 4–14. Impacts on Vegetation Communities within the INL VTR Alternative Proposed Project Area

Proposed Project Area	***Vegetation Community***	***Impacted Acreages***
Permanent Impact Area	Cheatgrass Ruderal Grassland	0.07
	Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland	10.37
	Previously disturbed/facilities	17.71
	Total	**28.15**
Temporary Impact Area	Cheatgrass Ruderal Grassland	1.07
	Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland	24.63

Proposed Project Area	Vegetation Community	Impacted Acreages
	Crested Wheatgrass Ruderal Grassland	0.07
	Green Rabbitbrush/Thickspike Wheatgrass Shrub Grassland and Needle and Thread Grassland	24.88
	Previously disturbed/facilities	20.71
	Total	**71.36**
	TOTAL IMPACT AREA	**~100 acres**

Note: Due to rounding, sums and products may not equal those calculated from table entries.

Under implementation of the INL VTR Alternative, development would cause permanent impacts on about 17.7 acres of previously disturbed habitat and 10.4 acres of sagebrush shrublands. Temporary impacts would affect about 20.7 acres of previously disturbed habitat and about 50.6 acres of shrublands and grassland communities (Table 4–13). Temporary impacts on vegetation could occur from the impermanent staging of VTR components, construction equipment, and worker parking for the duration of 51 months. These impacts would be temporary and localized and would not be anticipated to result in long-term or permanent impacts on surrounding vegetation communities. Vegetation would be restored within the staging and parking areas. Initially it would be very difficult to rehabilitate native vegetation similar in species composition, structure, and ecological function to that originally present, but over time the area would be expected to recover and serve similar ecological functions. These impacts on vegetation would account for less than 1 percent (about 0.02 percent) of the 496,877 acres of sagebrush steppe habitat available within the INL Site. However, the DOE implements a 'no net loss of sagebrush habitat' policy on the INL Site under the Candidate Conservation Agreement (CCA) for the sage-grouse. Therefore, impacts would be mitigated.

In compliance with the CCA, the project must complete pre and post-construction surveys to establish the amounts of sagebrush restoration and other native revegetation efforts needed to rehabilitate disturbed areas as determined by DOE's Environmental Science, Education and Research Program (ESER) contractor. To mitigate the loss of sagebrush and comply with DOE policy, the INL VTR Alternative would require monitoring sagebrush disturbance and planting amounts equal to that disturbed in non-project areas that are beneficial to sage-grouse. Replacement of about 36 acres of sagebrush habitat (11.0 acres due to permanent impacts and 25 acres due to temporary impacts) would be required. Revegetation would occur in accordance with annual INL Site Revegetation Assessment program practices (INL/EXT-19-56726). Refer to the *Invasive Species* section below for additional information regarding revegetation of the proposed project area.

Invasive Species

Under the INL VTR Alternative, construction and land clearing activities would potentially increase soil disturbance. Soil disturbance is a primary contributor to the spread of invasive plants and increases in weedy non-native invasive species. As a result, invasive species management and weed control would be necessary to facilitate re-establishment of native communities. Prior to revegetation efforts, the need for a Weed Management Plan will be evaluated and, if warranted, would be developed to establish proactive invasive species management goals. Invasive species management will continue to be implemented under the Proposed Action. INL staff identify and implements BMPs to reduce the need for revegetation efforts during the National Environmental Policy Act (NEPA) process (e.g., minimizing off-road vehicle travel, limiting soil disturbance to previously disturbed areas, mowing vegetation instead of grubbing, etc.). There is also an environmental checklist process to determine when project activities have the potential to result in soil disturbance and to identify when vegetation restoration is required (INL/EXT-19-56726).

Wildlife

Under the INL VTR Alternative, wildlife within the proposed project area could be permanently or temporarily disturbed or displaced due to an increase in noise and human activity associated with construction and/or the loss of habitat from land clearing activities. Noise effects from construction would be short term (lasting the duration of the project construction) and would only affect wildlife in the immediate project areas. Species would likely flush from the area to similar habitat(s) available nearby. Those affected would generally be able to return to the temporarily disturbed areas after project construction completion. While some wildlife might avoid project sites long term, the affected areas would be small compared with other, similar habitats available nearby.

Construction activities could also result in potential collisions between wildlife and motor vehicles. In addition, commuter traffic from facility operation could increase by about 5 percent (Section 4.13.1) and could directly impact species (e.g., snakes) through increased risk of collision over time.

In an effort to minimize potential impacts, the need for operational and administrative controls would be evaluated and implemented, if warranted, to reduce adverse effects to wildlife species. These controls include but are not limited to, daily and seasonal timing of project activities, reduced speed limits, ultrasonic warning whistles, hazing animals from the road, and preemptive awareness programs for construction crews. Administrative controls would include the posting of speed limit signs, and roping off sensitive areas (such as snake hibernacula and the pygmy rabbit burrow area). Increased vehicle activity within the proposed project area could potentially increase the risk for wildlife strikes by vehicles. Mortality to wildlife caused by a collision could be minimized by reducing speeds to less than 15 miles per hour and increasing awareness of construction crews to the presence of any animals that may frequent the area. If an animal is observed in the road, vehicles will stop and wait until the animal leaves the road, and if necessary, encourage the animal to move on by driving forward slowly.

Timing of Project Activities. The following information details sensitive breeding, nesting or generally more active times of wildlife known to occur within or near the proposed project area. Operational controls would be evaluated and implemented, if warranted, to minimize impacts on those species.

- Migratory Bird Treaty Act (MBTA)-protected species: waterfowl, corvids (ravens), owls, raptors (hawks, eagles), and passerine birds: All year. Surface and vegetation disturbing activities should avoid nesting season for the various groups of birds or be preceded by surveys to confirm the absence of nesting birds. Work during the migratory bird nesting season (April 1 through October 1) for passerines requires a migratory bird nesting survey 72 hours prior to vegetation disturbance in an area. Nesting season for owls, hawks, and eagles may begin earlier than passerines, as early as October, and peak nesting season for corvids is from February 1 – July 1. There is one common raven nest located within the proposed project footprint on a met tower. Nest removal and removal of the met tower has not been proposed at this time. The second closest active nest (common raven) is located about 0.97-mile northwest of the proposed project area. Under the Proposed Action, impacts on this nest would be avoided.

- Sage-grouse: March 15 – May 15 from 6 p.m. to 9 a.m. Eliminate human disturbance within 0.6 mile of active leks.

- Pygmy rabbits: All year. To the maximum extent practical areas known to be occupied by pygmy rabbit would be avoided. There is one documented pygmy rabbit burrow system located within the temporary disturbance area. Minimize activity or completely avoid rabbit locations (where practicable) within 300 feet to prevent direct impacts.

- Snakes: May – September. Potential suitable habitat for snakes is present within the sagebrush communities that occur throughout the proposed project area. There is one known hibernaculum (located in the southeast corner of the proposed project area). To avoid or reduce human-snake encounters, the hibernaculum location should be avoided and construction activity should be minimized during the summer active season when snakes are known to occur in high densities (May – early June and September – early October). If construction were to occur during these times, there could be an increased risk of snake mortality and an increase in safety concerns for workers. Construction workers would be encouraged to check dark places before operating machinery, to step on rather than over rocks where a snake may be hiding, and to be extra cautious during cooler times of the day throughout the summer.

Additionally, under the INL VTR Alternative indirect impacts on wildlife from habitat fragmentation could occur. Land clearing would cause disturbances in the landscape resulting in new habitat edges, potentially disrupting wildlife ecosystem processes and habitats. The degree of the loss would depend on the behavior response of the individual species. Infrastructure and traffic could impose dispersal barriers to most non-flying terrestrial animals. To mitigate the loss of sagebrush and comply with DOE policy in accordance with annual INL Site Revegetation Assessment program practices (INL/EXT-19-56), the proposed project would create additional sagebrush habitat that would provide opportunities for wildlife movement. Furthermore, there would be unaffected habitat in the region able to support wildlife movement thus impacts on habitat fragmentation would be limited.

Special Status Species

Land clearing activities within the proposed project area at the INL Site are not anticipated to result in temporary or permanent impacts on federally threatened and endangered species. No federally listed species or designated critical habitats have been recorded within the proposed project area and no federally listed species were observed during surveys conducted in September of 2019 and May of 2020 (Veolia 2019; VNSFS 2020). Additionally, no federally listed species have been historically documented within the INL Site under the ESER Program.

Land clearing activities could result in potential temporary and permanent impacts on State-listed species (such as bats and pygmy rabbits) at the INL Site. Bat roost sites and foraging habitat could be removed during construction and land clearing associated with the MFC; however, there would be no loss of bat hibernacula (or winter habitat). The Proposed Action could result in the direct loss of vegetation and associated indirect impacts on pygmy rabbit habitat. However, impacts are not expected to cause a loss in the local population. The recently (May 2020) documented burrow system is located within the temporary disturbance area, and direct impacts caused by construction activities within 300 feet would be avoided completely to the maximum extent practical. Noise effects from construction would be short term, lasting the duration of the project. Pygmy rabbits use burrows for means of escape and are closely tied to their burrow system; therefore, pre-construction/land clearing surveys would be conducted and any impacts on their burrows would be avoided and mitigated, as necessary. Therefore, no significant impacts on State listed species are expected under implementation of the Proposed Action.

While sage-grouse are known to utilize the INL Site, there are no sage-grouse lek locations within the proposed project area. The closest known active lek is located about 2.7 miles to the east of the proposed project area (see Chapter 3, Figure 3–8). Fecal pellets were observed during the May 2020 survey, indicating recent species presence likely moving between sagebrush habitats (VNSFS 2020). Nesting bird surveys, as indicated in the MBTA permit, would occur prior to any ground disturbance or vegetation removal to confirm the definitive absence of sage-grouse from the proposed project area. Although the sage-grouse does not warrant protection under the Endangered Species Act (ESA), the DOE and U.S. Fish and Wildlife Service (USFWS) continue to collaborate on sage-grouse protection at the INL Site under the CCA (DOE-ID & USFWS 2014). While the proposed project area is not within the established sage-grouse conservation area, the loss of potential suitable habitat is subject to the DOE's "no net loss of sagebrush habitat" policy on the INL Site. In compliance with the CCA, the project must complete pre- and post-construction surveys to establish the amounts of sagebrush restoration and other native revegetation efforts needed to rehabilitate disturbed areas as determined by DOE's ESER contractor. Revegetation of the project site with native grasses would be evaluated and implemented to address soil stabilization and long-term weed control. To mitigate the loss of sagebrush and comply with the DOE's policy, the Proposed Action requires monitoring sagebrush disturbance and planting amounts equal to that disturbed in areas beneficial to sage-grouse. This would include the 11.0 acres of sagebrush habitat within the permanent impact area and the 24.63 acres of sagebrush habitat within the temporary impact area. Although habitat fragmentation could occur from the loss of sagebrush because of land clearing, sage-brush habitats would be restored elsewhere onsite under the CCA.

Under the Proposed Action, breeding bird monitoring would continue to occur. DOE-ID has a USFWS MBTA *Special Purpose Permit* for limited nest relocation and destruction and the associated take of migratory birds if deemed absolutely necessary for mission-critical activities. The permit would be applied in very limited and extreme situations where no other recourse is practicable (INL 2019c). In accordance with the USFWS Mitigation Policy, DOE would be required to evaluate ways to avoid or minimize any such impacts during construction and operation of the proposed facilities. The addition of manmade features could entice wildlife, such as nesting birds. For example, the construction of new facilities could attract swallows to newly available eaves and overhangs where swallows like to build mud nests. To prevent swallows and other birds from building nests in newly constructed facilities, INL would take the following proactive steps:

- Install a physical barrier, such as bird netting under eaves and overhangs;
- Use of sound deterrents such as swallow distress calls; and/or
- Use of visual deterrents, such as flash tape, predator eye balloon and/or reflective eye diverters.

As previously discussed above under *Wildlife*, the need for operational and administrative controls would be evaluated and implemented, if warranted, and would include employing time of year restrictions during land clearing activities. Suitable bird nesting habitat is present throughout the proposed project area. Construction/land clearing activities, including vegetation removal, that occur from April 1 to October 1 would be controlled to preclude damage to active nests of passerines. Work during the migratory bird nesting season (April 1 through October 1) for passerines requires a migratory bird nesting survey 72 hours prior to soil or vegetation disturbance in an area. Nesting season for owls, hawks, and eagles may begin earlier than passerines, as early as October, and peak nesting season for corvids is from February 1 – July 1. Nesting bird surveys, as indicated in the MBTA permit, would occur prior to any ground disturbance or vegetation removal. If surveys discover active nests, the project would implement measures, such as creating suitable buffer areas around active nests or halting work, to prevent nest failure or abandonment until young have fledged.

The annual MFC Breeding Bird Survey Route intersects with the proposed project area, including both temporary and permanent disturbance areas (Figure 3-8). As a result, future annual routes may need to be modified accordingly. Therefore, impacts on migratory birds (including Birds of Conservation Concern [BCC] species) would be minimized and implementation of the Proposed Action would not result in any significant impacts.

No bald or golden eagles are known to nest in or near the proposed project area. Therefore, impacts on bald eagles are not expected to occur.

Aquatic Resources

There are no aquatic resources located within the proposed project area. Therefore, no impacts on aquatic resources are expected to occur under implementation of the Proposed Action.

Wildfire

Under the INL VTR Alternative, land clearing activities could cause disturbance to soil, which could indirectly promote the invasion of weeds that may alter the fire regime. An increase in weedy species can lead to high fuel loads (dense, dry vegetation) and generally lead to increased fire intensity and risk for a wildfire. As previously discussed under *Invasive Species*, invasive species management will continue to be implemented under the Proposed Action. Restoration and other native revegetation efforts would be evaluated and employed, if warranted, to rehabilitate the disturbed areas (as determined by DOE's ESER contractor). Revegetation of the project site with native grasses would be recommended to address soil stabilization and long-term weed control. Additionally, wildland fire management will continue to be employed at the INL Site to reduce the risk of wildfire and prevent any additional losses of sagebrush habitats.

4.5.1.2 Operations

As presented in Table 4–13, the VTR and associated facilities would occupy about 25 acres during operations. The 25 acres of land within the footprint of the completed VTR complex would be occupied by facilities, parking areas, walkways and roads, or revegetated. Operation of the VTR and associated facilities would not involve ground disturbance and therefore would have little additional impact on ecological resources, other than those previously described for construction/facility modification.

4.5.2 ORNL VTR Alternative

As described in Chapter 3, Section 3.2.5, the ROI for ecological resources under the ORNL VTR Alternative, includes ORR and the Melton Valley Site.

4.5.2.1 Construction/Facility Modification

Vegetation

Under the ORNL VTR Alternative, potential temporary and permanent impacts on vegetation could occur because of land clearing, excavation, and grading conducted as part of constructing building foundations, roadways, parking areas, and laydown areas. An estimated 144.8 acres of forested-hardwood areas (including 0.6 acres of early successional forest and 15.3 acres of mature forest) would be impacted under the Proposed Action. Additionally, about 2.5 acres of previously disturbed areas as well as 4.0 acres of right-of-way areas would be developed. The western portion (15.3 acres) of the proposed project area is mature forest (not subject to pine salvage during 1965-1966) that was used in 1960s and 1970s as an ORNL Ecological Field Area. Furthermore, the ORNL VTR Alternative could affect various special and sensitive natural resource areas (i.e., NA, RA, and HA) recognized in the NERP; thus impacting long-term research opportunities and on-going studies that have occurred within these unique habitats.

Additionally, up to 37 hemlock trees (among the largest trees on ORNL) could be removed. In Tennessee, hemlock trees are voluntarily protected as part of the Hemlock Conservation Partnership (TWRF 2018). If the ORNL VTR Alternative were selected, a forester (as administered by the ORNL Natural Resource Manager) would survey the site to assess the age and value of trees, as well inspect for non-native insect pests prior to construction and/or site clearing activities. If warranted, additional coordination between the ORNL Natural Resource Manager and the Hemlock Conservation Partnership would occur.

These impacts on vegetation would account for less than one percent (about 0.6 percent) of the 24,000 acres of forested-hardwood habitat and less than one percent (about 0.98 percent) of the 4,100 acres of interior forest within the ORNL. These impacts on vegetation from the ORNL VTR Alternative would generally be considered minor due to the availability of forested-hardwood habitats within the 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 on vegetation and may entail greater acreage than available elsewhere on ORNL (ORNL 2020d).

Invasive Species

Under the ORNL VTR Alternative, construction and land-clearing activities could potentially increase soil disturbance. Soil disturbance is a primary contributor to the spread of invasive plants and increases in weedy non-native species. As a result, invasive species management and weed control would be necessary to facilitate re-establishment of native communities. ORNL is proactive in the effort to prevent and control invasive species. Prior to revegetation efforts, the need for a *Weed Management Plan* would be evaluated and, if warranted, would be developed to establish invasive species management goals. This plan, as well as invasive species management, would continue to be implemented through the Invasive Plant Management Program under the Proposed Action.

Wildlife

Under the ORNL VTR Alternative, wildlife within the proposed project area could potentially be disturbed or displaced (permanently or temporarily) due to the loss of habitat from land clearing activities, an increase in noise, and human activity associated with construction and/or operations. Construction activities could also result in potential collisions between wildlife and motor vehicles. In addition, commuter traffic from facility operation could increase by about 5 percent (Section 4.13.2) and could directly impact species through increased risk of collision over time.

In an effort to minimize potential impacts, operational controls would be implemented by ORNL to reduce the possibility for adverse effects to wildlife species. These controls include (but are not limited to) seasonal timing of project activities, reduced speed limits, ultrasonic warning whistles, hazing animals from the road, and preemptive awareness programs for construction crews. Wildlife strikes by vehicles may occur when animals are present in roadways. Mortality may be minimized by reducing speeds to less than 15 miles per hour and increasing awareness of construction crews to the presence of any animal that might frequent the area. If an animal is observed in the road, vehicles will stop and wait until the animal leaves the road, and if necessary, encourage the animal to move on by driving forward slowly.

In addition to the potential for temporary wildlife disturbance during construction activities, vegetation removal could represent long-term habitat loss to wildlife as well as cause habitat fragmentation. Land clearing would cause disturbances in the landscape resulting in new habitat edges, potentially disrupting wildlife ecosystem processes and habitats. For less mobile species, such as amphibians and insects, loss of habitat could cause mortality and potentially impact local populations. Additional surveys, accounting for seasonal patterns of wildlife within the proposed project area, would be needed to determine the extent of projected loss to species. 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 on wildlife habitat, specifically to sensitive species.

Infrastructure and traffic could impose dispersal barriers to most non-flying terrestrial animals. Trees and other vegetation subject to clearing could support foraging, nesting, and other behaviors for mammals, birds (including migratory birds and BCC), amphibians, and reptiles. In an effort to avoid impacts on nesting birds, ORNL would time tree removal, to the extent practicable, to occur outside of migratory bird activity. Increased activity typically occurs from late March through early May (refer to section *Special Status Species* below for a more detailed discussion of migratory birds).

While any habitat loss could potentially adversely affect individual animals, the amount of impacted habitat would be relatively small (less than 1 percent) compared to similar habitat available within the ORNL and intermountain regions of Appalachia. It is expected that noise effects would be short term and would only affect wildlife in the immediate vicinity of the project. Those affected would generally be able to return to the area(s) after completion of construction and land clearing activities. While some wildlife might avoid the project sites long-term, the affected areas would be small compared with other, similar habitat available nearby.

Overall, population-level effects to wildlife species are not expected. Under the Proposed Action, species monitoring and management for the area would continue to be implemented through the *Wildlife Management Plan for the Oak Ridge Reservation* (ORNL 2020e).

Special Status Species

Under the ORNL VTR Alternative, direct and indirect impacts on federally and State-listed species could potentially occur due to construction and tree clearing activities associated with the Proposed Action. If the ORNL VTR Alternative were selected, additional species-specific surveys would be required to account for the seasonal patterns of various species (federally and State-listed plants and wildlife) to adequately determine the severity of effects to special status species from the Proposed Action. DOE would be required to consult with the USFWS Tennessee Ecological Services Field Office under Section 7 Interagency Cooperation regarding potential impacts on federally listed species protected under the ESA. Additionally, DOE would be required to consult with the Tennessee Wildlife Resources Agency (TWRA) and/or TDEC regarding State listed species of special concern.

Land clearing activities, including tree removal and any changes to hydroperiods, may affect special status bat and salamander species and their habitats (such as caves and underlying karst and aquatic subterranean habitat). Past surveys have identified multiple federally and State-listed species and special use habitats (such as nearby caves) within the vicinity of the proposed project area. Additional surveys would be required and would need to be conducted at specific times of the year for the various sensitive plant and wildlife species (Tables 3-22 and 3-23) to determine the level of impact. Species-specific survey protocols could be required as directed through consultations with the USFWS, U.S. Army Corps of Engineers (USACE), TWRA, and/or TDEC prior to work.

Mitigation for federally and State-listed species, aquatic features and sensitive habitats may also be required. Some species, such as federally and State-listed bats (e.g., Indiana bat, northern long-eared bat, gray bat, little brown bat, tricolored bat, small-footed bat), birds (e.g., wood thrush), amphibians (e.g., four-toed salamander), migratory birds, USFWS BCC and USFWS BMC would require tree removal and other activities to be avoided during certain times of the year. DOE would be required to consult with the USFWS about the potential impacts of construction and operation of from the proposed VTR and associated facilities action on migratory birds, bats, and amphibians. In accordance with the USFWS Mitigation Policy, DOE would be required to evaluate ways to avoid or minimize any such impacts during construction and operation of the proposed VTR land clearing activities (DOE 1999b). Construction/land clearing activities, including vegetation removal that occur from April 1 to October 1 would be controlled to preclude damage to active nests of passerines. Nesting season for owls, hawks, and eagles may begin earlier than passerines, as early as October. Work during the bird nesting season requires a migratory bird nesting survey 72 hours prior to vegetation disturbance in an area. If surveys discover active nests, the project would implement measures, such as creating suitable buffer areas or halting work, to prevent nest failure or abandonment until after the bird nesting season or until young have fledged. Any tree removal from April 1 to November 15 may impact foraging habitat and roosting sites for federally and State-listed bats. Direct impacts on amphibians (e.g., four-toed salamander) and suitable habitats may also be greater at certain times of the year. Implementation of studies and ongoing monitoring under the

ORNL management plan (ORNL 2020e) as well as pre-construction/ land clearing and species-specific protocol surveys will document occurrence of federally and State-listed species and necessary measures will be incorporated to minimize and avoid impacts on these species.

No bald or golden eagles are known to nest in or near the proposed project area. The nearest recorded active bald eagle nest is about 2 miles northeast of the site. Therefore, impacts on bald eagles or sensitive nesting habitats are not likely to occur. If bald or golden eagles appear to be nesting near (within 1 mile) the proposed project area prior to the initiation of construction-related activities, DOE would be required to obtain a permit if disturbance or relocation was determined to be necessary.

Aquatic Resources

Under the ORNL VTR alternative, direct and indirect impacts on aquatic resources could potentially occur due to construction and land clearing activities associated with the Proposed Action.

Direct impacts could include permanent habitat loss and/or alternation of the land due to construction and excavation activities. Indirect impacts could include temporary changes to hydrology from land-clearing activities, disruption of the soil profile, loss of vegetation, introduction of pollutants, creation of new impervious surfaces, and an increased rate or volume of runoff after major storm events. Generally, impacts can be avoided or minimized to a level of insignificance if proper construction techniques, erosion control measures, and structural engineering designs are incorporated.

Potential indirect impacts from proposed construction could result in additional sediment loads being transported to surface waters in the project vicinity. Additional sediment loads would be managed by appropriately designed conveyance structures (e.g., channels and culverts) in accordance with site-specific engineering standards that take into consideration surface water drainage within, adjacent to, and downstream of the project. In addition, surface water runoff control measures would be incorporated into the design. These measures would help to avoid or minimize conflicts with city, county, State, or Federal regulations and would prevent adversely affecting adjacent properties and/or the project area. These measures could include the use of porous materials, directing runoff to permeable areas, and use of detention basins to release runoff over time. All necessary permits, including a NPDES permit for stormwater discharges, would be obtained prior to construction. Refer to Section 4.3 *Water Resources* for a detailed discussion on impacts on groundwater, surface water, and stormwater resources.

Under the ORNL VTR Alternative aquatic features (e.g., channels, tributaries, drainages, catchments, seeps, springs, or wetlands) would be impacted. Vegetation within the proposed project area is comprised primarily of forested wetland habitats. About 10.5 acres (4.25 hectares) of wetlands, likely considered Exceptional Tennessee Waters (ETW), 15,637 feet (4,766 meters) of streams, conveyances and/or channels, and 30 seeps and active springs could be affected by the Proposed Action. These streams and channels are associated with creeks (e.g., Melton Branch and Bearden Creek) that flow into major rivers. Many of these areas are included in various ecological monitoring research and remediation activities thus long-term biological monitoring and research at ORNL would be impacted (ORNL 2020d).

If the ORNL VTR Alternative were selected, additional assessment would be required. Minimally, this would include wetland delineations (USACE 1987), stream evaluations (TDEC 2019a), and hydrologic determinations of currently unclassified channels and wet weather conveyances (TDEC 2020a). Any potential ETW would require additional assessment using the Tennessee Rapid Assessment Method, as required by the TDEC. Evaluation of aquatic resources at proposed mitigation sites might also be required to assess adequate mitigation actions (TDEC 2015, 2019a). A Section 404 wetland permit must be obtained from USACE prior to any construction work within jurisdictional features, and compensatory mitigation would be required for any unavoidable impacts. Mitigation ratios are broadly defined as 2:1 for restoration, 4:1 for creation/enhancement, and 10:1 for preservation and for ETW, TDEC equivalent quality habitat within the same watershed be placed into permanent conservatorship (preservation) and at rates higher than non-ETW (ORNL 2020d). Additional effort would be required to assess the full scale of impacts and to determine appropriate mitigation strategies given the number, complexity, and quality of aquatic resources (i.e., wetlands, streams, and conveyances). The ORNL Natural Resources Program is equipped for such assessment should the project proceed (ORNL 2020d).

Natural Areas

Under the ORNL VTR Alternative, direct and indirect impacts on eight natural areas within the ORR could potentially occur due to construction and land-clearing activities associated with the Proposed Action (NA14, 15, 17, 26, 30; RA10, 11; and HA1). Impacts on the ecological resources (vegetation, wildlife, special status species, and aquatic resources) within these areas would be the same as those previously described in the sections above.

If the ORNL VTR Alternative were selected, additional species specific surveys will need to occur to adequately determine the severity of effects to federally and State-listed special status species. Mitigation for federally and State-listed species, aquatic features and sensitive habitats may be required.

4.5.2.2 Operations

As presented in Table 4–13, the VTR and associated facilities would occupy about 50 acres during operations. The 50 acres of land within the footprint of the completed VTR complex would be occupied by facilities, parking areas, walkways and roads, or revegetated. Operation of the VTR and associated facilities would involve no ground disturbance and therefore would have little additional impact on ecological resources, other than those previously described for construction/facility modification.

4.5.3 Reactor Fuel Production Options

4.5.3.1 The INL Site Reactor Fuel Production Options

As described in Chapter 2, Section 2.6.2, modification and operation of the INL Site's MFC facilities to fabricate reactor fuel for the VTR would occur within existing buildings with no additional land disturbance. Therefore, no impacts on ecological resources would occur from these activities and are not discussed further in this section.

4.5.3.2 SRS Reactor Fuel Production Options

4.5.3.2.1 Construction/Facility Modification

Vegetation

Under the SRS options, activities associated with constructing/modifying and operating facilities in the K Area Complex would occur in previously developed or disturbed areas. No natural vegetation communities (such as forested areas) would be disturbed. If warranted, revegetation of the grass and landscaped areas that may be temporarily disturbed would be conducted as directed by the natural resource manager to minimize the potential for invasive species. Therefore, no significant impacts on vegetation would occur under implementation of the SRS options.

Wildlife

The areas planned for development within the K Area are highly disturbed yet create minimal habitat for urban adapted wildlife species. Noise resulting from constructing/modifying and operating facilities in support of the fuel fabrication option would be localized, short-term, and only occur during daylight hours. Although a small number of wildlife species could occur in the grass areas (generally those tolerant of human presence and activity) during construction, the limited habitat decreases the ecological value of the site. Additionally, all construction would be conducted consistent with the *Natural Resources*

Management Plan for the Savannah River Site (DOE 2019f). Therefore, no significant impacts on wildlife would occur under implementation of the SRS Options.

Special Status Species

No impacts on special status species would occur under the SRS fuel production options. No federally or State-listed species occur within the proposed project area and activities associated with constructing/modifying and operating facilities in the K Area Complex would occur in previously developed or disturbed areas. Noise resulting from constructing/modifying and operating facilities in support of the fuel fabrication option would be localized, short-term, and only occur during daylight hours. Additionally, all construction would be conducted consistent with the *Natural Resources Management Plan for the Savannah River Site* (DOE 2019f).

Under the SRS fuel production options, no impacts on migratory birds (including BCC) would occur as no habitats occur within the proposed project area. Bald eagle and golden eagles have been observed throughout the SRS; however, no nests are known to occur within or in the immediate vicinity (within 1 mile) of the K Area. Therefore, no impacts on bald eagles or sensitive nesting habitats would occur under the SRS Reactor Fuel Production Options.

4.5.3.3 Operations

As described in Chapter 2, Section 2.6.3, modification and operation of K Area Complex to fabricate fuel for the VTR would occur within existing buildings with no additional land disturbance. Therefore, no impacts on ecological resources would occur from these activities and are not discussed further in this section.

4.5.4 Combined INL VTR Alternative and the INL Site Reactor Fuel Production Options Impacts

Because there would be little or no ecological impacts from construction and operation of the fuel production capability at the INL Site, the impacts of the combined activities would be essentially the same as the impacts of the INL VTR Alternative alone as previously described in Section 4.5.1.

4.6 Cultural and Paleontological Resources

This section discusses the potential impacts on cultural resources of the VTR alternatives and reactor fuel production options. The INL and ORNL ROIs for cultural resources evaluation would include the land that would be disturbed by VTR facility construction, and buffer immediately adjacent with potential effects to setting of adjacent historic properties. For SRS, the ROI would be the K-Reactor Building. Facility construction and land disturbance would occur within undeveloped areas of the INL Site and ORNL. Only facility modifications would occur at SRS. No impacts on cultural resources would occur from facility construction and land disturbance (the INL Site and ORNL) or from facility modifications (the INL Site and SRS).

Table 4–15 presents a summary of the potential environmental consequences on cultural and paleontological resources for the INL and ORNL VTR Alternatives and the INL and SRS Reactor Fuel Production options.

Table 4–15. Summary of Environmental Consequences on Cultural Resources

Resource Area	VTR Alternatives	
	INL VTR	***ORNL VTR***
Cultural and Paleontological Resources	*Construction*: No impacts on significant cultural and paleontological resources would occur from facility construction and land disturbance. *Operations*: No impacts on significant cultural and paleontological resources would occur from facility operations.	*Construction*: No impacts on significant cultural and paleontological resources would occur from facility construction and land disturbance. *Operations*: No impacts on significant cultural and paleontological resources would occur from facility operations.
	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Cultural and Paleontological Resources	**Feedstock Preparation**	
	Construction: No impacts on significant cultural and paleontological resources as modifications/construction would occur in existing facilities (FCF) and not require construction of new facilities at the MFC. 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 CRMP (INL 2016f:51). *Operations*: No impacts on significant cultural and paleontological resources as feedstock preparation activities would occur in existing facilities at the MFC. 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 CRMP (INL 2016f:51).	*Construction*: No impacts on significant cultural and paleontological resources as modifications/construction would occur in existing facilities (in the K Area Complex) and not require construction of new facilities. *Operations*: No impacts on significant cultural and paleontological resources as feedstock preparation activities would occur in existing facilities in K Area.
	Fuel Fabrication	
	Construction: No impacts on significant cultural and paleontological resources as modifications/construction would occur in existing facilities (FMF and ZPPR) and not require construction of new facilities at the MFC. 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 CRMP (INL 2016f:51). *Operations*: No impacts on significant cultural and paleontological resources as fuel fabrication activities would occur in existing facilities at the MFC. 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 CRMP (INL 2016f:51).	*Construction*: No impacts on significant cultural and paleontological resources as modifications/construction would occur in existing facilities (in the K Area Complex) and not require construction of new facilities in K Area. *Operations*: No impacts on significant cultural and paleontological resources as fuel fabrication activities would occur in existing facilities in K Area.
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Cultural and Paleontological Resources	*Construction:* No impacts on significant cultural and paleontological resources would occur from facility construction and land disturbance. 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 CRMP (INL 2016f:51). *Operations:* No impacts on significant cultural and paleontological resources would occur from facility operations.	

4.6.1 INL VTR Alternative

4.6.1.1 Construction/Facility Modification

No impacts on significant cultural resources are anticipated to result from construction and facility modification for the proposed VTR at the INL Site. An intensive archeological survey was conducted across 167 acres that include the 138-acre area of potential effect (APE). The investigation identified five pre-contact cultural resources, but none of the resources were determined to meet the threshold of significance for listing in the National Register of Historic Places (NRHP).

Four buildings within the MFC facility have been proposed for modification to support fabrication of VTR reactor fuel: the Hot Fuels Examination Facility (HFEF), the Fuel Conditioning Facility (FCF), ZPPR, and FMF. Internal reconfiguration activities within these existing MFC facilities, in which additional equipment would be installed for proposed post-irradiation testing, spent fuel treatment, and fuel fabrication, are exempt from cultural resource review by agreement among INL, the Idaho State Historic Preservation Officer (SHPO), the Advisory Council on Historic Preservation (ACHP), and the Shoshone-Bannock Tribes (INL 2016f:51). The proposed activities would not compromise the integrity of these architectural resources. The Experimental Fuels Facility may also be used for testing VTR Fuel cladding. However, no modifications are anticipated, and similar work is currently being performed in the facility.

Visual, auditory, and atmospheric effects that may be imposed by the proposed undertaking on architectural properties within the MFC facility were considered. While noise levels may increase and there would likely be higher concentrations of dust particles in the air during construction, these impacts would be short term in duration. The new construction's visual impacts would be more permanent; however, the addition of VTR is consistent with the facility's historic function as a prime testing center for advanced technologies associated with nuclear energy power systems. MFC consists of a 90-acre developed area, which includes an undeveloped security perimeter. Structures include analytical laboratories and other facilities, which tend to be one- or two-story, block concrete buildings with towers and holding tank structures interspersed. The new construction design (Chapter 1, Figure 1) repeats the basic elements of form, line, color, and texture found within the existing building components and will not diminish the integrity of setting for any historic or potentially historic property located within the MFC complex. Construction of VTR and the proposed building modifications will have no effect on any historic properties.

There are no traditional cultural properties or sacred sites identified within the 138-acre APE for the Proposed Action. Therefore, impacts on these resources are not anticipated.

4.6.1.2 Operations

No impacts on ethnographic, cultural, and paleontological resources at the INL Site are anticipated to result from operations of the proposed VTR. Six existing facilities within the MFC at the INL Site are proposed for use in operations of the VTR, including post-irradiation testing and spent fuel treatment. Internal reconfiguration of active laboratories or other experimental or testing properties that accommodate new experiments or tests are considered exempt activities on the INL Site (INL 2016f:51). Therefore, no impacts on historic properties would result from this alternative.

In compliance with Section 106 of the National Historic Preservation Act (NHPA), DOE has initiated consultation with the Idaho State Historic Preservation Officer (SHPO); federally recognized tribes; and interested parties regarding its determination of effects for the proposed construction and operations of VTR at INL. If necessary, DOE would develop management actions and mitigation measures to resolve any adverse effects prior to implementing the Proposed Action.

4.6.2 ORNL VTR Alternative

4.6.2.1 Construction/Facility Modification

No impacts on cultural and paleontological resources at ORNL are anticipated to result from construction and facility modification for the proposed VTR. Although the 150-acre proposed area of potential disturbance has not been surveyed for cultural resources, there are no known NRHP-listed or -eligible archaeological or architectural resources within the APE for VTR facilities construction.

There is one cemetery potentially eligible for the NRHP within the 0.25-mile viewshed APE, which could be within visual range of the proposed new VTR facility. The cemetery is identified as the Friendship Baptist Church Cemetery. While the siting and massing of the proposed VTR are significant, it would not diminish the characteristics that make the cemetery potentially eligible for the NRHP. The minor change to the setting would not change the character or use of the cemetery. The minimal increase in visual elements introduced by the undertaking would not diminish the integrity of the cemetery's significant historic attributes and would not alter the characteristics that could qualify it for inclusion in the NRHP. Therefore, the proposed construction of VTR and subordinate buildings and structures would cause no adverse effect to the historic cemetery.

There are no traditional cultural properties or sacred sites identified within the 150-acre APE for direct physical effects for the Proposed Action. Therefore, impacts on these resources are not anticipated.

4.6.2.2 Operations

No impacts on ethnographic, cultural, and paleontological resources at ORNL are anticipated to result from operations of the proposed VTR. There are no known NRHP-listed or -eligible or architectural resources within the APE for VTR facilities construction.

If the ORNL VTR Alternative were selected and prior to any land disturbing activities, DOE would comply with Section 106 of the NHPA by consulting with the Tennessee Historical Commission, which acts as the SHPO; federally recognized tribes; and interested parties regarding potential effects for the proposed construction and operations of VTR at ORNL. If necessary, DOE would develop management actions and mitigation measures to resolve any adverse effects prior to implementing the Proposed Action.

4.6.3 Reactor Fuel Production Options

4.6.3.1 INL Reactor Fuel Production Options

Under the INL fuel production options, the VTR fuel fabrication process would be located in the existing FMF, FCF, and ZPPR. Installation of new equipment in existing space at FMF, FCF, and ZPPR would not impact ethnographic, cultural, and paleontological resources at the INL Site. Therefore, there would be no impacts on these resources at the INL Site under these fuel production options.

4.6.3.2 SRS Reactor Fuel Production Options

Under the SRS fuel production options, the VTR fuel fabrication process would be located in the K-Reactor Building (Building 105-K) in the K Area Complex. Building 105-K is not eligible for listing on the NRHP. Installation of new equipment in existing space would not involve ground disturbances outside the existing facility, and thus would not impact ethnographic, cultural, and paleontological resources at SRS. Therefore, there would be no impacts on these resources at SRS under these fuel production options.

4.6.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

Because there would be no impacts on ethnographic, cultural, and paleontological resources at the INL Site under the INL Reactor Fuel Production Options, combined impacts on cultural resources at the INL Site would be as described for the INL VTR Alternative.

4.7 Infrastructure

This section discusses the potential impacts associated with energy use and utility infrastructure for the ROI at each location. For the INL Site this would include overall capacities at the INL Site, MFC, and for the proposed VTR site associated with the alternatives. For ORNL, this would include ORNL, the proposed VTR Site, and portions of ORR. For SRS, the ROI would include the K Area Complex and SRS. Section 4.13, Traffic, addresses potential impacts on transportation infrastructure (i.e., roads and rails).

This section also evaluates increased demand and infrastructure modifications for the Proposed Action and compares them to the current operation of each location in the following areas:

- Consumption of electricity and fuel
- Changes to water, gas, and electrical systems
- Impacts from the consumption of electricity, fuel, and other resources would result if demand exceeds existing capacity at a given location. Impacts on utility infrastructure would occur if the existing infrastructure were insufficient to support the alternatives during either the construction or operational phase. **Table 4–16** summarizes potential environmental consequences on infrastructure.

Table 4–16. Summary of Environmental Consequences on Infrastructure

	VTR Alternatives	
Resource Area	***INL VTR***	***ORNL VTR***
Infrastructure	***Construction***: Some MFC infrastructure would be allocated during the 51-month construction period. But building requirements would not place excessive demand on existing systems at the INL Site or MFC. Construction electricity usage projected to be 1,000,000 KWh average annual value with annual peak value of 2,000,000 KWh. Diesel fuel usage would total 2,300,000 gallons. Total water usage during construction projected to be 128 million gallons. ***Operations***: VTR utility demands would be supplied by existing MFC utility systems. With the exception of electricity, no modifications to the MFC utility systems would be required to support the addition of the VTR. Operations at VTR are projected to use 150,000 MWh per year of electricity, 18,500 cubic feet of propane per year, and 4.4 million gallons of water per year. Some modifications of the existing electrical system at MFC would be required to handle the loads generated by VTR operations, including the installation of a dynamic volt amperage reactive device at the ATR and MFC (to ensure voltage stability).	***Construction***: Some ORNL infrastructure would be allocated during construction period but would not place excessive demand on existing systems at ORNL. Resources required would include not only those for the construction of facilities, but also the resources required for site preparation in a previously undisturbed, wooded area. Construction electricity usage projected to be 1,300,000 KWh average annual value with annual peak value of 2,600,000 KWh. Diesel fuel usage would total 3,300,000 gallons. Total water usage during construction projected to be 172 million gallons. ***Operations***: VTR utility demands (electricity, water, etc.) would be supplied by existing ORNL utility systems. As the proposed VTR is located in a previously undeveloped area, about 1 mile east of the HFIR, connections and modifications would need to be made to nearby ORNL infrastructure. Some new infrastructure would be required. Once connected, no modifications to the ORNL utility systems would be required to support the addition of the VTR. Operations at VTR are projected to use 180,000 MWh per year of electricity, 18,500 cubic feet of propane per year, and 4.4 million gallons of water per year.

	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Infrastructure	**Feedstock Preparation**	
	Construction: Use of existing facilities (e.g., FCF) and infrastructure at MFC. Minimal allocation of electricity, water, and other resources at MFC well below existing capacities.	*Construction*: Use of existing infrastructure would be well below capacity (build out of the equipment locations within K-Reactor Building). Electric use during construction would be minimal; Total water use during construction would be about 9.0 million gallons.
	Operations: Use of existing infrastructure within the FCF would be well below existing capacities. Electric demand would be 6,700 MWh per year and water usage would average 1.4 million gallons per year.	*Operations*: Use of existing infrastructure within K-Reactor Building would be well below existing capacities. Electric demand would be 6,700 MWh per year and water usage would average 1.4 million gallons per year.
	Fuel Fabrication	
	Construction: Use of existing facilities (FMF and ZPPR) and infrastructure at MFC. Minimal allocation of electricity, water, and other resources at MFC well under existing capacities.	*Construction*: Use of existing infrastructure would be well below capacity (build out of the equipment locations within K-Reactor Building). Electric use during construction would be minimal and about 9.0 million gallons of water would be used.
	Operations: Use of existing infrastructure within FMF and ZPPR would be well below existing capacities. Electric demand would be 8,300 to 13,300 MWh per year and water usage would average 0.88 million gallons per year.	*Operations*: Use of existing infrastructure within K-Reactor Building would be well below existing capacities. Electric demand would be 8,300 to 13,300 MWh per year and water usage would average 1.4 million gallons per year.
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Infrastructure	*Construction*: Additional impacts from fuel fabrication construction would be minimal in scale for most resources when compared to impact from VTR construction, therefore, impacts would be similar to those described for the VTR. *Operations*: Fuel fabrication operations would add an additional 8,300 to 13,300 MWh per year and 2.4 million gallons of water over VTR operations.	

4.7.1 INL VTR Alternative

4.7.1.1 Construction/Facility Modification

Construction of the VTR at the INL Site is estimated to occur over a 51-month period in a previously undeveloped area southeast of the MFC. During construction, an incremental and temporary increase in energy demand at existing MFC facilities may result due to the use of equipment and tools. Minimal utilization of existing INL Site infrastructure (e.g., electric, water) would be expected during the construction phase. It is assumed that the majority of energy expenditure will result from materials procured from offsite vendors and brought to the construction site by contractors. **Table 4–17** provides a summary of fuel and other resources that would be committed to construction of the VTR. These requirement projections assume the construction effort would ramp up until peaking in the third year.

Table 4–17. Resource Requirements During Construction of VTR at the INL Site

Resource	*Units*	*Annual Average Value*	*Annual Peak Value*	*Total* [a]
Electricity	KWh	1,000,000	2,000,000	4,300,000
Gasoline	gallons	87,000	145,000	370,000
Diesel Fuel				
Road Diesel	gallons	84,000	144,000	360,000
Non-Road Diesel	gallons	447,000	750,000	1,900,000
Total Diesel	gallons	531,000	894,000	2,300,000

Resource	Units	Annual Average Value	Annual Peak Value	Total [a]
Water				
Potable	gallons	8,000,000	16,000,000	34,000,000
Dust control, etc.	gallons	22,000,000	40,000,000	94,000,000
Total Water	gallons	30,000,000	56,000,000	128,000,000

FTE = full-time equivalent (person); KWh = kilowatt-hour.
[a] Total amount or resource used over 51-month construction period.
Note: Due to rounding, sums and products may not equal those calculated from table entries.
Source: INL 2020f.

4.7.1.2 Operations

Under the conceptual design for the VTR, existing infrastructure, including utilities and waste management facilities, would be used to support construction and operation of the VTR. While some modifications and upgrades to the infrastructure would be necessary during the construction phase, the current infrastructure should be largely adequate to support the VTR. When operations begin at the VTR, the facility will add to the overall infrastructure demands of the MFC. Specific estimated resource requirements for operation of the VTR are given in **Table 4–18**.

Table 4–18. Annual Resource Requirements for Operation of VTR at the INL Site

Resource	Units	Value
		Annual
Electricity	MWh	150,000
Diesel Fuel [a]	gallons	9,200
Propane [b]	cubic feet	18,500
Water		
Potable	gallons	2,400,000
Fire water	gallons	1,700,000
Demineralized Water	gallons	250,000
Total Water	gallons	4,400,000

MWh = megawatt-hour.
[a] Diesel generators would operate 1 percent of the time, 88 hours per year.
[b] Propane heaters are an alternative design for preheating air in the sodium to air heat exchangers. Use of this alternative design would be a site-specific decision. These heaters would be used for short periods when the reactor is shutdown following a test cycle. 1.5 million standard cubic feet would be used in years of peak usage (associated with an extended maintenance outage, projected to be needed once every 15 years).
Source: INL 2020f.

As the proposed VTR is located in a previously undeveloped area, connections and modifications would need to be made to existing infrastructure at MFC to provide electricity, water, and other needed services to the VTR, including the following:

Electricity: The proposed VTR complex has been estimated to require an additional 16.2 MW of electrical power annually (150,000 MWh/year). The existing transmission line can accommodate that additional power need, however, to prevent fluctuations in the voltage when the VTR is brought on- or off-line, a dynamic volt amperage reactive device will be included in the design of the MFC power distribution system. To provide longer-term power need, upgrades to the existing INL Site 13.8 kV transmission loop would be required. Two near-term actions are recommended for the INL Site power grid before 2022, including renegotiation of the power provider contract and installation of additional cooling capabilities on an Antelope substation transformer. An analysis of long-term options for power is under consideration for implementation by 2021. These options could include installation of a dynamic volt amperage reactive device at the Advanced Test Reactor (ATR) and MFC (to ensure voltage stability), construction of a 138-kV line between the ATR and MFC, construction of a 138-kV line between Scoville and the Test Area North, and conversion of the existing loop to 230 kV (Wayment et al. 2019).

Fire System/Potable Water: Average annual water usage at VTR is projected to be 4.4 million gallons per year. The existing deep well and pumps currently at the MFC would adequately support new demands from the VTR complex. Two options have been explored for fire/potable water routing from MFC to the proposed VTR site: 1) a new loop around the VTR site with new 12-inch and 10-inch water mains, providing 2 supply connections, and 2) completing the existing fire water loop around the east side of the MFC plant and provide a loop around the VTR site. Because the MFC water system is a combination of fire and potable water and the fire water demands are significantly higher, the existing system would be able to meet the potable water demands for the VTR facilities (INL 2017c).

Sanitary Sewer: Existing wastewater lagoons have been assessed to not have the capacity to store and treat flows from the existing MFC, VTR, and the future projects planned for the west side of MFC. The existing lagoons, built in 2012, were based on a buildout to the year 2020. Although the lagoons do not appear to have adequate capacity for a buildout of the year 2030, they have been assessed to be able to handle the volumes generated by the proposed VTR facilities. Calculations for the VTR and support facilities indicate that anticipated average daily flow would be 3,250 gallons per day, with an average daily flow of 2.4 gallons per minute. This assumes that no industrial waste flows will be routed into the sanitary sewer system or eventually into existing lagoons (INL 2017c).

Industrial Wastewater: New 6-inch gravity industrial wastewater lines will convey industrial wastewater from the VTR complex and tie-into an existing 6-inch pipe located near MFC-789. The VTR would produce industrial wastewater that would be required to be conveyed to a proper location for treatment. While the exact flows from the facility are not available, it is assumed that the facility would produce less than 1 million gallons per year. Therefore, the addition of industrial wastewater from the VTR facilities would not exceed the allowed flows permitted by the Idaho Department of Environmental Quality (INL 2017c).

Telecommunications: A telecommunications connection would need to be routed from existing facilities at MFC. The completion of the West Campus Utility Corridor Project would allow a tie-in point with available duct structure to install fiber and copper cabling from MFC-1728 to the VTR area. Two options have been explored for this routing, each of which would add two 144-count fiber optic cables and two 200-pair copper cables from MFC-1728 at two strategic locations that would serve as distribution or connectivity points for VTR buildings (INL 2017c).

4.7.2 ORNL VTR Alternative

4.7.2.1 Construction

Under the conceptual design for the VTR, existing ORNL infrastructure would need to be extended to the proposed VTR site. The location selected for the VTR is relatively undeveloped and does not have sufficient infrastructure to support construction and operation of the VTR. Existing waste management facilities within ORNL would be used to support waste management during the construction of the VTR. The environmental resources required or affected by construction of the VTR at ORNL would include not only the construction of necessary facilities, but also the resources required for site preparation in an undisturbed, wooded area. Specific estimated additional resource requirements for site preparation and construction of the VTR at ORNL are presented in **Table 4–19.**

Table 4–19. Resource Requirements During VTR Construction at ORNL

Resource	*Units*	*Annual Average Value*	*Annual Peak Value*	*Total* [a]
Electricity	KWh	1,300,000	2,600,000	5,600,000
Gasoline	gallons	110,000	190,000	480,000
Diesel Fuel				
Road Diesel	gallons	110,000	190,000	540,000
Non-Road Diesel	gallons	580,000	980,000	2,700,000
Total Diesel	gallons	690,000	1,170,000	3,300,000
Water				
Potable	gallons	10,000,000	20,000,000	52,000,000
Dust control, etc.	gallons	29,000,000	52,000,000	120,000,000
Total Water	gallons	39,000,000	72,000,000	172,000,000

KWh = kilowatt-hour.

[a] Total amount or resource used over 51-month construction period; site preparation duration of about 10 months; includes 5 months for tree removal and 5 months for site grading.

Source: INL 2020f.

4.7.2.2 Operations

Prior to operations beginning at VTR, 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 to support VTR operation. Existing waste management facilities within ORNL would support waste management during operation of the VTR. VTR utility demands would be supplied by existing ORNL utility systems. Additional infrastructure systems (e.g., electricity, wastewater) would need to be extended from nearby ORNL infrastructure or built new. Once connected, no modifications to the ORNL utility systems would be required to support the addition of the VTR. When operations begin at the VTR, the facility would add to the overall infrastructure demands of the ORR. The environmental resources required for operation of the VTR at ORNL would be the same as those described for the INL Site in 4.7.1.2 and are shown in **Table 4–20.**

Table 4–20. Annual Resource Requirements for operation of VTR at ORNL

Resource	*Units*	*Value*
		Annual
Electricity	MWh	180,000
Diesel Fuel [a]	gallons	11,900
Propane [b]	cubic feet	18,500
Water		
Potable	gallons	2,400,000
Fire water	gallons	1,700,000
Demineralized water	gallons	250,000
Total	gallons	4,400,000

MWh = megawatt-hour.

[a] Diesel generators would operate 1 percent of the time, 88 hours per year.

[b] Propane heaters are an alternative design for preheating air in the sodium to air heat exchangers. Use of this alternative design would be a site-specific decision. These heaters would be used for short periods when the reactor is shutdown following a test cycle. 1.5 million standard cubic feet would be used in years of peak usage (associated with an extended maintenance outage, projected to be needed once every 15 years).

Source: INL 2020f.

As the proposed VTR site is located in a previously undeveloped area about one mile southeast of the ORNL, connections and modifications would need to be made to existing infrastructure at ORNL to deliver electricity, water, and other needed services to the VTR, including the following:

Electrical: The proposed VTR complex has been estimated to require an additional 16.2 MW of electrical power annually (180,000 MWh/year at ORNL). While there are two 13.8 kV feeders near the proposed VTR siting area, the maximum capacity of each feeder is about 12 MW and there is currently not enough capacity to support loads that would be required by the VTR. In order to support this load, a new overhead feeder would have to be constructed from a nearby substation.

Fire System/Potable Water: Average annual water usage at VTR is projected to be about 4.4 million gallons per year. System capacity at ORNL is about 1,460 million gallons per year, with usage of an average of 730 million gallons per year from 2017 to 2019. Water supply to the proposed VTR site would be attained by extending the current existing 16-inch potable water pipeline that supplies water to High Flux Isotope Reactor (HFIR) and Radiochemical Engineering Development Center and the backup 12-inch water line that follows Melton Valley Drive.

Sanitary Sewer: Calculations for the VTR and support facilities indicate that anticipated Average Daily Flow would be 3,250 gallons per day, with an average daily flow of 2.4 gallons per minute. This assumes that no industrial waste flows will be routed into the sanitary sewer system or eventually into existing lagoons (INL 2017c). These flows would be well below ORNL's sanitary wastewater treatment plant current system capacity of 300,000 gallons per day.

Industrial Wastewater: The VTR would produce industrial wastewater that will be required to be conveyed to a proper location for treatment. While the exact flows from the facility are not available, it is assumed that the facility will produce less than 1 million gallons per year (INL 2017c). The existing industrial wastewater system at ORNL is not allowing new piping system connections; therefore, the proposed VTR site would need to be put on a new industrial wastewater system.

4.7.3 Reactor Fuel Production Options

4.7.3.1 INL Reactor Fuel Production Options

4.7.3.1.1 INL Feedstock Preparation Option

Construction/Facility Modification

Under this option, the VTR feedstock preparation activities would occur in existing facilities at the FCF. The only construction activities, occurring over a 3-year period, would be associated with the feedstock preparation facility and are limited to modifications to the FCF needed to convert space from its current purpose to feedstock preparation. **Table 4–21** gives a summary of the key resources committed to these construction activities.

Table 4–21. Resource Requirements for Feedstock Preparation Facility Construction at the INL Site

Resource	*Units*	*Value*	
		Annual Average	*Total* [a]
For Modifications to Existing Facilities			
Electricity	KWh	Minimal [b]	Minimal
Diesel Fuel			
Forklift Fuel [c]	gallons	-	32
Mobile Crane Diesel [d]	gallons	-	120
Total Diesel	gallons	-	150

Resource	Units	Value	
		Annual Average	Total [a]
Water			
Potable	gallons	75,000	230,000
Construction Area Cleaning	gallons	1,700	5,000
Total	gallons	76,700	235,000

KWh = kilowatt-hour.

[a] Construction duration of 3 years is assumed.

[b] Electrical use is limited to hand held or cordless hand tools and occasional welding.

[c] Assuming 40 hours of operation and fuel consumption of 0.8 gallons per hour of operation.

[d] Assuming 30 hours of operation and fuel consumption of 4 gallons per hour of operation.

Source: INL 2020f.

Operations

Under this option, feedstock preparation capabilities currently located at FCF would be relocated to the existing facilities at MFC. Usage of electricity and other infrastructure would be well within the existing capacities of the individual facilities and the MFC. **Table 4–22** gives a summary of the key resources committed to the preparation of feedstock at the VTR.

Table 4–22. Resource Requirements for Feedstock Preparation Facility Operations at the INL Site

Resource	Units	Value
		Annual
Electricity	MWh	6,700
Diesel Fuel		
Diesel (Centerra) [a]	gallons	1,500
Diesel (Operations) [a]	gallons	2,000
Total Diesel	gallons	3,500
Water		
Potable [b]	gallons	1,400,000

MWh = megawatt-hour.

[a] Diesel fuel for one additional security vehicle (Centerra) and an additional diesel generator (Operations).

[b] Water use provided as gpm, converted to annual assuming 10-hour workdays, 5 days a week, and 50 weeks per year.

4.7.3.1.2 INL Fuel Fabrication Option

Construction/Facility Modification

Under this option, the VTR fuel fabrication process at the INL Site would be located in existing facilities at MFC (FCF, FMF, and ZPPR). The only construction activities, occurring over a 2-year period, would be the build out of the equipment locations in the FMF, ZPPR, and FCF. **Table–23** provides a summary of the key resources committed to the construction of a fuel fabrication facility.

Table 4–23. Resource Requirements for Fuel Fabrication Facility Construction at the INL Site

Resource	Units	Value	
		Annual Average	Total [a]
For Modifications to Existing Facilities			
Electricity	KWh	Minimal [b]	minimal
Diesel Fuel			
Forklift Fuel [c]	gallons	—	32
Mobile Crane Diesel [d]	gallons	—	120
Total Diesel	gallons	—	152

Resource	Units	Value	
		Annual Average	Total [a]
Water			
Potable	gallons	75,000	230,000
Construction Area Cleaning	gallons	1,700	5,000
Total	gallons	76,700	235,000

KWh = kilowatt-hour.
[a] Construction duration of 3 years is assumed.
[b] Electrical use is limited to hand held or cordless hand tools and occasional welding.
[c] Assuming 40 hours of operation and fuel consumption of 0.8 gallons per hour of operation.
[d] Assuming 30 hours of operation and fuel consumption of 4 gallons per hour of operation.
Source: INL 2020f.

Operations

Under this option, the VTR fuel fabrication process at the INL Site would be located in existing facilities at MFC (FCF, FMF, and ZPPR). Usage of electricity and other infrastructure would be well within the existing capacities of the individual facilities and the MFC. **Table 4–24** provides a summary of the key resources committed to the operation of a fuel fabrication facility.

Table 4–24. Resource Requirements for Fuel Fabrication Facility Operations at the INL Site

Resource	Units	Value
		Annual
Electricity	MWh	8,300 – 13,300
Water		
Potable	gallons	880,000
Cleaning	gallons	1,000
Total Water	gallons	881,000

MWh = megawatt-hour.
Source: INL 2020f.

4.7.3.2 SRS Reactor Fuel Production Options

4.7.3.2.1 SRS Feedstock Preparation Option

Construction/Facility Modification

Under this option, no new facilities would be constructed at SRS. The capability would be located adjacent to the location for the fuel fabrication capability, in the K Area Complex, primarily at the -20-foot level (20 feet below grade). Key annual resource commitments for the operation of the feedstock preparation facility are provided in **Table 4–25**.

Table 4–25. Resource Requirements for Feedstock Preparation Facility Construction at SRS

Resource	Units	Value	
		Annual Average	Total [a]
For Modifications to Existing Facilities			
Electricity	KWh	minimal	minimal
Diesel Fuel	gallons	1,500	4,500
Gasoline	gallons	2,500	7,500
Water			
Potable	gallons	1,000,000	3,000,000
Construction	gallons	2,000,000	6,000,000
Total Water	gallons	3,000,000	9,000,000

Resource	Units	Value	
		Annual Average	Total [a]
Wastewater Treatment	gallons	1,000,000	3,000,000

KWh = kilowatt-hour.
Source: SRNS 2020.

Operations

The feedstock processing capability at SRS would be located adjacent to the location for the fuel fabrication capability, in the K Area Complex, and the process equipment would be located at the minus-20-foot level at the minus-40-foot level. **Table 4–26** provides a summary of the key resources committed to the feedstock preparation option at SRS.

Table 4–26. Resource Requirements for Feedstock Preparation Facility Operations at SRS

Resource	Units	Value
		Annual Average
For Modifications to Existing Facilities		
Electricity	MWh	6,700
Diesel (Centerra) [a]	gallons	1,500
Diesel (Operations) [a]	gallons	2,000
Water Supply [b]	gallons	1,400,000
Wastewater Treatment	gallons	1,400,000

MWh = megawatt-hour.
[a] Diesel fuel for one additional security vehicle (Centerra) and an additional diesel generator (Operations).
[b] Water use provided as gpm, converted to annual assuming 10-hour workdays, 5 days a week, and 50 weeks per year.
Source: SRNS 2020.

4.7.3.2.2 SRS Fuel Fabrication Option

Construction/Facility Modification

Under this option, no new facilities would be constructed at SRS. The only construction activities would be the build-out of the equipment locations within an existing facility in the K Area Complex and the removal of existing equipment. Construction is assumed to require 3 years. The fuel fabrication facility would be located on the minus-20- and minus-40-foot levels (20 and 40 feet below grade) of the Building 105-K. **Table 4–27** provides a summary of the key resources committed to the construction of a fuel fabrication facility at SRS.

Table 4–27. Resource Requirements for Fuel Fabrication Facility Construction at SRS

Resource	Units	Value	
		Annual Average	Total [a]
For Modifications to Existing Facilities			
Electricity	KWh	minimal	minimal
Diesel Fuel	gallons	1,500	4,500
Gasoline	gallons	2,500	7,500
Water			
Potable	gallons	1,000,000	3,000,000
Construction	gallons	2,000,000	6,000,000
Total Water	gallons	3,000,000	9,000,000

KWh = kilowatt-hour.
Source: SRNS 2020.

Operations

The fuel fabrication facility would be located on the minus-20- and minus-40-foot levels (20 and 40 feet below grade) of the Building 105-K. Although the VTR modifications have not been designed, based on similar K Area upgrade projects, the space needed for support facilities for the needed HVAC, fire suppression, etc., are expected to be substantial. At least one and possibly two of the adjacent 108-K buildings could be needed for these support operations. Key annual resource commitments for the operation of the fuel fabrication facility are provided in **Table 4–28**.

Table 4–28. Fuel Fabrication Facility Resource Requirements at SRS

Resource	*Units*	*Value*
		Annual
Electricity	MWh	8,300 – 13,300
Diesel (Centerra) [a]	gallons	3,000
Diesel (Operations) [a]	gallons	4,000
Water Supply	gallons	1,400,000
Wastewater Treatment	gallons (thousands)	1,400,000

MWh = megawatt-hour.
[a] Diesel fuel for one additional security vehicle (Centerra) and an additional diesel generator (Operations).
Source: SRNS 2020.

4.7.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

Table 4–29 outlines the total infrastructure usage for the combined construction of the VTR facility and the addition of fuel production equipment at the MFC. For many resources (e.g., electricity) the contribution of construction for fuel production equipment is negligible when compared to annual allocations for the construction of the VTR.

Table 4–29. Annual Resource Requirements for Combined INL VTR Alternative and Reactor Fuel Production Facility Options Construction at the INL Site

Resource	*Units*	*Annual Average Value*	*Annual Peak Value*	*Total*
Electricity [a]	KWh	1,000,000	2,000,000	4,300,000
Gasoline	gallons	87,000	145,000	370,000
Diesel Fuel				
Road Diesel	gallons	84,000	144,000	360,000
Non-Road Diesel	gallons	447,000	750,000	1,900,152
Total Diesel	gallons	531,000	894,000	2,300,152
Water				
Potable	gallons	8,550,000	16,000,000	24,460,000
Dust control, etc.	gallons	22,003,400	40,000,000	94,010,000
Total Water	gallons	30,553,400	56,000,000	128,470,000

FTE = full-time equivalent (person); KWh = kilowatt-hour.
[a] Negligible increase in electric use from fuel fabrication.
Source: INL 2020f.

Table 4–30 outlines the total infrastructure usage for the combined operations of the VTR facility and the fuel fabrication option at the MFC. For many resources (e.g., electricity) the contribution of fuel fabrication operations negligible when compared to annual allocations for operation of the VTR.

Table 4–30. Annual Resource Requirements for Combined INL VTR Alternative and Reactor Fuel Production Facilities Operations at the INL Site

Resource	*Units*	*Value*
		Annual
Electricity	MWh	180,000
Diesel Fuel [a]	gallons	12,700
Propane [b]	cubic feet	18,500
Water		
Potable Water	gallons	4,680,000
Other (e.g., fire, demineralized, cleaning)	gallons	1,950,000
Total Water	gallons	6,630,000

MWh = megawatt-hour.

[a] Diesel generators would operate 1 percent of the time, 88 hours per year.

[b] Current plan is to use electric heaters; propane heaters are included as an alternate.

Source: INL 2020f.

4.8 Noise

To evaluate impacts from noise and vibration, DOE considered the potential for noise and vibration levels to change as a result of the Proposed Action alternatives. Considerations of the potential changes in noise and vibration include new mobile and stationary sources from activities associated with construction and operation of the VTR alternatives and reactor fuel production options. For the purposes of this environmental consequences analysis the Proposed Action alternatives and No Action Alternative would result in adverse noise and vibration effects if the project were to cause any of the following:

- Conflict with any Federal, State, or local noise ordinances;
- Long-term perceptible increase in ambient noise levels above regulatory thresholds at sensitive receptors during operations; or
- Excessive ground-borne vibration to persons or property.

Adverse impacts would occur if noise and vibration from construction or operation were to cause harm or injury to adjacent communities or sensitive receptors (i.e., residences, schools, hospitals), or exceed applicable environmental noise limit guidelines.

This EIS uses aerial mapping to identify the closest noise and vibration sensitive receptors within the ROI. The analysis estimates and assesses the impact of noise and vibrations at these receptors during construction, normal operations, and maintenance activities. **Table 4–31** summarizes potential environmental consequences on noise and vibration.

Table 4–31. Summary of Environmental Consequences on Noise and Vibration

<table>
<tr><th rowspan="2">Resource Area</th><th colspan="2">VTR Alternatives</th></tr>
<tr><th>INL VTR</th><th>ORNL VTR</th></tr>
<tr><td rowspan="2">Noise</td><td>Construction:
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.
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.</td><td>Construction:
Estimated noise levels at the closest receptor (6,750 feet) would be about 47 dBA.
Operations:
Noise and vibration levels would be similar to other existing equipment at ORNL and would not impact offsite receptors.</td></tr>
<tr><td colspan="2">Discussion: Due to the large distance from the site and receptors, impacts would be minimal.</td></tr>
<tr><td rowspan="2">Vibration</td><td>Construction and Operations:
Ground-borne vibration due to typical construction and operational activities is expected to be below the threshold of human perception</td><td>Construction and Operations:
Ground-borne vibration due to typical construction and operational activities is expected to be below the threshold of human perception</td></tr>
<tr><td colspan="2">Discussion: Due to the large distance from the site and receptors, impacts would be minimal.</td></tr>
<tr><th rowspan="2"></th><th colspan="2">Reactor Fuel Production Options</th></tr>
<tr><th>INL Reactor Fuel Production</th><th>SRS Reactor Fuel Production</th></tr>
<tr><td rowspan="4">Noise and Vibration</td><td colspan="2">Feedstock Preparation and Fuel Fabrication</td></tr>
<tr><td>Construction:
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>Construction:
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="2">Operations:
Operational noise and vibration would be contained within the building and not perceptible at the boundary.</td></tr>
<tr><td colspan="2">Discussion: Due to the large distance from the site and receptors, impacts would be minimal.</td></tr>
<tr><th></th><th colspan="2">Combined INL VTR Alternative and INL Reactor Fuel Production Options</th></tr>
<tr><td>Noise and Vibration</td><td colspan="2">Construction: 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.
Operations: 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></tr>
</table>

dBA = decibels A-weighted.

4.8.1 INL VTR Alternative

Implementation of the INL VTR Alternative would result in short-term impacts of noise and vibration from construction of the new VTR facility and spent fuel pad facility modifications required for the post-irradiation examination and spent fuel treatment facilities. Potential operational noise and vibration impacts are described below.

4.8.1.1 Construction/Facility Modification

Construction of the INL VTR Alternative would have temporary adverse effects to noise and vibration. Construction activities would cause temporary increases in ambient noise levels in the immediate vicinity of the construction sites. Construction noise levels are rarely steady in nature, but instead fluctuate depending on the number and type of equipment in use at any given time. There would be times when no large equipment would be operating and noise would be at or near ambient levels. In addition, construction-related sound levels would vary by distance.

DOE anticipates a total duration of 60 months for construction from site mobilization to completion of startup. Major construction activities (e.g., foundations, structures, etc.) would require about 33 months. Onsite construction noise would mainly occur from site preparations, clearing and grading, construction of the new facility, vehicle traffic and other associated construction activities, including the use of heavy-duty construction equipment (e.g., trucks, backhoes, front-end loaders, cranes, etc.). **Table 4–32** presents typical construction equipment (mobile and stationary) and the corresponding typical noise emissions levels.

Table 4–32. Estimated Construction Noise from Construction Activities

Equipment [a]	*Typical Noise Level at 50 Feet (dBA)*	*Typical Noise Level at 500 Feet (dBA)*	*Typical Noise Level at 1,000 Feet (dBA)*	*Typical Noise Level at 1,500 Feet (dBA)*
Front Loaders	85	65	59	55
Backhoes, excavators	80	60	54	50
Tractors, dozers	85	65	59	55
Graders, scrapers	89	69	63	59
Trucks	88	68	62	58
Concrete pumps, mixers	85	65	59	55
Cranes (movable)	83	63	57	53
Generators	81	61	55	51
Compressors	81	61	55	51
Pneumatic tools	85	65	59	55
Compactors	82	62	56	52
Blasting	94	74	68	64
Horizontal Directional Drilling	82	62	56	52

dBA = decibels A-weighted.

Source: FHWA 2006; Lamancusa 2009; DOT 2012.

In general, average equivalent noise levels from typical construction sites range from 79 to 89 decibels A-weighted (dBA) at 50 feet (Bolt et al. 1971). Construction noise levels fluctuate depending on the type, number, and duration of use of heavy equipment for construction activities. Construction noise differs by the type of activity, distance to noise-sensitive uses, existing site conditions (vegetation to buffer sound) and ambient noise levels. With multiple items of construction equipment operating concurrently, noise levels could be relatively high during daytime periods at locations within several hundred feet of active construction sites. Accounting for the concurrent use of the construction equipment, noise levels could be conservatively estimated to about 83 dBA at 100 feet (DOT 2012, 2018). Combined construction noise reduces to about 63 dBA at 1,000 feet (Lamancusa 2009; DOT 2018). Other construction noise would occur from transportation-related activities, including workers' vehicle trips and materials and waste trucks. In addition to the standard construction activities, current project plans anticipate blasting would occur during the construction period. Blasting has a maximum noise level that could potentially reach 94 dBA (FHWA 2006). Using typical noise reductions over a distance, noise levels due to blasting would reduce to 68 dBA at 1,000 feet and 40 dBA at the closest noise-sensitive receptor. The proposed INL VTR Alternative site is about 2.9 miles from the INL Site boundary and 5.0 miles from the closest noise-sensitive receptor (i.e., home/farm site). Given the large distance, estimated construction noise would be indistinguishable to the closest noise-sensitive receptor. As a result, noise levels would remain within applicable noise regulation standards, as described in Section 3.1.8.2.

Similar to human sensitive receptors, wildlife can experience noise and vibration impacts from human activities. Stress, avoidance of feeding, and loss of breeding success can result from elevated noise and vibration exposure to species. Section 4.5.1.1 considers these noise effects on wildlife species in the immediate project area. In addition, because the INL Site is designated as a NERP, construction noise could temporarily disturb research studies and wildlife species if located in proximity to the proposed project. But impacts would be short-term and limited to construction activities.

As discussed in Section 3.1.8.3, the closest Federal and State parks are over 40 miles away from the construction area. The closest recreational area is Middle Butte about 7.5 miles southwest. Due to the long distance between the proposed construction and closest parks, construction noise is anticipated to be imperceptible at these locations.

To reduce potential impacts due to construction noise, contractors would try to limit construction to occur primarily during normal weekday business hours, and would properly maintain construction equipment mufflers.

Ground-borne vibration would be present during construction from site preparations, HDD, blasting, traffic, and other associated construction activities. Construction vibration would be temporary during construction and could be transient (e.g., single impact equipment), random (e.g., heavy construction equipment) or continuous (e.g., HDD). However, due to the distance to the nearest sensitive noise receptors, ground-borne vibration is expected to be below the threshold of human perception (refer to Section 3.1.8.1). As a result, impacts would not be expected.

4.8.1.2 Operations

Operation of the INL VTR Alternative would involve equipment that would emit noise and vibration levels typical of industrial activities. Operation would involve continuously operated equipment such as heat exchanger fans, HVAC condensing units and exhaust fans, in addition to intermittently or infrequently used equipment, such as compressors and standby diesel generators. Most equipment would be indoors or inside noise enclosures to reduce noise levels. Outdoor equipment (i.e., HVAC fans and compressors), employee vehicle trips, and routine maintenance activities involving trucks or other maintenance equipment would be perceptible in the immediate vicinity of the facility. Operation of the proposed VTR would add to baseline noise levels from existing operational equipment resulting in concurrent noise emissions. Section 3.1.8.3 describes the variation in baseline noise levels at the INL Site, including the recent noise measurements for existing facilities that are typically operated at the INL Site (e.g., the nearby MFC) and the estimated noise levels for the surrounding uninhabited, rural land. The noise generated from the proposed VTR would be consistent with other existing industrial equipment at the INL Site and the potential concurrent noise would be similar to existing levels at the INL Site. As a result, operation of the VTR and existing equipment would not impact offsite receptors.

Given the distance from the proposed site to the INL Site boundary (2.9 miles) and to the closest offsite noise-sensitive receptor (5.0 miles), operational noise and vibration would not be perceptible at the closest noise-sensitive receptor. As a result, the INL VTR Alternative would not cause a change in noise environment.

4.8.2 ORNL VTR Alternative

Implementation of the ORNL VTR Alternative would result in short-term impacts on noise and vibration from construction of the new VTR facility, post-irradiation examination facility, and spent fuel storage pad and operational noise and vibration impacts as described below.

4.8.2.1 Construction/Facility Modification

Construction of the ORNL VTR Alternative would have temporary adverse effects to noise and vibration. Construction activities would cause temporary increases in ambient noise levels in the immediate vicinity of the construction sites. Construction noise levels are rarely steady in nature, but instead fluctuate depending on the number and type of equipment in use at any given time. There would be times when no large equipment is operating and noise would be at or near ambient levels. In addition, construction-related sound levels would vary by distance.

Construction activities and associated noise levels would be similar to the levels estimated in Section 4.8.1.1 and Table 4–32. As discussed in Section 4.8.1.1, average equivalent noise levels from typical construction sites range from 79 to 89 dBA at 50 feet (Bolt et al. 1971). Construction noise levels fluctuate depending on the type, number, and duration of use of heavy equipment for construction activities, and differ by the type of activity, distance to noise-sensitive uses, existing site conditions (vegetation to buffer sound), and ambient noise levels. The closest noise-sensitive receptor to the ORNL VTR Alternative is a home site located about 6,750 feet from the construction area. Using typical noise reductions over a distance, this analysis conservatively estimated a combined construction level of about 89 dBA at 50 feet would reduce to about 47 dBA at 6,750 feet (closest receptor) (Lamancusa 2009; DOT 2018). Other construction noise would occur from transportation-related activities, including workers' private vehicle trips and site materials and waste trucks. In addition, if blasting would be required during construction, noise levels due to blasting could reach about 51 dBA at the home site that is 6,750 feet from the construction area.

Similar to human sensitive receptors, wildlife can experience noise and vibration impacts from human activities. Stress, avoidance of feeding and loss of breeding success can result from elevated noise and vibration exposure to species. Section 4.5.2.1 considers these noise effects on wildlife species in the immediate project area.

As described in Section 3.5.1.2, Anderson and Knox Counties have established residential noise level standards of 65 dBA during the daytime. The combined construction noise is estimated to remain below the noise standards at the closest receptor (i.e., 47 dBA at 6,750 feet). Given the distance, estimated construction noise would be minimal at the closest noise-sensitive receptor and noise levels would remain within applicable noise regulation standards, as described in Section 3.1.8.2. The construction noise would be short-term and would diminish, as the construction activity are completed. Typically, there would not be nighttime construction.

As discussed in Section 3.2.8, the closest Federal and State parks are over 17 miles away from the construction area. Due to the large distance between the proposed construction and closest parks, construction noise is anticipated to be imperceptible at these locations.

To reduce potential impacts due to construction noise, contractors would try to limit construction to occur primarily during normal weekday business hours, and would properly maintain construction equipment mufflers.

Ground-borne vibration would be present during construction from site preparations, HDD, blasting, traffic, and other associated construction activities. Construction vibration would be temporary during construction and could be transient (e.g., single impact equipment), random (e.g., heavy construction equipment), or continuous (e.g., HDD). Vibration levels from blasting depends on the blast method and plan. Blasting would be performed in accordance with any applicable State regulations and industry BMPs to minimize ground vibrations. Ground-borne vibration due to typical construction activities is expected to be below the threshold of human perception (refer to Section 3.5.1.1). As a result, impacts would not be expected.

4.8.2.2 Operations

Operation of the ORNL VTR Alternative would involve equipment that would emit noise and vibration typical of industrial activities. Operation would involve a variety of machinery, including continuously operated equipment such as heat exchanger fans, HVAC condensing units, and HVAC exhaust fans. In addition, operation would involve intermittently or infrequently used equipment, such as compressors and standby diesel generators. Most equipment would be indoors or inside noise enclosures to reduce noise levels. Outdoor equipment (i.e., HVAC fans and compressors), employee vehicle trips, and routine maintenance activities involving trucks or other maintenance equipment would be perceptible in the immediate vicinity of the facility, but noise and vibration levels would be similar to other existing equipment at ORNL and would not impact offsite receptors. The ORNL VTR Alternative would involve operating equipment with noise and vibration similar to existing industrial activities already present at ORNL. As a result, the ORNL VTR Alternative would not cause a change to the noise environment at ORNL or at the closest noise sensitive receptor.

4.8.3 Reactor Fuel Production Options

4.8.3.1 INL Reactor Fuel Production Options

Implementation of the INL fuel production options would result in short-term impacts on noise and vibration from construction of the fuel fabrication facility and operational noise and vibration impacts as described below.

Construction

Construction of the INL fuel production options would have temporary adverse effects to noise and vibration. Construction activities for the INL options would be performed within existing buildings and involve modifications to existing infrastructure. Use of large construction equipment is not anticipated but equipment delivery and equipment transport could require limited use of forklifts or cranes; however, such equipment is commonly used at the facility. As a result, the associated noise levels during construction would be consistent with existing background noise. Other construction noise would occur from transportation-related activities, including workers' vehicle trips, but would not result in a noticeable increase in vehicle traffic due to their commute. Construction activities would cause temporary increases in ambient noise levels in the immediate vicinity of the construction sites but due to the large distance to the site boundary (2.9 miles) and nature of the internal construction, potential noise and vibration during construction would not be perceptible to offsite receptors.

Operations

Operational noise would involve workforce vehicles and noise from operation of the fuel fabrication facility.

Operational noise levels would be located within the confines of the facilities. The existing facilities consist of thick walls that would create a noise barrier to reduce and contain noise levels. Operation of the existing operational equipment cannot be heard outside of the building. As a result, the existing building is expected to act as a noise-reduction for the new fuel fabrication equipment. Outdoor equipment (i.e., HVAC fans and compressors), employee vehicle trips, and routine maintenance activities involving trucks or other maintenance equipment would be perceptible outside of the building but noise and vibration levels would be similar to other existing equipment and given the distance to the site boundary (2.9 miles) would not be distinguishable to the offsite receptors.

4.8.3.2 SRS Reactor Fuel Production Options

Implementation of the SRS fuel production options would result in short-term impacts on noise and vibration from construction of the fuel fabrication facility and operational noise and vibration impacts as described below.

Construction

Construction of the SRS fuel production options would have temporary adverse effects to noise and vibration. Construction activities for the SRS fuel production options would be performed within existing buildings and involve modifications to existing infrastructure. Typical construction equipment would be used such as forklifts, cranes, compressors, trucks, etc. Section 4.8.2.1 discusses the estimated noise levels from the various construction equipment present in Table 4–32. Other construction noise would occur from transportation-related activities, including workers' vehicle trips, but would not result in a noticeable increase in vehicle traffic due to their commute. Construction activities would cause temporary increases in ambient noise levels in the immediate vicinity of the construction sites but due to the large distance to the site boundary (5.5 miles) and nature of the internal construction, potential noise and vibration due to construction would not be perceptible to offsite receptors.

Similar to human sensitive receptors, wildlife can experience noise and vibration impacts from human activities. As discussed in Section 4.5.3.2.1, construction noise would not cause significant impacts since the areas planned for development within the K Area are highly disturbed and provide minimal habitat for urban adapted wildlife species.

Operations

Operational noise would involve workforce vehicles and noise from operation of the fuel fabrication facility.

Operational noise levels would be located within the confines of the facilities. The existing facilities consist of thick walls that would create a noise barrier to reduce and contain noise levels. Operation of the existing operational equipment cannot be heard outside of the building. As a result, the existing building is expected to act as a noise-reduction for the new fuel fabrication equipment. Outdoor equipment (i.e., HVAC fans and compressors), employee vehicle trips, and routine maintenance activities involving trucks or other maintenance equipment would be perceptible outside of the building but noise and vibration levels would be similar to other existing equipment and given the distance to the site boundary (5.5 miles) would not be distinguishable to the offsite receptors.

4.8.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

Implementation of the Combined INL VTR Alternative and INL Reactor Fuel Production Options would result in short-term impacts on noise and vibration from construction and no long-term impacts due to operation of the facilities. Construction activities would cause temporary increases in ambient noise levels in the immediate vicinity of the construction sites. Construction of the VTR would result in noise from site preparations, clearing and grading, construction of the new facility, vehicle traffic and other associated construction activities, including the use of heavy-duty construction equipment (e.g., trucks, backhoes, front-end loaders, cranes) (refer to Table 4–32). Construction of the reactor fuel production facilities would be performed within existing buildings and involve modifications to existing infrastructure. Depending on the final project schedule, construction of the VTR and reactor fuel production facilities could occur concurrently. Combined noise levels from the construction of the VTR and reactor fuel production facilities would be similar to the noise levels described in Section 4.8.2.1. But given the distance from the proposed VTR site to the INL Site boundary (2.9 miles) and closest noise-sensitive receptor (i.e., home and farm site 5 miles), estimated construction noise would be indistinguishable to the closest noise-sensitive receptor.

Like the construction stage, operation of the VTR and reactor fuel production at the INL Site would not impact offsite receptors. Operational noise would be perceptible in the immediate vicinity of the facility, but noise is expected to be similar to other existing equipment at the INL Site. Given the distance, operational noise and vibration would not be perceptible at the INL Site boundary (2.9 miles away) and at the closest noise-sensitive receptor (i.e., home and/farm site 5.0 miles away). As a result, the Combined

INL VTR Alternative and INL Reactor Fuel Production Options would not cause a change in noise environment.

4.9 Waste Management and Spent Nuclear Fuel Management

This section discusses the potential waste management and spent nuclear fuel management consequences associated with the INL and ORNL VTR Alternatives (the VTR reactor, post-irradiation examination facilities, other support facilities, and SNF management facilities). Waste management is also associated with the construction or facility modifications and operations of reactor fuel production at INL and SRS. Waste management and associated facilities are discussed in Sections 3.1.9, 3.2.9, and 3.3.9 for INL, ORNL, and SRS, respectively. The Proposed Action alternatives and options would provide preparation and packaging capabilities for wastes generated. Wastes would be managed within the current waste management systems and sent offsite for treatment and/or disposal.

Table 4–33 presents a summary of the potential environmental consequences on waste and SNF management for the INL and ORNL VTR Alternatives and INL and SRS Reactor Fuel Production Options.

Table 4–33. Summary of Environmental Consequences on Waste and Spent Nuclear Fuel Management

	VTR Alternatives	
Resource Area	***INL VTR***	***ORNL VTR***
Waste Management	*Construction*: About 9,900 cubic meters of construction waste will be generated during construction activities. This represents less than one (1) percent of the current remaining capacity of 3.4 million cubic meters of the CFA Landfill Complex *Operations*: LLW, MLLW, TRU waste, and hazardous and TSCA wastes will be generated. The waste types' additional annual generation quantities range from 0.89 to 540 cubic meters with associated percentage increases ranging from 0.081 to 16 percent over the baseline average annual generation rates (see Table 4–34). The characteristics of these wastes would be similar to the 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.	*Construction*: About 13,000 cubic meters of construction waste will be generated during construction activities. This represents less than one (1) percent of the current remaining capacity of 2.0 million cubic meters of the three (3) onsite landfills. *Operations*: During operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes will be generated. The waste types' additional annual generation quantities range from 0.89 to 540 cubic meters with associated percentage increases ranging from 0.6 to 5.4 percent over the baseline average annual generation rates (see Table 4–35). 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.
Spent Fuel Management	*Construction*: No spent fuel is generated during construction. *Operations*: The heavy metal from 45 spent fuel assemblies per refueling (66 for the final core offload at the end of the VTRs operational lifetime) would be treated and packaged as spent nuclear fuel. The total number of spent fuel assemblies over the lifetime of the program represent about 110 metric tons of heavy metal.	*Construction*: No spent fuel is generated during construction. *Operations*: The heavy metal from 45 spent fuel assemblies per refueling (66 for the final core offload at the end of the VTRs operational lifetime) would be treated and packaged as spent nuclear fuel. The total number of spent fuel assemblies over the lifetime of the program represent about 110 metric tons of heavy metal.

	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Waste Management	**Feedstock Preparation and Fuel Fabrication**	
	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 be generated during the modifications of facilities and the relocation of existing equipment and the installation of the new equipment.	
	Operations: During operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes will be generated. The waste types' additional annual generation quantities range from 2 to 400 cubic meters with associated percentage increases range from 0.043 to 18 percent over the baseline average annual generation rates for either feedstock preparation or fuel fabrication and 0.087 to 36 percent for the combination of both (see Table 4–36). 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 alternatives and options would provide preparation and packaging capabilities for the TRU waste that would be generated; TRU waste would be shipped to the WIPP facility for disposal.	*Operations:* During operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes will be generated. The waste types' additional annual generation quantities range from 2 to 400 cubic meters with associated percentage increases range from 0.077 to 1,800 (TRU waste) percent over the baseline average annual generation rates for either feedstock preparation or fuel fabrication and 0.15 to 3,600 (TRU waste) percent for the combination of both (see Table 4–37). 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 alternatives and options would provide preparation and packaging capabilities for the TRU waste that would be generated; TRU waste would be shipped to the WIPP facility for disposal. The large percentage increase for TRU waste is due to the very small volumes that have been generated over the last 5 years not the volumes that will be generated which are relatively small quantities.
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Waste Management	*Construction*: About 9,900 cubic meters of construction waste will be generated during VTR construction activities. This represents less than one (1) percent of the current remaining capacity of 3.4 million cubic meters of the CFA Landfill Complex. For 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.	
	Operations: LLW, MLLW, TRU waste, and hazardous and TSCA wastes will be generated during VTR operations (see Table 4–34). The waste types' additional annual generation rates range from 0.081 to 16 percent increases over the baseline average annual generation rates. During reactor fuel production operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes will be generated (see Table 4–36). The waste types' additional annual generation rates range from 0.043 to 18 percent increases over the baseline average annual generation rates for either feedstock preparation or fuel fabrication and 0.097 to 36 percent for the combination of both. Totals for VTR and Reactor Fuel Production activities would range from 0.91 to 36 percent. The characteristics of most of these wastes would be similar to the wastes currently generated by existing activities and would be managed within the current waste management system. 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.	

Spent Nuclear Fuel Management	*Construction*: No spent nuclear fuel is generated during construction. *Operations*: The heavy metal from 45 spent fuel assemblies per refueling (66 for the final core offload at the end of the VTRs 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 program represent about 110 metric tons of heavy metal.

4.9.1 INL VTR Alternative

Under the INL VTR Alternative, the VTR and associated support facilities and SNF storage pad would be constructed and operated. Existing facilities would be used for post-irradiation examination and spent fuel treatment with some modifications.

4.9.1.1 Construction/Facility Modification

During construction and facility modifications, construction and demolition (C&D) materials would be generated. No radioactive or hazardous wastes are anticipated to be generated. About 9,900 cubic meters (INL 2020f, 2020g) of C&D materials would be generated during construction activities. This represents less than 1 percent of the current remaining capacity of 3.4 million cubic meters of the CFA Landfill Complex discussed previously in Section 3.1.9.3.

4.9.1.2 Operations

During operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes would be generated. **Table 4–34** provides a comparison to the average annual baseline generation rates for each of those waste types estimated to be generated during operations. The waste types' additional annual generation rates range from 0.081 to 16 percent increases over the baseline average annual generation rates. The characteristics of these wastes would be similar to the wastes currently generated by existing activities and would be managed within the current waste management systems. 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.

In addition, the heavy metal from 45 spent fuel assemblies per refueling (66 for the final core offload at the end of the VTRs operational lifetime) would be managed and packaged as spent fuel. The total number of spent fuel assemblies over the lifetime of the program represent about 110 metric tons of heavy metal (MTHM). Spent fuel would be managed in accordance with applicable laws and other requirements.

Table 4–34. Percentage Increase in Waste Generation at the INL Site in Average Annual Generation Rates Due to VTR Operations

Waste Type	*Average Annual Baseline 2015-2019 in Cubic Meters*	*INL VTR Alternative Operations – Average Annual Generation in Cubic Meters*	*INL VTR Percentage of Average Annual Baseline*
LLW	8,600	540	6.3
MLLW	4,600	38	0.82
TRU Waste	1,100	0.89	0.081
Hazardous and TSCA	45	7.2	16

LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; TRU = transuranic; TSCA = Toxic Substances Control Act.
Note: All numbers are rounded to two significant figures. Due to rounding, sums and products may not equal those calculated from table entries.
Sources: INL 2020a, 2020f, 2020g.

4.9.2 ORNL VTR Alternative

Under the ORNL VTR Alternative, the VTR and associated support facilities, post-irradiation examination, spent fuel treatment facilities, and SNF storage pad would be constructed and operated.

4.9.2.1 Construction/Facility Modification

During construction activities, C&D materials would be generated. No radioactive or hazardous wastes are anticipated to be generated. About 13,000 cubic meters (ORNL 2020c) of C&D materials would be generated during construction activities. This represents less than 1 percent of the current remaining capacity of 2.0 million cubic meters of the 3 onsite landfills discussed previously in Section 3.2.9.3.

4.9.2.2 Operations

During operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes would be generated. **Table 4–35** provides a comparison to the average annual baseline generation rates for each of those waste types estimated to be generated during operations. The waste types' additional annual generation rates range from 0.64 to 5.4 percent increases over the baseline average annual generation rates. The characteristics of these wastes would be similar to the wastes currently generated by existing activities and would be managed within the current waste management systems. 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.

In addition, the heavy metal from 45 spent fuel assemblies per refueling (66 for the final core offload at the end of the VTRs operational lifetime) would be managed and packaged as spent fuel. The total number of spent fuel assemblies over the lifetime of the program represent about 110 MTHM. Spent fuel would be managed in accordance with applicable laws and other requirements.

Table 4–35. Percentage Increase in Waste Generation at ORNL in Average Annual Generation Rates Due to VTR Operations

Waste Type	*Average Annual Baseline 2015-2019 in Cubic Meters*	*ORNL VTR Alternative Operations – Average Annual Generation in Cubic Meters*	*ORNL VTR Percentage of Average Annual Baseline*
LLW	81,000	540	0.67
MLLW	700	38	5.4
TRU Waste	140	0.89	0.64
Hazardous and TSCA	610	7.2	1.2

LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; TRU = transuranic; TSCA = Toxic Substances Control Act.
Note: All numbers are rounded to two significant figures. Due to rounding, sums and products may not equal those calculated from table entries.
Source: ORNL 2020c.

4.9.3 Reactor Fuel Production Options

4.9.3.1 INL Reactor Fuel Production Options

Under the INL option, existing facilities would be modified and used for both the feedstock preparation and fuel fabrication activities.

4.9.3.1.1 Feedstock Preparation and Fuel Fabrication

Construction/Facility Modification

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 C&D, 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.

Operations

During operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes would be generated. **Table 4–36** provides a comparison to the average annual baseline generation rates for each of those waste types estimated to be generated during operations. The waste types' additional annual generation rates range from 0.043 to 18 percent increases over the baseline average annual generation rates for either feedstock preparation or fuel fabrication and 0.087 to 36 percent for the combination of both. The characteristics of these wastes would be similar to the wastes currently generated by existing activities and would be managed within the current waste management systems. 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.

Table 4–36. Percentage Increase in Waste Generation at the INL Site in Average Annual Generation Rates Due to Feedstock Preparation and Fuel Fabrication Operations

Waste Type	*Average Annual Baseline 2015-2019 in Cubic Meters*	*INL Feedstock Preparation/Fuel Fabrication Operations – Average Annual Generation in Cubic Meters*	*INL Reactor Fuel Production Percentage of Average Annual Baseline*
LLW	8,600	170 [a] /170 [b]	2.0/2.0
MLLW	4,600	2 [a, c] /2 [b, c]	0.043/0.043
TRU Waste	1,100	200 [a] /200 [b]	18/18
Hazardous and TSCA	45	1 [a] /1 [b]	2.2/2.2

LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; TRU = transuranic; TSCA = Toxic Substances Control Act.
[a] These quantities are estimates and could be different depending on the process for the feedstock.
[b] These quantities are fuel fabrication with no feedstock preparation.
[c] These quantities are included in the LLW quantities.
Note: All numbers are rounded to two significant figures. Due to rounding, sums and products may not equal those calculated from table entries.
Sources: INL 2020a, 2020f, 2020g; SRNL 2020; SRNS 2020.

4.9.3.2 SRS Reactor Fuel Production Options

Under the SRS option, existing facilities would be modified and used for both the feedstock preparation and fuel fabrication activities.

4.9.3.2.1 Feedstock Preparation and Fuel Fabrication

Construction/Facility Modification

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 to other facilities. Small volumes of C&D, 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.

Operations

During operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes would be generated. **Table 4–37** provides a comparison to the average annual baseline generation rates for each of those waste types estimated to be generated during operations. The waste types' additional annual generation rates range from 0.077 to 1,800 (TRU waste) percent increases over the baseline average annual generation rates for either feedstock preparation or fuel fabrication and 0.15 to 3,600 (TRU waste) percent for the combination of both. The characteristics of these wastes would be similar to the wastes currently generated by existing activities and would be managed within the current waste management systems. 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. The large percentage increase for TRU waste is due to the very small volumes that have been generated over the last 5 years not the volumes that will be generated which are relatively small quantities.

Table 4–37. Percentage Increase in Waste Generation at SRS in Average Annual Generation Rates Due to Feedstock Preparation and Fuel Fabrication Operations

Waste Type	*Average Annual Baseline 2015-2019 in Cubic Meters*	*SRS Feedstock Preparation/Fuel Fabrication Operations – Average Annual Generation in Cubic Meters*	*SRS Reactor Fuel Production Percentage of Average Annual Baseline*
LLW	5,300	170 [a]/170 [b]	3.2/3.2
MLLW	55	2 [a, c] /2 [b, c]	3.6/3.6
TRU Waste	11	200 [a] /200 [b]	1,800/1,800
Hazardous and TSCA	1,300	1 [a] /1 [b]	0.077/0.077

LLW = low-level radioactive waste; MLLW = mixed low-level radioactive waste; TRU = transuranic; TSCA = Toxic Substances Control Act.

[a] These quantities are estimates and could be different depending on the process for the feedstock.

[b] These quantities are fuel fabrication with no feedstock preparation.

[c] These quantities are included in the LLW quantities.

Note: All numbers are rounded to two significant figures. Due to rounding, sums and products may not equal those calculated from table entries.

Sources: SRNL 2020; SRNS 2020.

4.9.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

Construction

About 9,900 cubic meters of C&D materials would be generated during VTR construction activities. This represents less than one (1) percent of the current remaining capacity of 3.4 million cubic meters of the CFA Landfill Complex. For the reactor fuel production option, 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 C&D, 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.

Operations

LLW, MLLW, TRU waste, and hazardous and TSCA wastes would be generated during VTR operations (see Table 4–34). The waste types' additional annual generation rates range from 0.081 to 16 percent increases over the baseline average annual generation rates. During reactor fuel production operations, LLW, MLLW, TRU waste, and hazardous and TSCA wastes would be generated (see Table 4–36). The waste types' additional annual generation rates range from 0.043 to 18 percent increases over the baseline average annual generation rates for either feedstock preparation or fuel fabrication and 0.097 to 36 percent for the combination of both. Totals for VTR and Reactor Fuel Production activities would range from 0.91 to 36 percent. The characteristics of these wastes would be similar to the wastes currently generated by existing activities and would be managed within the current waste management systems.

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.

The heavy metal from 45 spent fuel assemblies per refueling (66 for the final core offload at the end of the VTRs operational lifetime) would be managed and packaged as spent fuel. The total number of spent fuel assemblies over the lifetime of the program represent about 110 MTHM. Spent fuel will be managed in accordance with applicable laws and other requirements.

4.10 Human Health – Normal Operations

This section presents potential radiological impacts on workers and the public from the construction and operation of the VTR; the post-irradiation examination facilities; spent fuel treatment, conditioning, and storage facilities; feedstock preparation facilities; and fuel fabrication facilities. This section also presents potential nonradiological impacts (from accidents and exposure to nonradiological chemicals) to workers from the construction and operation of these facilities. Radiological human health risks are considered for involved workers, a noninvolved worker, the offsite population, a member of the public that is exposed to the average radiological dose, and a member of the public identified as the maximally exposed individual (MEI). Workers and members of the public are protected from exposure to radioactive material and hazardous chemicals by facility design and administrative procedures. DOE regulations and directives include 10 CFR Part 820, "Procedural Rules for DOE Nuclear Facilities," DOE Order 458.1, "Radiation Protection of the Public and the Environment," 10 CFR Part 835, "Occupational Radiation Protection," and 10 CFR Part 851, "Worker Safety and Health Program."

Involved worker (worker): A worker directly or indirectly involved with VTR operations at either the INL MFC or ORNL or fuel production at either INL MFC or SRS who may receive an occupational radiation exposure from direct radiation (i.e., neutron, x-ray, beta, or gamma) or from radionuclides released to the environment. Direct exposure from handling plutonium materials within a facility would be the chief source of occupational exposure for fuel production workers (primarily from gamma radiation emitted by americium -241).

Noninvolved workers: A site worker outside of the facility who would not be subject to direct radiation exposure but could be incidentally exposed to radiological emissions from the VTR or fuel production facility.

Offsite population: Comprises members of the general public who live within 50 miles of the VTR or fuel production facilities.

Maximally exposed individual (MEI): A hypothetical individual who – because of realistically assumed proximity, activities, and living habits – would receive the highest radiation dose, taking into account all pathways, from a given event, process, or facility (DOE Order 458.1). In this EIS, this individual is assumed to be at the site boundary during normal operations.

Average individual: A member of the public who receives the average dose as determined by dividing the offsite population dose by the number of people in the population.

DOE uses both radiation dose, expressed in rem, millirem, or person-rem, and latent cancer fatalities (LCFs) to represent the human health effects of exposure to radiation. In this EIS, a single risk factor is used for all isotopes to convert dose (in rem or person-rem) to an LCF regardless of the source of the dose. A risk factor of 0.0006 LCFs per person-rem or rem is used, consistent with DOE guidance (DOE 2003). An LCF of less than one can be interpreted as the probability of an LCF. For an individual, this would be the probability of the MEI or average individual getting a fatal cancer. For a population, this can be interpreted as the probability of at least one LCF within the population.

DOE Order 458.1 imposes an annual individual dose limit of 10 millirem from airborne pathways (incorporating the requirements of 40 CFR Part 61 Subpart H), 100 millirem from all pathways, and 4 millirem from the drinking-water pathway. Public doses from all pathways are maintained to levels as low as reasonably achievable (ALARA). To protect workers from impacts from radiological exposure, 10 CFR Part 835 imposes an individual dose limit of 5,000 millirem in a year. However, DOE's goal is to maintain radiological exposures ALARA. Therefore, DOE has recommended an administrative control levels for worker doses (DOE 1999c), typically 500 millirem per year.

Additional information on the methodology used to develop radiological impacts from airborne releases can be found in Appendix C.

Table 4–38 summarizes the human health environmental consequences from normal operations for all of the action alternatives and options considered in this EIS.

Table 4–38. Summary of Human Health Environmental Consequences from Normal Operations

<table>
<tr><th rowspan="2">Resource Area</th><th colspan="2">VTR Alternatives</th></tr>
<tr><th>INL VTR</th><th>ORNL VTR</th></tr>
<tr><td rowspan="2">The Public</td><td>Construction: No impact
Operations:
Total population dose: 0.044 person-rem; No LCFs (3×10^{-5}).
Individual Doses: MEI - 0.0068 millirem; LCF probability 4×10^{-9}. Average – 1.2×10^{-4} millirem; LCF risk less than 1×10^{-10}</td><td>Construction: No impact
Operations:
Total population dose: 0.58 person-rem; No LCFs (3×10^{-4}).
Individual Doses: MEI - 0.031 millirem; LCF probability 2×10^{-8}. Average – 3.6×10^{-4} millirem LCF risk 2×10^{-10}</td></tr>
<tr><td colspan="2">Discussion: Construction does not result in any radiological releases. Individual doses from operations would be well below DOE and regulatory limits (10 millirem per year: DOE Order 458.1 and 40 CFR Part 61, Subpart H). No additional LCFs would be anticipated among the general population.</td></tr>
<tr><td rowspan="2">Workers</td><td>Construction:
Radiological impacts – A dose of 1 rem to individual involved workers, 0.0006 LCF risk and a total involved worker dose of 10 person-rem, with no expected LCFs (0.006).
Nonradiological impacts: 79 worker injuries are possible, but no fatalities.
Operations:
Radiological impacts – Annual involved worker dose of 53 person-rem from all VTR activities (reactor operation, test assembly post-irradiation examination, spent fuel treatment and storage, and general support) with no LCFs (0.03). Average individual involved worker dose of 148 millirem per year with an LCF risk of 9×10^{-5}.
Nonradiological impacts: 9 staff injuries per year are possible, but no fatalities.</td><td>Construction:
Radiological impacts – None.
Nonradiological impacts - 100 worker injuries are possible, but no fatalities.
Operations:
Radiological impacts - Annual involved worker dose of 44 person-rem from all VTR activities (reactor operation, test assembly post-irradiation examination, and spent fuel treatment and storage) with no LCFs (0.03). Average individual involved worker dose of 147 millirem per year with an LCF risk of 9×10^{-5}.
Nonradiological impacts: 9 staff injuries per year are possible, but no fatalities.</td></tr>
<tr><td colspan="2">Discussion: Construction of new facilities does not result in worker radiological exposure. Individual worker doses from facility modifications and operations would be limited to meet DOE administrative worker dose limits (DOE STD-1098-2017).</td></tr>
</table>

	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
The Public	**Feedstock Preparation**	
	Construction: No Impact *Operations*: **Total population dose:** 0.012 person-rem; No LCFs (7×10^{-6}). **Individual Doses**: MEI - 0.0012 millirem; LCF probability 7×10^{-10}. Average – 3.2×10^{-5}; millirem LCF risk less than 1×10^{-10}.	*Construction*: No Impact *Operations*: **Total population dose:** 0.042 person-rem; No LCFs (2×10^{-5}). **Individual Doses**: MEI - 0.0015 millirem; LCF probability 9×10^{-10}. Average – 4.7×10^{-5} millirem; LCF risk less than 1×10^{-10}.
	Fuel Fabrication	
	Construction: No impact *Operations*: **Total population dose:** 0.0053 person-rem; No LCFs (3×10^{-6}). **Individual Doses**: MEI - 0.0016 millirem; LCF probability 1×10^{-9}. Average – 1.5×10^{-5} millirem; LCF risk less than 1×10^{-10}.	*Construction*: No impact *Operations*: **Total population dose:** 0.020 person-rem; No LCFs (1×10^{-5}). **Individual Doses**: MEI - 0.00071 millirem; LCF probability 4×10^{-10}. Average – 2.3×10^{-5} millirem; LCF risk less than 1×10^{-10}.
	Discussion: Construction does not result in any radiological releases. Individual doses would be well below DOE and regulatory limits (10 millirem per year: DOE Order 458.1 and 40 CFR Part 61, Subpart H). No additional LCFs would be anticipated among the general population.	
Workers	**Feedstock Preparation**	
	Construction: **Radiological**– No impact **Nonradiological**– No impact	*Construction*: **Radiological impacts** – Total involved worker dose 1.3 person-rem, no expected LCFs (0.0008). Average involved worker dose of 50 millirem with an LCF risk of 3×10^{-5}. **Nonradiological impacts** – A total of 10 worker injuries are possible, but no fatalities.
	Operations: **Radiological impacts** – Annual involved worker dose of 51 person-rem with no LCFs (0.03). Average individual involved worker dose of 170 millirem per year with an LCF risk of 1×10^{-4}. **Nonradiological impacts**: 9 staff injuries per year are possible, but no fatalities.	*Operations*: **Radiological impacts** – Annual involved worker dose of 51 person-rem with no LCFs (0.03). Average individual involved worker dose of 170 millirem per year with an LCF risk of 1 x 10^{-4}. **Nonradiological impacts**: 9 staff injuries per year are possible, but no fatalities.
	Fuel Fabrication	
	Construction: **Radiological**– Total involved worker dose 21 person-rem, no expected LCFs (0.01). Maximum individual involved worker dose of 3.6 rem with an LCF risk of 0.002. **Nonradiological**– No impacts	*Construction*: **Radiological**– Total involved worker dose 0.8 person-rem, no expected LCFs (0.0005). Average individual involved worker dose of 30 millirem with an LCF risk of 2×10^{-5}. **Nonradiological**– A total of 10 worker injuries are possible, but no fatalities
	Operations: **Radiological impacts** – Annual involved worker dose of 51 person-rem with no LCFs (0.03). Average individual involved worker dose to workers directly supporting VTR of 170 millirem per year with an LCF risk of 1 x 10^{-4}. **Nonradiological impacts**: 9 staff injuries per year are possible, but no fatalities	*Operations*: **Radiological impacts** – Annual involved worker dose of 51 person-rem with no LCFs (0.03). Average individual involved worker dose to workers directly supporting VTR of 170 millirem per year with an LCF risk of 1×10^{-4}. **Nonradiological impacts**: 9 staff injuries per year are possible, but no fatalities
	Discussion: Doses to individual workers from facility modifications and operations would be limited to meet DOE dose limits (DOE STD-1098-2017) and site administrative worker dose controls.	

	Combined INL VTR Alternative and INL Reactor Fuel Production Options
The Public	*Construction*: No Impact. *Operations*: **Total population dose:** 0.06 person-rem. No LCFs (4×10^{-5}). **Individual Doses**: MEI - 0.0096 millirem LCF probability 6×10^{-9} Average – 1.7×10^{-4} millirem LCF 1×10^{-10}
Workers	*Construction*: **Radiological impacts:** A total involved worker dose of 32 person-rem, 0.02 LCF risk. Average annual individual involved worker dose of 760 millirem with an LCF risk of 0.0005. **Nonradiological impacts**: 80 worker injuries are possible, but no fatalities. *Operations*: **Radiological impacts** – Annual worker dose of 160 person-rem with no LCFs (0.09). Average individual involved worker dose of 160 millirem per year with an LCF risk of 0.0001. **Nonradiological impacts**: 26 staff injuries per year are possible, but no fatalities.

4.10.1 INL VTR Alternative

This section presents potential radiological and chemical hazard impacts associated with the construction and operational activities associated with establishing the VTR alternative at the INL Site. Public and worker radiological impacts (doses and LCFs) are presented in the form of individual and population impacts. Additionally, for the public impacts, an MEI impact is presented. Public impacts are from air emissions. The impacts would include those from: construction and operation of the VTR; facility modifications to the Hot Fuel Examination Facility (HFEF) and incremental operational impacts for performing post-irradiation examination of test items; facility modifications to FCF and incremental operational impacts for preparing SNF for long-term storage and disposal; and construction and operation of a new long-term storage pad.

4.10.1.1 Construction/Facility Modification

Public Health

The construction of new facilities associated with the INL VTR Alternative would have no radiological impact on the general public. Construction of the VTR reactor facility and its associated structures (e.g., switchyard, operational support building) and the SNF storage pad would occur outside of the current MFC facilities. No radiological emissions would result from this activity.

Modifications to existing MFC facilities associated with the VTR alternative at the INL Site would have no radiological impact on the general public. Required facility modifications are minimal (equipment replacement within the HFEF and FCF) and are typical activities currently performed in these facilities. No additional radiological emissions would be expected from these activities.

Worker Health

The construction of new facilities associated with the VTR alternative at the INL Site would have no radiological impact on the construction workforce. Construction of the VTR reactor facility and its associated structures (e.g., switchyard, operational support building) and the spent fuel storage pad would occur outside of the current MFC facilities. No radiological impacts would result from this activity.

Modifications to the facilities proposed for post-irradiation examination (i.e., HFEF) and spent fuel treatment and conditioning (i.e., FCF) would require workers to replace equipment within existing hot cells. Such work, while within the range of activities normally performed at these facilities, could result in worker exposure. Most work related to the installation of new equipment within the HFEF hot cell would be performed outside of the hot cell, in radiologically clean areas. Only final assembly and installation would occur within the hot cell. Within the HFEF, this work would be performed remotely and would not result in worker exposure. A hot cell window replacement would be required for the FCF (modified to allow fuel assembly transfer into the cell). At the FCF, the modification effort would require about 10 workers over a 2-year period. The total worker dose associated with this activity would be 10 person-rem (individual worker dose not expected to exceed 1 rem) (INL 2020f). This exposure is not expected to result in any additional LCFs (0.006) among the workers and an individual LCF risk of 0.0006 to each worker.

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

The estimated number of accidental worker injuries and fatalities were based on the number of workers that would be involved in construction/facility modification activities and national worker injury and fatality rates. For a construction effort of this size, accidents would be expected. On average, about 640 workers would be involved in the construction of the VTR facilities (INL 2020f) and 10 workers over 2 years would be invovled in FCF modifications. During the 51 months of VTR construction, assuming the peak number of workers for the full duration of construction, there would be no expected fatalities (0.3) based on an average worker fatality rate in the construction industry of 9.5 fatalities per 100,000 worker years (BLS 2018a). In 2018, the national average for construction workers for accidents resulting in lost worker days was 2.9 accident per 100 full time workers (BLS 2018b). This accident rate results in an estimated 79 construction worker injuries per year during VTR construction.

4.10.1.2 Operations

Public Health

Under the INL VTR Alternative, the annual radiological emissions from the VTR facilities would be no more than the quantities listed in **Table 4–39**. For the VTR reactor facility, emissions are anticipated from the gaseous radioactive waste system. These emissions would be released through the radioactive waste area HVAC system and the Reactor Vessel Auxiliary Cooling System (RVACS)[1]. The HVAC includes both charcoal adsorbers and HEPA filters (INL 2019g). No other systems are anticipated to have appreciable releases. Multiple facilities could be used for the post-irradiation examination of test specimens, the releases identified in Table 4–39 are the sum of the potential releases from all of these facilities. All test specimens are transferred to the HFEF for handling and test preparation prior to being transferred to other facilities (such as the Irradiated Materials Classification Laboratory [IMCL]). The specimens within the test assembly would be removed from the test assembly at the HFEF and prepared for examination within the facility hot cells. Releases associated with post-irradiation examination would be released through the HFEF cell exhaust system. All emissions from the decontamination and main cells pass through a series of HEPA filters, additionally the main cell exhaust passes through an activated charcoal filter, before being released through the HFEF stack. Radiological emissions from the FCF are associated with the treatment of the spent fuel. Disassembly, sodium removal, and fuel packaging would all occur within the facility hot cells. All emissions would be through the facility's safety exhaust system, which includes HEPA filters, and out the FCF stack (DOE 2000a).

[1] Only argon-41 (27 of the 27.1 curies) would be released from the RVACS. All others would be released from the gaseous radioactive waste system exhaust.

Table 4–39. INL VTR Alternative – Radiological Emissions During Normal Operations

Nuclide	Emissions (curies per year)		
	VTR Reactor Facility	Post-Irradiation Examination Facilities	FCF
Americium-241	--	8.4×10^{-12}	--
Antimony-125	--	3.2×10^{-5}	1.57×10^{-7}
Argon-41	27.1	--	--
Cadmium-109	--	5.2×10^{-4}	--
Cadmium-113m	--		4.15×10^{-10}
Cadmium-115	--	1.0×10^{-7}	--
Carbon-14	--	3.1×10^{-4}	--
Cerium-144	--		1.41×10^{-6}
Cobalt-60	--	7.9×10^{-13}	2.08×10^{-9}
Cesium-134	--	8.0×10^{-7}	2.62×10^{-7}
Cesium-135	9.0×10^{-16}	--	--
Cesium-137	1.2×10^{-12}	2.5×10^{-2}	1.96×10^{-6}
Cesium-138	2.0×10^{-6}	--	--
Chlorine-36	--	1.0×10^{-5}	--
Europium-154	--	--	1.73×10^{-10}
Europium-155	--	--	2.07×10^{-9}
Hydrogen-3 (Tritium)	1.2	3.7×10^{-2}	510
Iodine-129	--	1.8×10^{-5}	--
Iodine-131	--	8.9×10^{-3}	--
Iron-55	--	--	5.50×10^{-8}
Krypton-83m	1.8×10^{-6}	--	--
Krypton-85	0.70	4.4×10^{-3}	8.25×10^{3}
Krypton-85m	3.5×10^{-6}	--	--
Krypton-87	4.8×10^{-6}	--	--
Krypton-88	8.9×10^{-6}	--	--
Neptunium-237	--	3.2×10^{-9}	--
Nickel-63	--	--	2.76×10^{-10}
Phosphorus-32	--	2.6×10^{-5}	--
Phosphorus-33	--	4.9×10^{-9}	--
Promethium-147	--	--	1.25×10^{-7}
Plutonium-238	--	1.2×10^{-10}	1.24×10^{-10}
Plutonium-239	--	9.5×10^{-8}	2.83×10^{-9}
Plutonium-240	--	3.0×10^{-12}	1.87×10^{-10}
Plutonium-241	--	--	1.17×10^{-9}
Plutonium-242	--	1.8×10^{-9}	--
Ruthenium-106	--	--	5.66×10^{-6}
Samarium-151	--	--	8.97×10^{-10}
Sodium-22	--	3.2×10^{-6}	--
Sodium-24	--	1.7×10^{-8}	--
Strontium-90	--	3.8×10^{-7}	3.47×10^{-8}
Sulfur-35	--	1.2×10^{-4}	--
Xenon-131m	1.6×10^{-2}	--	--
Xenon-133	1.0×10^{-3}	--	--
Xenon-133m	5.4×10^{-7}	--	--
Xenon-135	4.2×10^{-5}	--	--
Xenon-135m	1.5×10^{-6}	--	--
Xenon-137	7.4×10^{-7}	--	--
Xenon-138	4.4×10^{-6}	--	--

FCF = Fuel Conditioning Facility; VTR = Versatile Test Reactor.
Source: INL 2020f.

The movement of spent fuel from the VTR to the spent fuel storage pad, from the storage pad to the FCF, and from the FCF (treated and conditioned spent fuel) back to the storage pad would all be performed in sealed transfer/storage casks. Under normal conditions, no radiological releases are expected from these casks. All of these activities occur well away from the general public. The nearest offsite member of the public would be about 3 miles from the VTR facilities. There would be no risk of exposure to the general public from direct exposure. Therefore, the storage and movement of spent fuel would have no radiological impact on the public.

Radiological impacts were estimated for the general public living within 50 miles of the VTR located at the MFC of the INL Site. **Table 4–40** shows the annual radiological impacts on the population projected to be living within a 50-mile radius of the VTR in 2050, a population of about 364,000, and two individuals. Impacts are generated for an average member of the public and an offsite MEI (a hypothetical member of the public, who receives the maximum dose while residing at the INL Site boundary, in this instance, the boundary south of the facility. (See Appendix C for additional information about the methodology used to generate these dose estimates.)

Table 4–40 shows the estimated population dose associated with VTR operations to be 0.044 person-rem per year. The MEI would receive an estimated annual dose of 0.0068 millirem and the average annual dose to an individual in the population would be 1.2×10^{-4} millirem under this alternative. EPA and DOE have established an annual limit of 10 millirem to the individual via the air pathway from all DOE sources. Both the average individual and MEI dose from VTR operation would be less than 0.1 percent of this limit. For comparison, the population dose and individual doses from exposure to natural background radiation levels for the INL Site are given. As shown in Table 4–40 the population and individual doses from VTR operation are well below 0.01 percent of the dose from natural background radiation.

Table 4–40. INL VTR Alternative – Annual Radiological Impacts on the Public

	Maximally Exposed Individual	*Population Within 50 Miles* [a]	*Average Individual within 50 Miles*
Dose	0.0068 millirem	0.044 person-rem	1.2×10^{-4} millirem
Cancer fatality risk [b]	4×10^{-9}	0 (3×10^{-5})	less than 1×10^{-10}
Regulatory dose limit [c]	10 millirem	Not applicable	10 millirem
Dose as a percentage of the regulatory limit	0.07	Not applicable	0.001
Dose from natural background radiation [d]	383 millirem	139,000 person-rem	383 millirem
Dose as a percentage of background dose	0.002	3×10^{-5}	3×10^{-5}

[a] The population dose for this table was based on a projected 2050 population estimate of 364,000 within 50 miles of the VTR at MFC.

[b] Based on a risk estimator of 0.0006 LCFs per person-rem (DOE 2003).)

[c] 40 CFR Part 61, Subpart H, establishes an annual limit of 10 millirem via the air pathway to any member of the public from DOE operations.

[d] Based on an individual annual dose of 383 millirem from natural background radiation to the projected population of about 364,000.

No LCFs would be expected within the general population. This population dose would increase the annual risk of a latent fatal cancer in the population by 3×10^{-5}. Another way of stating this is that the likelihood that one fatal cancer would occur in the population because of radiological releases associated with this alternative is about 1 chance in 40,000 per year. The corresponding increased risk of an individual developing a latent fatal cancer would be less than 1×10^{-10}, or less than 1 chance in 10 billion per year. For the MEI an increased annual risk of developing a latent fatal cancer would be about 4×10^{-9}. In other words, the likelihood that the MEI would develop a fatal cancer is about 1 chance in 250 million for each year of operations.

Worker Health

Involved worker exposures would result from operations in the VTR facility, post-irradiation examination in the HFEF, and spent fuel treatment in the FCF. Additional worker exposure would result from the transfer of spent fuel between these three facilities and during storage at the spent fuel storage pad. Worker doses from this activity are expected to be a small percentage of the doses received from activities within the three facilities.

Transfer operations are an intermittent activity. During steady state operation of the facilities, the equivalent of up to 45 reactor fuel assemblies would be transferred from the VTR Reactor Facility to the storage pad, from the storage pad to the FCF, and from the FCF (in the form of treated and diluted spent fuel) to the storage pad. The number of transfers would be significantly less as multiple fuel assemblies could be transferred in the same cask. During transfer and storage, the spent fuel would be contained in transportation/storage casks, limiting exposure to workers. DOE limits the dose resulting from the handling of these casks to 10 millirem per hour at a distance of 2 meters from the cask. Spent fuel handling would not appreciably add to the total involved worker exposure.

VTR operations are projected to require 200 staff (INL 2020f). This would include operators, maintenance personnel, radiological controls personnel, supervisors, and management. All would be radiation workers. Based on historical Fast Flux Test Facility operational dose and estimates for PRISM operations, the average individual occupational dose would be 100 millirem per year. The total dose to the work force would be 20 person-rem/year.

No additional staff would be required to support post-irradiation examination operations within the MFC facilities identified for this activity. However, post-irradiation examination operations at HFEF would be expected to result in an increase in the occupational exposure to the current involved workers from 11 to 15.4 person-rem, an increase of 4.4 person-rem per year (INL 2020g). While no additional HFEF staff would be required, all 80 existing staff would be expected to support VTR operations. This would result in an increase to the average dose to these workers of 55 millirem per year. This would raise the average dose to an involved worker to 190 millirem per year.

Spent fuel treatment and conditioning activities would be expected to result in an increase in the occupational exposure to involved workers of 8.8 person-rem per year (INL 2020g). The 18 new staff at FCF would support spent fuel treatment of VTR fuel (INL 2020f). The increase in total worker dose would result in a dose of 490 millirem per year to the average worker.

In addition to the staff that would be tasked to the VTR project, other MFC personnel would provide support to the VTR as part of their work. INL has estimated that the each individual MFC worker would receive an additional 5.71 millirem per year, and a total workforce dose of 9.3 person-rem per year from supporting VTR.

For all four activities (VTR operation, post-irradiation examination, spent fuel treatment and conditioning, and general support) the total annual involved worker dose would be about 53 person-rem (assuming the entire worker dose at HFEF results from VTR associated activities), with an average individual worker dose of 148 millirem per year for those workers directly supporting the VTR. This exposure is not expected to result in any additional LCFs (calculated value of 0.03) among the workforce and result in a 9×10^{-5} increase in an individual workers LCF risk.

To protect workers from impacts from radiological exposure, 10 CFR Part 835 imposes an individual dose limit of 5,000 millirem in a year. In addition, worker doses are monitored and controlled below the regulatory limit to ensure that individual doses are less than an INL administrative limit of 700 millirem per year, and maintained at ALARA levels (DOE 2017f). INL would monitor worker doses and take appropriate action to limit individual worker doses below this administrative level.

The VTR facilities would be located within the MFC (in HFEF, FCF, FMF, and ZPPR) or adjacent to MFC (the VTR Reactor Facility). Other workers (noninvolved workers) within the MFC would be exposed to the radiological emissions associated with the VTR facilities. Based on the radiological emissions identified previously (Table 4–38) the dose to a worker within the MFC was estimated. This noninvolved worker would receive a dose of about 2×10^{-3} millirem per year. This exposure is not expected to result in an additional LCF, and results in a low risk of an LCF (calculated risk value of 1×10^{-9}).

Safety and health requirements for DOE workers are governed by 10 CFR Part 851 that establishes requirements for a worker safety and health program to ensure that DOE workers have a safe work environment. Included are provisions to protect against hazardous chemicals. VTR workers could be exposed to hazardous chemicals during operation of the VTR facilities. For example, hazardous chemicals used in the HFEF include hydrochloric acid, sulfuric acid, acetone, and alcohol (INL 2020f). Generally, the quantity of material would be small, and in many cases their use would be within areas not inhabited by workers (inside hot cells). Worker safety would not be impacted by the use of these hazardous chemicals.

Operational staff would also be susceptible to industrial accidents that could result in injury or death. The estimated number of accidental worker injuries and fatalities were based on the number of staff involved in operational activities and national worker injury and fatality rates. For an operation of this size, accidents would be expected. On average about 300 staff would be involved in VTR, post-irradiation, and spent fuel treatment operations (INL 2020f). During each year of operation, there would be no expected fatalities (0.007) based on an average worker fatality rate in the manufacturing industry of 2.2 fatalities per 100,000 worker years (BLS 2018a). In 2018, the national average for manufacturing workers for accidents resulting in lost worker days was 3.1 accident per 100 full time workers (BLS 2018b). This accident rate results in an estimated nine staff injuries per year during operation.

4.10.2 ORNL VTR Alternative

This section presents potential radiological and chemical hazard impacts associated with the construction and operational activities associated with establishing the VTR alternative at ORNL. Public and worker radiological impacts (doses and LCFs) are presented in the form of individual and population impacts. Additionally for the public impacts, an MEI impact is presented. Public impacts are from air emissions. The impacts would include those from construction and operation of

- The VTR,
- A combined test article post-irradiation examination and spent fuel treatment facility, and
- The fuel storage pad.

All of these facilities would be located within a new Perimeter Intrusion Detection Assessment System (PIDAS) for the VTR complex.

4.10.2.1 Construction/Facility Modification

Public Health

The construction of new facilities associated with the ORNL VTR Alternative would have no radiological impact on the general public. Construction of a VTR reactor facility and its associated structures (e.g., switchyard, operational support building), the post-irradiation examination and spent fuel treatment facility, and the spent fuel storage pad would occur outside of current ORNL facilities. Modifications to existing ORNL facilities have not been identified. No radiological emissions would result from this activity.

Worker Health

The construction of new facilities associated with the VTR at ORNL Alternative would have no radiological impact on the construction workforce. Construction of the VTR Reactor Facility and its associated structures (e.g., switchyard, operational support building), the test article post-irradiation examination and spent fuel treatment facility, and the spent fuel storage pad would occur outside of the current ORNL

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

The estimated number of accidental worker injuries and fatalities were based on the number of workers that would be involved in construction/facility modification activities and national worker injury and fatality rates. For a construction effort of this size, worker accidents would be expected. The site selected for the VTR facilities at ORNL is a wooded undeveloped site. Prior to facility construction, the land would be cleared and graded. This effort is expected to require 48 workers individually working for periods of a few days to several months over about a year (16 full-time, equivalent workers). At the peak of construction, about 500 to 750 workers would be involved in the construction of the VTR facilities (INL 2020f). Construction of the post-irradiation examination/spent fuel treatment and conditioning facility would require an additional 230 workers during peak construction periods. Construction of both facilities is projected to take 51 months. On average, an additional 14 workers would be involved in construction of the spent fuel storage pad over a 6-month span (7 full-time equivalent workers) (Leidos 2020). During the 51 months of construction, assuming the peak number of workers for the full duration of construction, there would be no expected fatalities (0.4) based on an average worker fatality rate in the construction industry of 9.5 fatalities per 100,000 worker years (BLS 2018a). In 2018, the national average for construction workers for accidents resulting in lost worker days was 2.9 accidents per 100 full-time workers (BLS 2018b). This accident rate results in an estimated 120 construction worker injuries during construction.

4.10.2.2 Operations

Public Health

Under the VTR at ORNL alternative, the annual radiological emissions from the VTR facilities would be no more than the quantities listed in **Table 4–41**. The difference between these facilities and those at the INL Site is that the entire radiological emissions from the new post-irradiation examination facility would be attributable to VTR related activities. While multiple facilities could be used for the post-irradiation examination of test specimens, most releases are expected to be from the new post-irradiation examination facility. All test specimens are transferred to this facility for handling and test preparation prior to being transferred to other facilities (such as the hot cells in Buildings 3025E and 3525 and the LAMDA facility). The specimens within the test assemblies would be removed from the test assembly at the new post-irradiation examination facility and prepared for examination within the facility hot cells. Releases associated with post-irradiation examination would be released through the new facility cell exhaust system. All emissions from the decontamination and main cells pass through a series of HEPA filters, additionally the main cell exhaust passes through an activated charcoal filter, before being released through the facility stack. Radiological emissions from the Spent Fuel Treatment and Conditioning Facility are associated with the treatment of the spent reactor fuel. Disassembly, sodium removal, and fuel packaging all occur within the facility hot cells. All emissions would be through the safety exhaust system, which includes HEPA filters, and out the facility stack (Leidos 2020).

Table 4–41. ORNL VTR Alternative – Radiological Emissions During Normal Operations

Nuclide	Emissions (curies per year)		
	VTR Reactor Facility	Post-Irradiation Examination Facility [a]	Spent Fuel Treatment and Conditioning Facility [a]
Americium-241	--	8.4×10^{-12}	--
Antimony-125	--	3.2×10^{-5}	1.57×10^{-7}
Argon-41	27.1	--	--
Cadmium-109	--	5.2×10^{-4}	--
Cadmium-113m	--		4.15×10^{-10}
Cadmium-115	--	1.0×10^{-7}	--
Carbon-14	--	3.1×10^{-4}	--
Cerium-144	--		1.41×10^{-6}
Cobalt-60	--	7.9×10^{-13}	2.08×10^{-9}
Cesium-134	--	8.0×10^{-7}	2.62×10^{-7}
Cesium-135	9.0×10^{-16}	--	--
Cesium-137	1.2×10^{-12}	2.5×10^{-2}	1.96×10^{-6}
Cesium-138	2.0×10^{-6}	--	--
Chlorine-36	--	1.0×10^{-5}	--
Europium-154	--	--	1.73×10^{-10}
Europium-155	--	--	2.07×10^{-9}
Hydrogen-3 (Tritium)	1.2	3.7×10^{-2}	510
Iodine-129	--	1.8×10^{-5}	--
Iodine-131	--	8.9×10^{-3}	--
Iron-55	--	--	5.50×10^{-8}
Krypton-83m	1.8×10^{-6}	--	--
Krypton-85	0.70	4.4×10^{-3}	8.25×10^{3}
Krypton-85m	3.5×10^{-6}	--	--
Krypton-87	4.8×10^{-6}	--	--
Krypton-88	8.9×10^{-6}	--	--
Neptunium-237	--	3.2×10^{-9}	--
Nickel-63	--	--	2.76×10^{-10}
Phosphorus-32	--	2.6×10^{-5}	--
Phosphorus-33	--	4.9×10^{-9}	--
Promethium-147	--	--	1.25×10^{-7}
Plutonium-238	--	1.2×10^{-10}	1.24×10^{-10}
Plutonium-239	--	9.5×10^{-8}	2.83×10^{-9}
Plutonium-240	--	3.0×10^{-12}	1.87×10^{-10}
Plutonium-241	--	--	1.17×10^{-9}
Plutonium-242	--	1.8×10^{-9}	--
Ruthenium-106	--	--	5.66×10^{-6}
Samarium-151	--	--	8.97×10^{-10}
Sodium-22	--	3.2×10^{-6}	--
Sodium-24	--	1.7×10^{-8}	--
Strontium-90	--	3.8×10^{-7}	3.47×10^{-8}
Sulfur-35	--	1.2×10^{-4}	--
Xenon-131m	1.6×10^{-2}	--	--
Xenon-133	1.0×10^{-3}	--	--
Xenon-133m	5.4×10^{-7}	--	--
Xenon-135	4.2×10^{-5}	--	--
Xenon-135m	1.5×10^{-6}	--	--
Xenon-137	7.4×10^{-7}	--	--
Xenon-138	4.4×10^{-6}	--	--

[a] Isotopes listed are generally limited to release of 10^{-10} curies or more. Both facilities are housed within the same structure.
Source: INL 2020f, SRNS 2020.

The movement of spent fuel from the VTR to the spent fuel storage pad, from the storage pad to the fuel treatment and conditioning facility, and from the fuel treatment and conditioning facility (treated and conditioned spent fuel) back to the storage pad would all be performed in sealed transfer/storage casks. Under normal conditions, no radiological releases would be expected from these casks. All of these activities occur well away from the general public, the nearest offsite member of the public would be at about a mile from the VTR facilities. There would be no risk of exposure to the public from direct exposure. Therefore, the storage and movement of spent fuel would have no radiological impact on the public.

Radiological impacts were estimated for the public living within 50 miles of the VTR located at the site near ORNL. **Table 4–42** shows the annual radiological impacts on the population projected to be living within a 50-mile radius of the VTR in 2050 (a population of about 1,618,000), and two individuals. Impacts are shown for an average member of the public and an offsite MEI (a hypothetical member of the public, who receives the maximum dose living at the ORNL VTR Alternative site boundary, in this instance, the site boundary southeast of the facility). (See Appendix C for additional information about the methodology used to generate these dose estimates.)

Table 4–42. ORNL VTR Alternative – Annual Radiological Impacts on the Public

	Maximally Exposed Individual	***Population Within 50 Miles*** [a]	***Average Individual within 50 Miles***
Dose	0.031 millirem	0.58 person-rem	3.6×10^{-4} millirem
Cancer fatality risk [b]	2×10^{-8}	0 (3×10^{-4})	2×10^{-10}
Regulatory dose limit [c]	10 millirem	Not applicable	10 millirem
Dose as a percentage of the regulatory limit	0.3	Not applicable	0.004
Dose from natural background radiation [d]	300 millirem	485,000 person-rem	300 millirem
Dose as a percentage of background dose	0.01	1×10^{-4}	1×10^{-4}

[a] The population dose for this table was based on a projected 2050 population estimate of 1,618,000 within 50 miles of the VTR at ORNL.
[b] Based on a risk estimator of 0.0006 LCFs per person-rem (DOE 2003).
[c] 40 CFR Part 61, Subpart H, establishes an annual limit of 10 millirem via the air pathway to any member of the public from DOE operations.
[d] Based on an individual annual dose of 300 millirem from natural background radiation to the projected population of about 1,618,000.

Table 4–42 shows the estimated population dose associated with VTR operations to be 0.58 person-rem per year. The MEI would receive an estimated annual dose of 0.031 millirem and the average annual dose to an individual in the population would be 3.6×10^{-4} millirem under this alternative. EPA and DOE have established an annual limit of 10 millirem to the individual via the air pathway from all DOE sources. Both the average individual and MEI doses from VTR operations would be about or less than 1 percent of this limit. Additionally, for comparison, the population and individual doses from exposure to natural background radiation levels for the INL Site are given. As shown in Table 4–42 the population and individual doses from VTR operation are below 0.01 percent of the dose from natural background radiation.

No LCFs would be expected within the general population. This population dose would increase the annual risk of a latent fatal cancer in the population by 3×10^{-4}. Another way of stating this is that the likelihood that one fatal cancer would occur in the population because of radiological releases associated with this alternative is about 1 chance in 3,000 per year. The corresponding increased risk of an individual developing a latent fatal cancer would be less than 1×10^{-10}, or less than 1 chance in 10 billion per year. For the MEI, an increased annual risk of developing a latent fatal cancer would be about 2×10^{-8}. In other words, the likelihood that the MEI would develop a fatal cancer is about 1 chance in 50 million for each year of operations.

Worker Health

Worker exposures would result from operations in the VTR facility, post-irradiation examination and spent fuel treatment in the new test article post-irradiation examination and spent fuel treatment and conditioning facility (hot cell facility). Additional worker exposure would result from the transfer of spent fuel between these three facilities and during storage at the spent fuel storage pad. Worker doses from this activity are expected to be a small percentage of the doses received from activities within the three facilities.

Transfer operations are an intermittent activity. During steady state operation of the facilities, the equivalent of up to 45 reactor fuel assemblies would be transferred from the VTR Reactor Facility to the storage pad, from the storage pad to the hot cell facility, and from the hot cell facility (in the form of treated and diluted spent fuel) back to the storage pad. Multiple reactor fuel assemblies would be placed in a single transfer/storage cask. The number of transfers would be significantly less than the number of assemblies moved. During transfer and storage, the spent fuel would be contained in transportation/ storage casks, limiting exposure to workers. DOE limits the dose resulting from the handling of these casks to 10 millirem per hour at a distance of 2 meters from the cask. Spent fuel handling would not impact the total worker exposure.

VTR operations are projected to require 200 staff (INL 2020f). This would include operators, maintenance personnel, radiological controls personnel, supervisors, and management. All would be radiation workers. Based on historical Fast Flux Test Facility operational dose and estimates for PRISM operations, the average individual occupational dose would be 100 millirem per year. The total dose to the work force would 20 person-rem per year.

Post-irradiation examination and spent fuel treatment and conditioning operations within the new facilities are projected to require 100 staff (full-time equivalents) (Leidos 2020).[2] Based on the total worker dose of 24 person-rem for these activities (assumed to be the same as for the equivalent operations at the INL Site), this would result in an average individual worker dose of 240 millirem per year.

The involved worker exposure from all VTR-related activities (reactor operation, post-irradiation examination, and spent fuel treatment) would result in a total annual worker dose of 44 person-rem per year with an average individual worker dose of 147 millirem per year for those workers directly supporting the VTR. This dose is not expected to result in any additional LCFs (calculated value of 0.03) among the workforce.

To protect workers from impacts from radiological exposure, 10 CFR Part 835 imposes an individual dose limit of 5,000 millirem in a year. In addition, worker doses are monitored and controlled below the regulatory limit to ensure that individual doses are less than an administrative limit of 2,000 millirem per year, and maintained at ALARA levels (DOE 2017f). ORNL would monitor worker doses and take appropriate action to limit individual worker doses below this administrative level.

The VTR facilities would be located about between 4,000 and 5,800 feet from the nearest permanently occupied ORNL facility. While other workers at ORNL would be exposed to the radiological emissions associated with the VTR facilities, the noninvolved worker dose would be minimal. Based on the radiological emissions identified previously (Table 4–41) the largest dose to a worker at other ORNL facilities was estimated. This noninvolved worker, located at the High Flux Irradiation Reactor (HFIR) complex, would receive a dose of 4.8×10^{-3} millirem per year. This exposure is not expected to result in an additional LCF and results in a small risk of an LCF (calculated value less than 3×10^{-9}).

[2] Totals do not include personnel, such as security, expected to receive negligible doses.

Safety and health requirements for DOE workers are governed by 10 CFR Part 851, which establishes requirements for a worker safety and health program to ensure that DOE workers have a safe work environment. Included are provisions to protect against hazardous chemicals. VTR workers could be exposed to hazardous chemicals during operation of the VTR facilities. For example, hazardous chemicals used in the post-irradiation examination facility include hydrochloric acid, sulfuric acid, acetone, and alcohol (INL 2020f). Generally, the quantity of material would be small, and in many cases, their use would be within areas not inhabited by workers (inside hot cells). Worker safety would not be impacted by the use of these hazardous chemicals.

Operational staff would also be susceptible to industrial accidents that could result in injury or death. The estimated number of accidental worker injuries and fatalities were based on the number of staff involved in operational activities and national worker injury and fatality rates. For an operation of this size, accidents would be expected. On average about 300 staff would be involved in VTR, post-irradiation, and spent fuel treatment operations (Leidos 2020). During each year of operation, there would be no expected fatalities (0.006) based on an average worker fatality rate in the manufacturing industry of 2.2 fatalities per 100,000 worker years (BLS 2018a). In 2018, the national average for manufacturing workers for accidents resulting in lost worker days was 3.1 accident per 100 full time workers (BLS 2018b). This accident rate results in an estimated nine staff injuries per year during operation.

4.10.3 Reactor Fuel Production Options

Two sites are being considered for reactor fuel production in support of the VTR. Reactor fuel production could be located within the MFC at the INL Site. Equipment would be installed in existing space, with minimal removal of existing equipment. Alternatively, reactor fuel production could be located in the K-Reactor Building at SRS. As at the INL Site, new equipment would be installed for fuel production.

For each site, two phases of reactor fuel production are evaluated. The first phase is a feedstock preparation capability. This phase involves the receipt of plutonium, which contains impurities, e.g., americium-241 (present as the result of the decay of plutonium-241 in 'older' plutonium) that would make the plutonium unsuitable for use as VTR driver fuel or plutonium in other than metal form (e.g., plutonium oxide). The presence of impurities impacts worker dose during operation and could impact the radiological emissions from the fuel fabrication facility. Potential additional impurities in emissions would influence public health. The feedstock preparation facility would address these issues by polishing the plutonium to meet VTR fuel specifications and reduce the involved worker dose rate and potential radiological emissions prior to fuel fabrication. The second phase of reactor fuel production would involve the alloying of plutonium with uranium and zirconium, and fabricating fuel pins and fuel assemblies.

4.10.3.1 INL Reactor Fuel Production Options

This section presents the impacts from establishing the reactor fuel production at the INL Site. Impacts would be from facility construction or modifications to the FCF, which provides the necessary capability for feedstock preparation and to the FMF and ZPPR facilities, which makes possible the fabrication of an alloy uranium-plutonium-zirconium (U-Pu-Zr) reactor fuel for the VTR. Impacts would also result from the operation of the feedstock preparation and fuel fabrication capabilities. Facility modifications and operations are described in Appendix B.

4.10.3.1.1 INL Feedstock Preparation Option

Construction/Facility Modification

Public Health

Modifications to FCF would have no radiological impact on the public. Required facility modifications in FCF involve the installation of new equipment, not major facility construction. No additional radiological emissions would be expected from these activities.

Worker Health

Modifications to the FCF would include the installation of the gloveboxes required for plutonium conversion (e.g., from oxide to metal) and plutonium polishing. (Equipment to be installed in the facilities have been described in Appendix B.) The area identified for the feedstock preparation equipment is a clean area (FCF Operating Floor/High Bay, the Mockup Area, and Workshop) (INL 2020g). Therefore, there would be no radiological impact on the workers installing the equipment.

Using the nonradiological fatality and injury rates provided in Section 4.10.2.1, no nonradiological impacts (fatalities or injuries) would be anticipated. This is due to the limited number of workers involved and the relatively short timeframe for construction.

Operations

Public Health

Under the INL Feedstock Preparation Option, the annual radiological emissions from FCF are expected to be no more than the quantities listed in **Table 4–43**. Radiological emissions would be expected to include americium-241, because this isotope builds up as plutonium-241 decays. Feedstocks of plutonium are assumed to have aged and not been polished. All emissions would be through the FCF exhaust system, which includes HEPA filters, and out the facility stack.

Table 4–43. INL Feedstock Preparation Option – Radiological Emissions During Normal Operations

Nuclide	*Emissions (curies per year)*	*Nuclide*	*Emissions (curies per year)*
Americium-241	6.6×10^{-4}	Uranium-232	5.8×10^{-12}
Plutonium-238	9.5×10^{-6}	Uranium-234	1.7×10^{-9}
Plutonium-239	9.6×10^{-6}	Uranium-235	1.5×10^{-11}
Plutonium-240	1.4×10^{-5}	Uranium-236	2.2×10^{-10}
Plutonium-241	2.0×10^{-4}	Uranium-238	4.3×10^{-11}
Plutonium-242	2.2×10^{-8}		

Source: SRNS 2020.

Radiological impacts were estimated for the public living within 50 miles of the spent fuel facility located in the FMF. **Table 4–44** shows the annual radiological impacts on the population projected to be living within a 50-mile radius of the fuel fabrication facility in 2050, a population of about 364,000, and two individuals. Impacts are shown for an average member of the public, and an offsite MEI (a hypothetical member of the public, who receives the maximum dose residing at the INL Site boundary, in this instance, the site boundary south of the facility). (See Appendix C for additional information about the methodology used to generate these dose estimates.)

Table 4–44. INL Feedstock Preparation Option – Annual Radiological Impacts on the Public

	Maximally Exposed Individual	*Population within 50 Miles* [a]	*Average Individual within 50 Miles*
Dose	0.0012 millirem	0.012 person-rem	3.2×10^{-5} millirem
Cancer fatality risk [b]	7×10^{-10}	0 (7×10^{-6})	less than 10^{-10}
Regulatory dose limit [c]	10 millirem	Not applicable	10 millirem
Dose as a percentage of the regulatory limit	0.01	Not applicable	3×10^{-4}
Dose from natural background radiation [d]	383 millirem	139,000 person-rem	383 millirem
Dose as a percentage of background dose	0.0003	0.000008	0.000008

[a] The population dose for this table was based on a projected 2050 population estimate of about 364,000 within 50 miles of the VTR at the INL Site.

[b] Based on a risk estimator of 0.0006 LCFs per person-rem (DOE 2003).

[c] 40 CFR Part 61, Subpart H, establishes an annual limit of 10 millirem via the air pathway to any member of the public from DOE operations.

[d] Based on an individual annual dose of 383 millirem from natural background radiation to the projected population of about 364,000.

Table 4–44 shows the estimated population dose associated with feedstock preparation operations to be 0.012 person-rem per year. The MEI would receive an estimated annual dose of 0.0012 millirem and the average annual dose to an individual in the population would be 3.2×10^{-5} millirem under this alternative. EPA and DOE have established an annual limit of 10 millirem to the individual via the air pathway from all DOE sources. Both the average individual and MEI dose from feedstock preparation would be less than 0.1 percent of this limit. Additionally, the population and individual doses from exposure to natural background radiation levels for the INL Site are compared. As shown in Table 4–44 the population and individual doses from feedstock preparation operations are well below 0.001 percent of the dose from natural background radiation.

No LCFs would be expected within the general population. This population dose would increase the annual risk of a latent fatal cancer in the population by 7×10^{-6}. Another way of stating this is that the likelihood that one fatal cancer would occur in the population because of radiological releases associated with this INL Feedstock Preparation Option is about 1 chance in 140,000 per year. The corresponding increased risk of an individual developing a latent fatal cancer would be less than 1×10^{-10}, or about 1 chance in 10 billion] per year. For the MEI, an increased annual risk of developing a latent fatal cancer would be about 7×10^{-10}. In other words, the likelihood that the MEI would develop a fatal cancer is about 1 chance in a billion for each year of operations.

Worker Health

Staffing projections estimate about 300 additional operations staff, which includes workers for feedstock preparation and waste handling. All would be radiation workers (SRNS 2020). The gloveboxes to be used during fuel fabrication would use shielding and radiological designs adequate to limit operator radiological exposure. The final design would consider additional/alternative shielding concepts and automation opportunities to further reduce projected worker doses. Additionally, the site may rotate workers between higher and lower dose activities to limit individual exposures. Estimates of individual worker doses would range from 0.05 rem per year for supporting personnel to 0.2 rem per year per person to 0.75 rem per year per glovebox operator (SRNS 2020). Based on this range of worker doses, the total worker dose would be 51 person-rem per year. The annual individual risk of cancer from the average worker dose of about 170 millirem would not result in an LCF (probability of 1×10^{-4}) and the 0.75 rem per year maximum individual worker dose also would not result in an LCF (probability of 0.0005). The total worker dose would not result in an LCF among the worker population (calculated value of 0.03).

The feedstock preparation facilities would be located within the MFC (in FCF). Other workers within the MFC would be exposed to the radiological emissions associated with the VTR facilities. Based on the radiological emissions identified previously (Table 4–43) the dose to a noninvolved worker within the MFC was estimated. This noninvolved worker would receive a dose of about 0.002 millirem per year. This exposure is not expected to result in an additional LCF and results in a low risk of an LCF (calculated risk value of 1×10^{-9}).

Safety and health requirements for DOE workers are governed by 10 CFR Part 851, which establishes requirements for a worker safety and health program to ensure that DOE workers have a safe work environment. Included are provisions to protect against hazardous chemicals. Workers within the FCF facility are protected by the majority of chemical hazards to which they are exposed by the use of gloveboxes and other enclosures. In the rare instance that these devices fail, workers could potentially be exposed to sodium, toxic metals (such as uranium and plutonium), and inert gases such as argon, which poses an asphyxiant concern.

Operational staff would also be susceptible to industrial accidents that could result in injury or death. The estimated number of accidental worker injuries and fatalities were based on the number of staff involved in feedstock preparation activities and national worker injury and fatality rates. For an operation of this size, accidents would be expected. On average about 300 staff would be involved in feedstock preparation operations (SRNS 2020). During each year of operation, there would be no expected fatalities (0.007) based on an average worker fatality rate in the manufacturing industry of 2.2 fatalities per 100,000 worker years (BLS 2018a). In 2018, the national average for manufacturing workers for accidents resulting in lost worker days was 3.1 accident per 100 full time workers (BLS 2018b). This accident rate results in an estimated nine staff injuries per year during operation.

4.10.3.1.2 INL Fuel Fabrication Option

Construction/Facility Modification

Public Health

Modifications to existing FMF and ZPPR MFC facilities would have no radiological impact on the public. Required facility modifications in the FMF and ZPPR involve the installation of new equipment, not major facility construction. No additional radiological emissions would be expected from these activities.

Required modifications are described in Appendix B.

Worker Health

Modifications to the FMF and ZPPR would include the installation of the gloveboxes required for fuel alloying and fuel pin assembly in FMF and assembly fabrication in ZPPR. (Equipment to be installed in the facilities have been described in Appendix B.) These modifications have a construction timeline of 3 years and would involve about 6 construction workers. Modifications would require a variety of different workers with varying levels of effort within the facility dependent upon particular construction tasks. Typically, these workers would be anticipated to work a standard, 40-hour workweek, with up to 20 percent overtime if needed to meet construction schedules. The radiation environment in the areas where the work would be performed is typically less than 0.5 millirem per hour (INL 2020f).

The average annual individual worker dose would be less than 1.2 rem and the total annual worker dose would be less than 7.2 person-rem. Average individual and total worker doses for the modification effort would be less than 3.6 rem and 21 person-rem. No additional LCFs (0.01) would be anticipated from this modification effort. This estimate of worker dose is likely conservative in that no INL Site worker during the years 2014 to 2018 received an individual dose in excess of 750 millirem (see Chapter 3, Section 3.1.10.1).

Using the nonradiological fatality and injury rates given in Section 4.10.2.1, no nonradiological impacts (fatalities or injuries) would be anticipated. This is due to the limited number of workers involved and the relatively short time frame for construction.

Operations

Public Health

Under the INL fuel fabrication option, the annual radiological emissions from the fuel fabrication facility within the FMF are expected to be no more than the quantities listed in **Table 4–45**. Plutonium feedstock under this option is assumed to have been recently polished (e.g., during feedstock preparation). Therefore, little or no americium-241 would be in the radiological emissions. Radiological emissions would primarily come from operations in the FMF, not in the ZPPR. Only fully assembled fuel pins are transferred to ZPPR. The fuel pins are completely sealed and assembly fabrication does not involve mechanically altering (e.g., cutting) the fuel pins. All emissions would be through the FMF exhaust system, which includes HEPA filters, and out the facility stack.

Table 4–45. INL Fuel Fabrication Option – Radiological Emissions During Normal Operations

Nuclide	*Emissions (curies per year)*	*Nuclide*	*Emissions (curies per year)*
Americium-241	3.3×10^{-4}	Uranium-232	7.3×10^{-12}
Plutonium-238	2.3×10^{-6}	Uranium-234	2.2×10^{-9}
Plutonium-239	3.7×10^{-6}	Uranium-235	1.9×10^{-11}
Plutonium-240	2.4×10^{-6}	Uranium-236	2.8×10^{-10}
Plutonium-241	5.7×10^{-5}	Uranium-238	5.4×10^{-11}
Plutonium-242	1.7×10^{-9}		

Source: SRNS 2020.

Radiological impacts were estimated for the public living within 50 miles of the fuel fabrication facility located in the FMF. **Table 4–46** shows the annual radiological impacts on the population projected to be living within a 50-mile radius of the fuel fabrication facility in 2050 (a population of about 364,000) and two individuals. Impacts generated for an average member of the public and an offsite MEI (a hypothetical member of the public, who receives the maximum dose while residing at the INL Site boundary, in this instance, south of the facility). (See Appendix C for additional information about the methodology used to generate these dose estimates.)

Table 4–46. INL Fuel Fabrication Option – Annual Radiological Impacts on the Public

	Maximally Exposed Individual	*Population within 50 Miles* [a]	*Average Individual within 50 Miles*
Dose	0.0016 millirem	0.0053 person-rem	1.5×10^{-5} millirem
Cancer fatality risk [b]	1×10^{-9}	0 (3×10^{-6})	less than 1×10^{-10}
Regulatory dose limit [c]	10 millirem	Not applicable	10 millirem
Dose as a percentage of the regulatory limit	0.02	Not applicable	0.0002
Dose from natural background radiation [d]	383 millirem	139,000 person-rem	383 millirem
Dose as a percentage of background dose	0.0004	0.000004	0.000004

[a] The population dose for this table was based on a projected 2050 population estimate of 364,300 within 50 miles of the VTR at the INL Site.

[b] Based on a risk estimator of 0.0006 LCFs per person-rem (DOE 2003).

[c] 40 CFR Part 61, Subpart H, establishes an annual limit of 10 millirem via the air pathway to any member of the public from DOE operations.

[d] Based on an individual annual dose of 383 millirem from natural background radiation to the projected population of 364,000.

Table 4–46 shows the estimated population dose associated with fuel fabrication facility operations to be 0.0053 person-rem per year. The MEI would receive an estimated annual dose of 0.0016 millirem and the average annual dose to an individual in the population would be 1.5×10^{-5} millirem under this alternative. EPA and DOE have established an annual limit of 10 millirem to the individual via the air pathway from all DOE sources. Both the average individual and MEI dose from fuel fabrication operation would be less than 0.1 percent of this limit. Additionally, the population and individual doses from exposure to natural background radiation levels for the INL Site are compared. As shown in Table 4–46, the population and individual doses from operating the fuel fabrication facility are well below 0.01 percent of the dose from natural background radiation.

No LCFs would be expected within the general population, this population dose would increase the annual risk of a latent fatal cancer in the population by 3×10^{-6}. Another way of stating this is that the likelihood that one fatal cancer would occur in the population because of radiological releases associated with this option is about 1 chance in 300,000 per year. The corresponding increased risk of an individual developing a latent fatal cancer would be less than 1×10^{-10}, or less than 1 chance in 10 billion per year. For the MEI an increased annual risk of developing a latent fatal cancer would be about 1×10^{-9}. In other words, the likelihood that the MEI would develop a fatal cancer is about 1 chance in a billion for each year of operations.

Worker Health

Staffing projections estimate about 70 additional operations staff, of which 61 are involved in VTR fuel fabrication and 9 are associated with the additional analytical chemistry efforts. These staff positions would be in addition to current staffing levels, and all would be radiation workers (INL 2020f). An estimated total of 300 existing and new staff would be involved with fuel fabrication (SRNS 2020). The gloveboxes to be used during fuel fabrication would use shielding and radiological designs adequate to limit operator radiological exposure. The final design would consider additional or different shielding concepts and automation opportunities to further reduce projected worker doses. Estimates of individual worker doses would range from 0.05 rem per year for supporting personnel to 0.2 to 0.75 rem per year per glovebox operator (SRNS 2020). Based on this range of worker doses, the total worker dose would be 51 person-rem per year. The annual individual risk of cancer from the average worker dose of about 170 millirem would not result in an LCF (probability of 0.0001) and the 0.75 rem per year maximum individual worker dose also would not result in an LCF (probability of 0.0005). The total annual worker dose would not result in an LCF among the worker population (calculated value of 0.03).

Some of the worker dose would be incurred by current workers and would not result in a cumulative increase in worker dose. It has been assumed that the 70 new workers would be among those receiving the highest dose from fuel fabrication activities. In that case, these workers would receive a total dose of about 32 person-rem (out of the 51 person-rem dose received by all workers). This annual dose would not result in an LCF (0.02) among these workers. The average worker dose for these employees would be 460 millirem.

The fuel fabrication facilities would be located within the MFC (in the FMF and ZPPR facilities). Other workers within the MFC would be exposed to the radiological emissions associated with the VTR facilities. Based on the radiological emissions identified previously (Table 4–45) the dose to a noninvolved worker within the MFC was estimated. This noninvolved worker would receive a dose of about 0.067 millirem per year. This exposure is not expected to result in an additional LCF, and results in a low risk of an LCF (calculated risk value of 4×10^{-8}).

Section 4.10.3.1.1 discusses worker protection from chemical hazards.

Operational staff would also be susceptible to industrial accidents that could result in injury or death. The estimated number of accidental worker injuries and fatalities were based on the number of staff involved in fuel fabrication activities and national worker injury and fatality rates. For an operation of this size, accidents would be expected. On average about 300 staff would be involved in fuel fabrication operations (SRNS 2020). During each year of operation, there would be no expected fatalities (0. 007) based on an average worker fatality rate in the manufacturing industry of 2.2 fatalities per 100,000 worker years (BLS 2018a). In 2018, the national average for manufacturing workers for accidents resulting in lost worker days was 3.1 accident per 100 full time workers (BLS 2018b). This accident rate results in an estimated 9 staff injuries per year during operation.

4.10.3.2 SRS Reactor Fuel Production Options

This section presents the possible impacts of establishing feedstock preparation and fuel fabrication capabilities at SRS. Impacts would be from facility modifications (equipment installation) to the 105-K Building to offer the necessary technologies for feedstock preparation (conversion and polishing) and fuel fabrication of a metal uranium-plutonium-zirconium fuel for the VTR. (Modifications required for the 105-K Building are described in Appendix B.) Additionally, existing equipment would have to be removed.

4.10.3.2.1 SRS Feedstock Preparation Option

Construction/Facility Modification

Public Health

Modifications to the 105-K Building would have no radiological impact on the public. Required facility modifications in the building involve the installation of new equipment, not major facility construction. No additional radiological emissions would be expected from these activities. Modifications are described in Appendix B.

Worker Health

The majority of the K Area Complex being considered for use for feedstock preparation is clean. However, there is the potential of using some footprint that is slightly contaminated (e.g., K-Assembly basement). Based upon an analysis for a similar space in K Area, the construction effort to decontaminate and roll back contaminated space could result in a dose of 50 millirem per person for a crew of 25 construction and radiological controls personnel over a 3-year period. The total worker dose for the entire decontamination effort would be 1.3 person-rem. No LCFs (0.0008) would be expected among the construction workforce.

After the areas are decontaminated, equipment installation would not be expected to result in radiological exposure to the installation workers.

Nonradiological injuries and fatalities during construction are based on the duration of construction and the number of workers involved. Construction for feedstock preparation at SRS is estimated to take 3 years and the number of workers would be expected to rapidly reach the peak number of workers (120) and remain at this level for the duration of construction. Using the nonradiological fatality and injury rates provided in Section 4.10.2.1, there would be no expected fatalities (0.003) and an estimated 10 construction worker injuries during construction.

Operations

Public Health

Under the feedstock preparation at SRS option, the annual radiological emissions from the fuel fabrication facility within the 105-K Building are expected to be as shown in **Table 4–47**. All emissions would be through a new 105-K Building exhaust system, which includes HEPA filters, and out a new facility stack (SRNS 2020). The existing K area exhaust system would not be used.

Table 4–47. SRS Feedstock Preparation Option – Radiological Emissions During Normal Operations

Nuclide	*Emissions (curies per year)*	*Nuclide*	*Emissions (curies per year)*
Americium-241	6.6×10^{-4}	Uranium-232	5.8×10^{-12}
Plutonium-238	9.5×10^{-6}	Uranium-234	1.7×10^{-9}
Plutonium-239	9.6×10^{-6}	Uranium-235	1.5×10^{-11}
Plutonium-240	1.4×10^{-5}	Uranium-236	2.2×10^{-10}
Plutonium-241	2.0×10^{-4}	Uranium-238	4.3×10^{-11}
Plutonium-242	2.2×10^{-8}		

Source: SRNS 2020.

Radiological impacts were estimated for the public living within 50 miles of the reactor fuel production capabilities located in the 105-K Building. **Table 4–48** shows the annual radiological impacts on the population projected to be living within a 50-mile radius of the facility in 2050, a population of about 889,000, and two individuals. Impacts are generated for an average member of the public and an offsite MEI (a hypothetical member of the public who receives the maximum dose residing at the SRS site boundary, in this instance, the site boundary south-southwest of the facility). (See Appendix C for additional information about the methodology used to generate these dose estimates.)

Table 4–48. SRS Feedstock Preparation Option – Annual Radiological Impacts on the Public

	Maximally Exposed Individual	*Population within 50 Miles* [a]	*Average Individual within 50 Miles*
Dose	0.0015 millirem	0.042 person-rem	4.7×10^{-5} millirem
Cancer fatality risk [b]	9×10^{-10}	0 (2×10^{-5})	less than 1×0^{-10}
Regulatory dose limit [c]	10 millirem	Not applicable	10 millirem
Dose as a percentage of the regulatory limit	0.02	Not applicable	0.0004
Dose from natural background radiation [d]	311 millirem	276,000 person-rem	311 millirem
Dose as a percentage of background dose	0.0005	0.00002	0.00002

[a] The population dose for this table was based on a projected 2050 population estimate of about 889,000 within 50 miles of the K Area Complex at the Savannah River Site.

[b] Based on a risk estimator of 0.0006 LCFs per person-rem (DOE 2003).

[c] 40 CFR Part 61, Subpart H, establishes an annual limit of 10 millirem via the air pathway to any member of the public from DOE operations.

[d] Based on an individual annual dose of 311 millirem from natural background radiation to the projected population of about 889,000.

Table 4–48 shows the estimated population dose associated with feedstock preparation operations to be 0.042 person-rem per year. The MEI would receive an estimated annual dose of 0.0015 millirem and the average annual dose to an individual in the population would be 4.7×10^{-5} millirem. EPA and DOE have established an annual limit of 10 millirem to the individual via the air pathway from all DOE sources. Both the average individual and MEI doses from feedstock preparation operations would be less than 0.1 percent of this limit. Additionally, the population and individual doses from exposure to natural background radiation levels for SRS area are compared. As shown in Table 4–48 the population and individual doses from feedstock preparation operations are well below 0.001 percent of the dose from natural background radiation.

No LCFs would be expected within the general population; the population dose from feedstock preparation would increase the annual risk of a latent fatal cancer in the population by about 2×10^{-5}. Another way of stating this is that the likelihood that one fatal cancer would occur in the population because of radiological releases would be about 1 chance in 40,000 per year. The corresponding increased risk of an individual developing a latent fatal cancer would be less than 1×10^{-10} or less than 1 chance in 10 billion per year. For the MEI an increased annual risk of developing a latent fatal cancer would be about 9×10^{-10}. In other words, the likelihood that the MEI would develop a fatal cancer is about 1 chance in a billion for each year of operations.

***Worker Health*[3]**

Staffing projections estimate about 300 additional operations staff, which includes workers for feedstock preparation and waste handling. All would be radiation workers (SRNS 2020). The gloveboxes to be used during fuel fabrication would use shielding and radiological designs adequate to limit operator radiological exposure. The final design would consider additional/alternative shielding concepts and automation opportunities to further reduce projected worker doses. Additionally, the site may rotate workers between higher and lower dose activities to limit individual exposures. Estimates of individual worker doses would range from 0.05 rem per year for supporting personnel to 0.2 rem per year per person to 0.75 rem per year per glovebox operator (SRNS 2020). Based on this range of worker doses, the total worker dose would be 51 person-rem per year. The annual individual risk of cancer from the average worker dose of about 170 millirem would not result in an LCF (probability of 1×10^{-4}) and the 0.75 rem per year maximum individual worker dose also would not result in an LCF (probability of 0.0005). The total worker dose would not result in an LCF among the worker population (calculated value of 0.03).

The feedstock preparation facilities would be located within the K-Reactor Building. Other workers within the K Area would be exposed to the radiological emissions associated with the VTR facilities. Based on the radiological emissions identified previously (Table 4–47) the dose to a worker within the MFC was estimated. This noninvolved worker would receive a dose of about 0.0061 millirem per year. This exposure is not expected to result in an additional LCF, and results in a low risk of an LCF (calculated risk value of 4×10^{-9}).

Section 4.10.3.1.1 discusses worker protection from chemical hazards.

Operational staff would also be susceptible to industrial accidents that could result in injury or death. The estimated number of accidental worker injuries and fatalities were based on the number of staff involved in feedstock preparation activities and national worker injury and fatality rates. For an operation of this size, accidents would be expected. On average about 300 staff would be involved in feedstock preparation operations (SRNS 2020). During each year of operation, there would be no expected fatalities (0.007) based on an average worker fatality rate in the manufacturing industry of 2.2 fatalities per 100,000 worker years (BLS 2018a). In 2018, the national average for manufacturing workers for accidents resulting in lost worker days was 3.1 accident per 100 full time workers (BLS 2018b). This accident rate results in an estimated nine staff injuries per year during operation.

4.10.3.2.2 SRS Fuel Fabrication Option

Construction/Facility Modification

Public Health

Modifications to the 105-K Building would have no radiological impact on the public. Required facility modifications in the building involve the installation of new equipment, not major facility construction. No additional radiological emissions would be expected from these activities.

Worker Health

The majority of the K Area Complex being considered for use for VTR fuel fabrication is clean. However, there is the potential of using some footprint that is slightly contaminated (e.g., K-Assembly basement).

[3] In addition to the DOE administrative limit of 2 rem per year per worker, SRS has a site administrative limit of 500 millirem per year per worker (SRNS 2020).

Based upon an analysis for a similar space in K Area, the construction effort to decontaminate and roll back contaminated space could result in a dose of 30 millirem per person for a crew of 25 construction and radiological control personnel over a three-year period (SRNS 2020). The total worker dose for the entire decontamination effort would be 0.8 person-rem. No LCFs (0.0005) would be expected among the construction workforce.

Once the areas are decontaminated, equipment installation would not be expected to result in radiological exposure to the installation workers.

Nonradiological injuries and fatalities during construction are based on the duration of construction and the number of workers involved. Construction for fuel fabrication at SRS is estimated to take three years and the number of workers would be expected to rapidly reach the peak number of workers (120) and remain at this level for the duration of construction. Using the nonradiological fatality and injury rates provided in Section 4.10.2.1, there would be no expected fatalities (0.003) and an estimated 10 construction worker injuries during construction.

Operations

Public Health

Under the SRS fuel fabrication option, the annual radiological emissions from the fuel fabrication within the 105-K Building are expected to be the same as those estimated for the INL Site fuel fabrication option, see Table 4–45. All emissions would be through a new 105-K Building exhaust system, which includes HEPA filters, and out a new facility stack. The existing K area exhaust system would not be used.

Radiological impacts were estimated for the public living within 50 miles of the fuel fabrication capability located in the 105-K Building. **Table 4–49** shows the annual radiological impacts on the population projected to be living within a 50-mile radius of the facility in 2050, a population of about 889,000, and two individuals. Impacts are generated for an average member of the public and an offsite MEI (a hypothetical member of the public who receives the maximum dose while residing at the SRS site boundary, in this instance, the site boundary south-southwest of the facility). (See Appendix C for additional information about the methodology used to generate these dose estimates.)

Table 4–49. SRS Fuel Fabrication Option – Annual Radiological Impacts on the Public

	Maximally Exposed Individual	***Population Within 50 Miles*** [a]	***Average Individual within 50 Miles***
Dose	0.00071 millirem	0.020 person-rem	2.3×10^{-5} millirem
Cancer fatality risk [b]	4×10^{-10}	0 (1×10^{-5})	less than 1×10^{-10}
Regulatory dose limit [c]	10 millirem	Not applicable	10 millirem
Dose as a percentage of the regulatory limit	0.007	Not applicable	2×10^{-4}
Dose from natural background radiation [d]	311 millirem	276,000 person-rem	311 millirem
Dose as a percentage of background dose	0.0002	0.000007	0.000007

[a] The population dose for this table was based on a projected 2050 population estimate of about 889,000 within 50 miles of the K Area Complex at the Savannah River Site.

[b] Based on a risk estimator of 0.0006 LCFs per person-rem (DOE 2003).

[c] 40 CFR Part 61, Subpart H, establishes an annual limit of 10 millirem via the air pathway to any member of the public from DOE operations.

[d] Based on an individual annual dose of 311 millirem from natural background radiation to the projected population of about 889,000.

Table 4–49 shows the estimated population dose associated with fuel fabrication facility operations to be 0.020 person-rem per year. The MEI would receive an estimated annual dose of 0.00071 millirem and the average annual dose to an individual in the population would be 2.3×10^{-5} millirem under this alternative. EPA and DOE have established an annual limit of 10 millirem to the individual via the air pathway from all DOE sources. Both the average individual and MEI doses from fuel fabrication operation would be less than 0.1 percent of this limit. Additionally, for comparison, the population and individual doses from exposure to natural background radiation levels for the INL Site are provided. As shown in Table 4–49 the population and individual doses from operating the fuel fabrication facility are well below 0.001 percent of the dose from natural background radiation.

No LCFs would be expected within the general population, this population dose would increase the annual risk of a latent fatal cancer in the population by 1×10^{-5}. Another way of stating this is that the likelihood that one fatal cancer would occur in the population because of radiological releases associated with this option is about 1 chance in 80,000 per year. The corresponding increased risk of an individual developing a latent fatal cancer would be less than 1×10^{-10}, or less than 1 chance in 10 billion per year. For the MEI an increased annual risk of developing a latent fatal cancer would be about 4×10^{-10}. In other words, the likelihood that the MEI would develop a fatal cancer is about 1 chance in 2 billion for each year of operations.

***Worker Health*[4]**

Staffing projections estimate about 300 additional operations staff, which includes workers for fuel fabrication and waste handling. All would be radiation workers (SRNS 2020). The gloveboxes to be used during fuel fabrication would use shielding and radiological designs adequate to limit operator radiological exposure. The final design would consider additional/alternative shielding concepts and automation opportunities to further reduce projected worker doses. Additionally, the site may rotate workers between higher and lower dose activities to limit individual exposures. Estimates of individual worker doses would range from 0.05 rem per year for supporting personnel to 0.2 to 0.75 rem per year per glovebox operator (SRNS 2020). Based on this range of worker doses, the total worker dose would be 51 person-rem per year. The annual individual risk of cancer from the average worker dose of about 170 millirem would not result in an LCF (probability of 1×10^{-4}) and the 0.75 rem per year maximum individual worker dose also would not result in an LCF (probability of 0.0005). The total worker dose would not result in an LCF among the worker population (calculated value of 0.03).

The fuel fabrication facilities would be located within the K-Reactor Building. Other workers within the K Area would be exposed to the radiological emissions associated with the VTR facilities. Based on the radiological emissions identified previously (Table 4–45) the dose to a worker within the MFC was estimated. This noninvolved worker would receive a dose of about 0.0030 millirem per year. This exposure is not expected to result in an additional LCF and results in a low risk of an LCF (calculated risk value of 2×10^{-9}).

Section 4.10.3.1.1 discusses worker protection from chemical hazards.

Operational staff would also be susceptible to industrial accidents that could result in injury or death. The estimated number of accidental worker injuries and fatalities were based on the number of staff involved in fuel fabrication activities and national worker injury and fatality rates. For an operation of this size, accidents would be expected. On average about 300 staff would be involved in fuel fabrication operations (SRNS 2020). During each year of operation, there would be no expected fatalities (0.007) based on an

[4] In addition to the DOE administrative limit of 2 rem per year per worker, SRS has a site administrative limit of 500 millirem per year per worker.

average worker fatality rate in the manufacturing industry of 2.2 fatalities per 100,000 worker years (BLS 2018a). In 2018, the national average for manufacturing workers for accidents resulting in lost worker days was 3.1 accident per 100 full time workers (BLS 2018b). This accident rate results in an estimated 9 staff injuries per year during operation.

4.10.4 Combined INL VTR Alternative and INL Reactor Fuel Production Impacts

This section presents the total human health impacts from normal operations that would occur at the INL Site if the INL VTR Alternative and the INL option for both phases of reactor fuel production (feedstock preparation and fuel fabrication) were implemented at the INL Site. **Table 4–50** provides a summary of the individual impacts and a summation of impacts from the INL VTR Alternative and the two phases of reactor fuel production.

Table 4–50. Human Health Impacts for the Combined INL VTR Alternative and Reactor Fuel Production Options

Impact		*VTR Alternative*		*Feedstock Preparation Option*		*Fuel Fabrication Option*		*Total*	
		Construction	*Operation*	*Construction*	*Operation*	*Construction*	*Operation*	*Construction*	*Operation*
Public Health									
Population	Dose (person-rem)	NA	0.044	NA	0.012	NA	0.0053	NA	0.060
	LCF	NA	0 (3×10^{-5})	NA	0 (7×10^{-6})	NA	0 (3×10^{-6})	NA	0 (4×10^{-5})
MEI	Dose (millirem)	NA	0.0068	NA	0.0012	NA	0.0016	NA	0.0096
	LCF	NA	4×10^{-9}	NA	7×10^{-10}	NA	1×10^{-9}	NA	6×10^{-9}
Average Individual	Dose (millirem)	NA	0.00012	NA	3.2×10^{-5}	NA	1.5×10^{-5}	NA	0.00017
	LCF [a]	NA	0	NA	0	NA	0	NA	1×10^{-10}
Involved Worker Health									
Average individual worker - Annual	Dose (millirem)	500	150	NA	170	1,200	170	760	160
	LCF	0.0003	9×10^{-5}	NA	0.0001	0.0007	0.0001	0.0005	0.0001
Total Worker – Annual	Dose (person-rem)	5	53	NA	51	7.2	51	12	160
	LCF	0.003	0.03	NA	0.03	0.004	0. 03	0.007	0.1
Total Worker – Construction Duration	Dose (person-rem)	10	NA	NA	NA	21	NA	31	NA
	LCF	0.006	NA	NA	NA	0.01	NA	0.02	NA
Noninvolved Worker Health									
Noninvolved Worker [b]	Dose (millirem)	NA	0.0021	NA	0.0017	NA	0.067	NA	0.071
	LCF	NA	1×10^{-9}	NA	1×10^{-9}	NA	4×10^{-8}	NA	4×10^{-8}

[a] Individually the LCF for each alternative/option is less than 1×10^{-10}.

[b] Doses to noninvolved workers have been conservatively assumed to impact the same noninvolved worker. Emissions from the activities are from 3 different locations, the noninvolved worker for each activity is located at different locations within the MFC.

4.11 Human Health – Facility Accidents

This section contains analysis of radiological impacts from postulated accidents on workers and the general population. Hazardous material releases are not addressed in this section but are presented in Appendix D. Intentional destructive acts are enveloped by the beyond-design-basis accident discussed in Appendix D and not discussed in this section. Details about the assumptions and methods used to evaluate the impacts on human health from postulated accidents at DOE facilities are summarized in Appendix D of this VTR EIS.

Human health risks from construction, normal operations, and facility accidents are considered for individual receptors and population groups. Depending on the source of radiation exposure (and whether normal or accidental conditions are being considered), these receptors and population groups include involved and noninvolved workers, the offsite population, and an MEI member of the public within the offsite population.

> **Involved worker** is someone directly or indirectly involved with VTR operations at either the INL MFC or ORNL or fuel fabrication at either INL MFC or SRS who may receive an occupational radiation dose from direct radiation (i.e., neutron, x-ray, beta, or gamma) or from radionuclides released to the environment. Direct exposure from handling plutonium materials within a facility would be the chief source of occupational exposure for onsite workers (primarily from gamma radiation emitted by americium-241).
>
> **Noninvolved worker (NIW)** is a site worker outside of the facility who would not be subject to direct radiation exposure but could be incidentally exposed to emissions from the VTR or fuel fabrication related accidents if they occurred.
>
> **Offsite population** comprises members of the general public who live within 50 miles of the facility being evaluated.
>
> **Maximally exposed individual (MEI)** is a hypothetical individual at a location of public access that would result in the highest exposure; considered to be located at Highway 20 at INL MFC, the nearest public access on Melton Lake at ORNL, and the site boundary at SRS.

DOE uses the term "latent cancer fatality" or LCF to represent the potential human health impacts of exposure to radiation. LCFs are estimated by multiplying the radiation dose by a factor (risk estimator) representing the rate at which radiation exposure could result in latent mortality. Estimates of potential LCFs are provided in this VTR EIS using a risk estimator of 0.0006 LCFs per rem or person-rem (DOE 2003). For doses equal to or greater than 20 rem resulting from an acute exposure, the risk estimator is doubled (ICRP 1991).[5]

Potential accident scenarios have been identified for the INL MFC, ORNL, and SRS facilities, including the VTR at the INL MFC and ORNL; the VTR fuel fabrication facility at the INL MFC and the SRS; and the post-irradiation examination facility, the spent fuel treatment facility, and the spent fuel storage pad at the INL MFC and ORNL. The analysis in this EIS includes accident scenarios and consequences. The analysis includes accidents that have a low frequency of occurrence, but large consequences, and a spectrum of other accidents that have higher frequencies of occurrence and smaller consequences.

Each of the facilities addressed in this EIS in which VTR reactor or supporting activities would occur have been (or would be) designed and operated to reduce the likelihood of these accidents. For these facilities, sufficient safety controls are expected to be in place so that the probability of accidental releases would be "extremely unlikely" or lower; and if the accidents were initiated, the consequences would likely be much less than those reported in this VTR EIS. Accident frequencies are generally grouped into the bins of "anticipated," "unlikely," "extremely unlikely," and "beyond extremely unlikely," with estimated

[5] DOE considers LCFs less than 0.5 to be 0. The rounded LCF value is provided in the tables and the text, followed by the calculated value in parentheses.

frequencies of greater than 1×10^{-2}, 1×10^{-2} to 1×10^{-4}, 1×10^{-4} to 1×10^{-6}, and less than 1×10^{-6} per year, respectively.

For each potential accident, impacts are estimated for three receptors: a noninvolved worker, an MEI, and the offsite population within 50 miles projected to the year 2050. Consequences for these receptors were estimated without regard for emergency response measures (e.g., evacuation, sheltering). Consequences to the public were evaluated for both the near-term due to passage of a plume of radioactive materials following an accident and over the longer term after the plume has passed. Potential longer-term impacts due to chronic exposures to radionuclides remaining after the plume passage due to various pathways, including resuspension of remaining particulates and ingestion of contaminated food presented in Appendix D. The food pathway could be the largest source of longer-term dose from accidents releasing fission products unless mitigated by the interdiction of the nearby food chain

Consequences for workers directly involved in the processes under consideration are not quantified. The uncertainties involved in quantifying accident consequences for an involved worker are quite large because of the high sensitivity of results to assumptions (e.g., plume dispersion within a short distance). No major consequences for the involved worker are expected from leaks, spills, and smaller fires because involved workers should be able to evacuate immediately or be unaffected by the events. Explosions could result in immediate injuries from flying debris, as well as the uptake of radioactive materials. If an accidental criticality occurred, workers in the immediate vicinity could receive high to fatal radiation exposures from the initial burst. The dose would depend on the magnitude of the criticality, the worker's distance from the criticality, and amount of shielding created by intervening structures and equipment. Earthquakes could also have substantial consequences, ranging from workers being killed by debris from collapsing structures to high radiation doses from uptake of radionuclides.

The following sections present the consequences of "bounding accidents," which are the highest consequence events resulting from operational and natural phenomena-related accidents for both alternatives and reactor fuel production options. Most of these accidents fall within the overall group of "design-basis" accidents and as such, safety systems should restrict releases to the atmosphere. Other accidents in which the safety systems fail could also occur. Because of their extremely low probability, these events are designated as beyond-design-basis events. For the VTR facilities, beyond-design-basis accidents would most likely be initiated by a major earthquake so severe as to cause major damage to structures throughout the region. All these events are included in Appendix D.

Impacts are presented in terms of the number of LCFs that are estimated. Impacts are generated for all of the locations where VTR-related activities would occur for each of the three receptors (50-mile population, MEI, and a noninvolved worker). The potential environmental consequences of bounding postulated operational and natural phenomena-caused radiological accidents/external events at INL, ORNL, and SRS are presented in **Table 4–51** for the offsite population, the MEI, and the noninvolved. More details are provided in Appendix D.

Table 4–51. Summary of Human Health Consequences from Facility Accidents

		VTR Alternatives			
		INL VTR		ORNL VTR	
	Bounding Event [a,b]	***MEI (LCF)*** [c]	***Population (LCFs)*** [c]	***MEI (LCF)*** [c]	***Population (LCFs)*** [c]
Construction		NA	NA	NA	NA
Operations	*VTR-Specific Operations: Bounding Operational and Natural Phenomena/External Events*				
	Operational (Fire involving VTR spent fuel assemblies)	1×10^{-4}	$0\ (2\times10^{-2})$	9×10^{-3}	$1\ (9\times10^{-1})$
	NPH/External (BDBE)	4×10^{-5}	$0\ (8\times10^{-3})$	3×10^{-3}	$0\ (3\times10^{-1})$
	VTR Support Operations-Post-Irradiation Examination: Bounding Operational and Natural Phenomena/External Events				
	Operational (None)	0	0	0	0
	NPH (Fire)	1×10^{-8}	$0\ (2\times10^{-6})$	8×10^{-7}	$0\ (8\times10^{-5})$
	VTR Support Operations-Spent Fuel Treatment: Bounding Operational and Natural Phenomena/ External Events				
	Operational (Criticality)	2×10^{-6}	$0\ (8\times10^{-5})$	9×10^{-5}	$0\ (3\times10^{-3})$
	NPH (Sodium fire with spent fuel)	7×10^{-6}	$0\ (1\times10^{-3})$	5×10^{-4}	$0\ (5\times10^{-2})$
	VTR Support Operations-Spent Fuel Storage: Bounding Operational and Natural Phenomena/ External Events				
	Operational (Cask drop)	1×10^{-6}	$0\ (2\times10^{-4})$	8×10^{-5}	$0\ (8\times10^{-3})$
	NPH (Seismic failure)	2×10^{-6}	$0\ (4\times10^{-4})$	2×10^{-4}	$0\ (2\times10^{-2})$
	Combined VTR and Support Operations: Bounding Operational and Natural Phenomena/External Events [d]				
	Operational (Fire involving VTR spent fuel assemblies)	1×10^{-4}	$0\ (2\times10^{-2})$	9×10^{-3}	$1\ (9\times10^{-1})$
	NPH/External (BDBE)	4×10^{-5}	$0\ (8\times10^{-3})$	3×10^{-3}	$0\ (3\times10^{-1})$
Discussion	For the VTR at INL or ORNL, operational accidents would be managed so that no fuel melts and resulting releases would be negligible. A fire involving VTR spent fuel assemblies in the VTR Experiment Hall is postulated as the bounding operational accident at the VTR. This accident is in the extremely unlikely category and may not be credible. A beyond-design-basis seismic event resulting in collapse of the Experiment Hall, damage to spent fuel, and loss of confinement is also postulated. For the VTR support activities, including post-irradiation examination and spent fuel handling, conditioning, and storage, the bounding operational accidents are a criticality, which results in unfiltered releases and a filtered release from fire, and a dropped cask of fuel. In a severe seismic event, building structures, process enclosures, and process equipment could be damaged enough that unfiltered releases could occur. This event has lower impacts than the fire involving VTR spent fuel assemblies in the VTR Experiment Hall. Results differ between the INL VTR Alternative and the ORNL VTR Alternative because of meteorology, receptor distance, and population distribution, but are similar in characteristics and magnitude. Construction accidents are discussed in Section 4.10 of this VTR EIS.				

		Reactor Fuel Production Options			
		INL Reactor Fuel Production		***SRS Reactor Fuel Production***	
	Bounding Event [a,b]	***MEI (LCF)*** [c]	***Population (LCFs)*** [c]	***MEI (LCF)*** [c]	***Population (LCFs)*** [c]
Construction		NA	NA	NA	NA
Feedstock Preparation Operations	*VTR Fuel Feedstock Preparation Operations: Bounding Operational and Natural/External Events*				
	Operational (Uncontrolled reaction)	01×10^{-7}	0 (2×10^{-5})	05×10^{-8}	0 (1×10^{-4})
	NPH (Am-241 waste)	07×10^{-8}	0 (1×10^{-5})	03×10^{-8}	0 (7×10^{-5})
Fuel Fabrication Operations	*VTR Fuel Fabrication Operations: Bounding Operational and Natural/External Events*				
	Operational (3013 explosion)	06×10^{-5}	0 (1×10^{-2})	02×10^{-5}	0 (7×10^{-2})
	NPH (Spill molten Pu)	07×10^{-6}	0 (1×10^{-3})	03×10^{-6}	0 (8×10^{-3})
Combined Feedstock Preparation and Fuel Fabrication	*VTR Fuel Feedstock Preparation and Fuel Fabrication Operations: Bounding Operational and Natural/External Events*				
	Operational (3013 explosion)	6×10^{-5}	0 (1×10^{-2})	0 2×10^{-5}	0 (7×10^{-2})
	BDBE (with all Pu)	7×10^{-4}	0 (1×10^{-1})	03×10^{-4}	1 (7×10^{-1})
Discussion	For the VTR fuel fabrication activities at either INL or SRS, the bounding operational accident would be a high-pressure explosion of a 3013 container of plutonium oxide. Although this event is considered extremely unlikely, it does have the potential for a large release. Releases from other accidents involving liquid, oxide, or molten forms of plutonium would be filtered before release to the environment. In a severe, beyond-design-basis earthquake, severe damage to the structures and process equipment was postulated. This could result in spillage and unfiltered release from liquid, oxide and molten forms of plutonium. In a severe seismic event, the building and glovebox structures could be damaged enough that an unfiltered release could occur. Even so, most of the material not specifically being processed at the time of the earthquake would be in metal form and would not result in a substantial release even with loss of glovebox and building integrity. Results differ between the INL option and the SRS option because of meteorology, receptor distance, and population distribution. Construction accidents are discussed in Section 4.10 of this VTR EIS.				
	Combined INL VTR and Reactor Fuel Production Impacts				
		MEI (LCF) [c]	***Population (LCFs)*** [c]		
Construction	Not applicable				
Operations	*VTR Combined Operations with Fuel Production at INL/MFC: Bounding Operational and Natural/External Events* [d]				
	Operational (Fire involving VTR spent fuel assemblies)	1×10^{-4}	0 (2×10^{-2})		
	NPH/External (BDBE)	7×10^{-4}	0 (1×10^{-1})		
Discussion	The results presented are for the combined reactor and support operations plus reactor fuel production at INL. The highest operational accident is a fire involving VTR spent fuel assemblies in the VTR Experiment Hall. The beyond-design-basis earthquake would cause severe damage and loss of confinement of the VTR, support facilities, and reactor fuel production facilities. The impacts would be dominated by releases of plutonium from reactor fuel production. Construction accidents are discussed in Section 4.10 of this VTR EIS.				

BDBE = beyond-design-basis earthquake; LCF = latent cancer fatality; MEI = maximally exposed individual; NPH = natural phenomena hazard; Pu = plutonium.

[a] Impacts, in terms of potential LCFs, are presented for the bounding operational accident and a bounding NPH (typically a beyond-design-basis earthquake). For these purposes, the term bounding means the highest consequence, credible event.

For NEPA purposes, events with an estimated frequency of less than one in 10 million per year are not considered unless they contribute significantly to the overall accident risk.

[b] Bounding operational and NPH/External events are identified and quantified in Appendix D.

[c] LCF (latent cancer fatality) represents the potential human health impacts of exposure to radiation in terms of excess cancers. The reported value represents the risk of an LCF for the MEI and the number of LCFs that would be expected in the offsite population within 50 miles of the facility. For population impacts, the calculated value is presented in appendices.

[d] For the combined facilities at INL and ORNL NPH/External event, a beyond-design-basis earthquake is assumed to be of sufficient magnitude to damage both the reactor and the support facilities. The impacts are summed over all the VTR-relate facilities that might release radionuclides in the seismic event. Releases from the rest of INL and ORNL are not included.

Sources: Appendix D.

4.11.1 INL VTR Alternative

This section presents the impacts from facility accidents with establishing the VTR at INL. The impacts would include those from construction and operation of the VTR; facility modifications and incremental operational impacts for performing post-irradiation examination of test items; facility modifications and incremental operational impacts for preparing SNF for long-term storage and disposal; and construction and operation of a new long-term storage pad near ZPPR.

4.11.1.1 Construction/Facility Modification

Facility accidents associated with construction of the VTR, facility modifications for post-irradiation examination, facility modifications for spent fuel treatment, and construction of a new spent fuel storage pad are discussed in Section 4.10.1.1 of this VTR EIS.

4.11.1.2 Operations

Radiological Impacts

This section presents potential radiological impacts on the public and a noninvolved onsite worker due to accidents during operation of the VTR and the operation of the post-irradiation examination facility. Those potential impacts along with those from the operation of the SNF treatment facility (including transuranic waste accidents) and that of the spent fuel storage pad are also presented and summarized in Table 4–51. Appendix D presents a detailed analysis of facility accidents, with the associated assumptions.

The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, spills, criticality, earthquake, and aircraft crash. **Table 4–52** presents the frequencies and consequences of the postulated set of accidents to the maximally exposed member of the public, the offsite population residing within 50 miles of the facility, and a noninvolved worker located 330 feet from the facility. Receptor doses were calculated for the mean meteorological conditions.

For the VTR at INL, results of the VTR probabilistic risk analysis and other safety analyses indicate that all operational accidents would be controlled and not result in fuel melting. This includes the typical reactor accidents associated with light water reactors, including loss of offsite power, transient overpower events, experiment malfunctions, and seismic events. The passive heat removal systems are sufficiently robust that all of the conventional reactor accidents are either prevented or mitigated and no radioactive releases would be expected. No fuel would melt and the releases from the gaseous cooling systems have very small radiological consequences. Within the Experiment Hall of the VTR building, spent fuel is washed and handled and is potentially vulnerable for operational accidents. A fire involving VTR spent fuel assemblies in the VTR Experiment Hall is postulated as the bounding operational accident at the VTR. This accident is certainly in the extremely unlikely category and may not be credible.

Table 4–52. Accident Frequency and Radiological Impacts from VTR-Related Accidents at INL

Accident	Frequency [e] (per year)	Impacts on Noninvolved Worker (100 meters)		Impacts on an MEI at 5 Kilometers [a]		Near-Term Impacts on Population within 50 Miles [b]	
		Dose (rem)	Probability of an LCF [c]	Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs [d]
VTR Accident Impacts							
Test Assembly Failure following Seismically Induced Fire	Extremely Unlikely	5×10^{-2}	3×10^{-5}	6.5×10^{-5}	4×10^{-8}	1.2×10^{-2}	0 (7×10^{-6})
Fire Involving VTR Spent Fuel Assemblies	Extremely Unlikely to Beyond Extremely Unlikely	160	2×10^{-1}	2.4×10^{-1}	1×10^{-4}	36	0 (2×10^{-2})
VTR Fuel Assembly Drop in Experiment Hall	Extremely Unlikely	7.3×10^{-4}	4×10^{-7}	1.3×10^{-6}	8×10^{-10}	1.7×10^{-4}	0 (1×10^{-7})
VTR Seismic Event Resulting in Collapse of the Experiment Hall	Extremely Unlikely	58	7×10^{-2}	7.1×10^{-2}	4×10^{-5}	13	0 (8×10^{-3})
Spent Fuel Handling and Treatment							
Criticality Involving Melted Spent Fuel (failed containment)	Extremely Unlikely	1.0	6×10^{-4}	3.9×10^{-3}	2×10^{-6}	1.3×10^{-1}	0 (8×10^{-5})
Spill of Melted Spent Fuel with Seismically Induced Confinement Failure	Extremely Unlikely	0.66	4×10^{-4}	8.0×10^{-4}	5×10^{-7}	0.14	0 (9×10^{-5})
Na Fire Involving Spent Fuel with Cladding and Confinement Failure	Extremely Unlikely	9.0	5×10^{-3}	1.1×10^{-2}	7×10^{-6}	2.0	0 (1×10^{-3})
Transuranic Waste Accident Impacts							
Fire Outside Confinement (waste from fuel fabrication or spent fuel treatment)	Extremely Unlikely	6.0×10^{-5}	4×10^{-8}	7.4×10^{-8}	4×10^{-11}	1.3×10^{-6}	0 (8×10^{-10})
Fire Outside Involving a Waste Drum with 23 g of Am-241	Extremely Unlikely	8.2×10^{-2}	5×10^{-5}	1.1×10^{-4}	7×10^{-8}	1.8×10^{-2}	0 (1×10^{-5})
Post-Irradiation Examination Accident Impacts							
Fire Involving Test Assembly (Seismically Induced Confinement Failure)	Extremely Unlikely	1.6×10^{-2}	9×10^{-6}	1.9×10^{-5}	1×10^{-8}	3.5×10^{-3}	0 (2×10^{-6})
Spent Fuel Storage Accident Impacts							
Seismic Event Causes Failure of Storage Structure and Failure of Spent Fuel Storage Casks with Fuel Release	Beyond Extremely Unlikely	3.1	2×10^{-3}	3.9×10^{-3}	2×10^{-6}	6.9×10^{-1}	0 (4×10^{-4})
Seismic Event Causes Failure of Storage Structure and Failure of Spent Fuel Storage Casks with Criticality	Beyond Extremely Unlikely	1.0	6×10^{-4}	3.9×10^{-3}	2×10^{-6}	1.3×10^{-1}	0 (8×10^{-5})
Drop of Fuel-Loaded Cask	Extremely Unlikely	1.6	9×10^{-4}	1.9×10^{-3}	1×10^{-6}	3.5×10^{-1}	0 (2×10^{-4})

Accident	Frequency [e] (per year)	Impacts on Noninvolved Worker (100 meters)		Impacts on an MEI at 5 Kilometers [a]		Near-Term Impacts on Population within 50 Miles [b]	
		Dose (rem)	Probability of an LCF [c]	Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs [d]

HRS = heat removal system; LCF = latent cancer fatality; MEI = maximally exposed individual; Na = sodium; of PuO_2 = plutonium oxide; rem = roentgen equivalent man; RVACS = Reactor Vessel Auxiliary Cooling System; TRU = transuranic.

[a] An MEI was assumed to be on Highway 20, 5 kilometers from the VTR complex at MFC. Assumptions and methods for the evaluation of consequences are presented in Section D.1.4.

[b] Potential longer-term impacts due to chronic exposures to radionuclides remaining after the plume passage due to various pathways, including resuspension of remaining particulates and ingestion of contaminated food, were also calculated and presented in Appendix D. The food pathway could be the largest source of longer-term dose from accidents releasing fission products unless mitigated by the interdiction of the nearby food chain.

[c] For hypothetical individual doses equal to or greater than 20 rem, the probability of an LCF was doubled.

[d] Numbers of LCFs in the population are whole numbers; the statistically calculated values are provided in parentheses for when the reported result is 1 or less. The LCF value presented represents the risk of an LCF for the MEI and the number of LCFs that would be expected in the offsite population within 50 miles of the facility.

[e] Accident frequencies are generally grouped into the bins of "anticipated," "unlikely," "extremely unlikely," and "beyond extremely unlikely," with estimated frequencies of greater than 1×10^{-2}, 1×10^{-2} to 1×10^{-4}, 1×10^{-4} to 1×10^{-6}, and less than 1×10^{-6} per year, respectively.

A beyond-design-basis seismic event could damage the building structure and equipment enough to threaten any spent fuel assemblies in the Experiment Hall that are not in a protective cask. Such an event could result in a fire in the exposed spent fuel and release radioactive material through the damaged building structure. An event of this magnitude would also cause extensive damage to buildings and infrastructure throughout the area. Such an event is estimated to require a seismic event much above the design-basis earthquake (with a return interval of 2,500 years).

For the VTR support activities, including the post-irradiation examination and spent fuel handling, conditioning, and storage, the bounding operational accidents are a criticality, which results in unfiltered releases and a filtered release from fire and spill involving molten spent fuel. In a severe seismic event, building structures, process enclosures, and process equipment could be damaged enough that unfiltered releases could occur. This event has lower impacts than the fire involving VTR spent fuel assemblies in the VTR Experiment Hall. During all of the VTR support operations, the radiological materials are either in a cask designed to contain the radionuclides in virtually all accidents or in a heavily shielded hot cell. As such, only controlled, filtered releases would be expected. Workers would be protected from accidents within the hot cells by the heavy shielding and the ventilation system that direct hot cell releases through HEPA filters and to an outside stack.

In a severe seismic event, the building and hot cell structures could be damaged enough that an unfiltered release could occur. Even so, most of the material not specifically being processed at the time of the earthquake would be in metal form and would not result in a substantial release even with loss of hot cell integrity and loss of the inert hot cell argon atmosphere. Since a severe seismic event could affect multiple VTR support operations, the results presented for the NPH/Ext event represent the sum of the potential impacts from the beyond design-basis earthquake from all of the VTR support activities.

Hazardous Material Impacts

Nonradiological impacts are evaluated in terms of comparison to Emergency Response Planning Guideline (ERPG) values. ERPG values are estimates of airborne concentration thresholds above which one can reasonably anticipate observing adverse effects. The hazardous material impacts of potential facility accidents associated with the INL VTR Alternative are shown in Appendix D.

4.11.2 ORNL VTR Alternative

This section presents the impacts from establishing the VTR at ORNL. The impacts would include those from operation of the VTR; operation of a new hot cell facility for performing post-irradiation examination of test items and for preparing SNF for long-term storage and disposal; and operation of a new long-term storage pad within the VTR complex at ORNL.

4.11.2.1 Construction/Facility Modification

Facility accidents associated with construction of the VTR, facility modifications for post-irradiation examination, facility modifications for spent fuel treatment, and construction of a spent fuel storage facility are discussed in Section 4.10.2 of this VTR EIS.

4.11.2.2 Operations

Radiological Impacts

Presented in this section are potential radiological impacts on the public and a noninvolved, onsite worker from accidents during operation of the VTR and operations of the post-irradiation examination facility and the SNF treatment facility (including transuranic waste accidents). Impacts from operations of the spent fuel storage facility, summarized in Table 4–51, are also presented in this section. The detailed analysis of facility accidents, with the associated assumptions, is presented in Appendix D.

The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, spills, criticality, earthquake, and aircraft crash. **Table 4–53** presents the frequencies and consequences of the postulated set of accidents to the maximally exposed member of the public, assumed to be a boater on an arm of Melton Lake about 800 meters from the VTR complex, the offsite population residing within 50 miles of the facility, and a noninvolved worker located 330 feet from the facility. Receptor doses were calculated for the mean meteorological conditions.

Table 4–53. Accident Frequency and Radiological Impacts from VTR-Related Accidents at ORNL

		Impacts on Noninvolved Worker (100 meters)		*Impacts on an MEI at 0.8 Kilometers* [a]		*Near-Term Impacts on Population within 50 Miles* [d]	
Accident	*Frequency* [e] *(per year)*	*Dose (rem)*	*Probability of an LCF* [b]	*Dose (rem)*	*Probability of an LCF*	*Dose (person-rem)*	*LCFs* [c]
VTR Accident Impacts							
Test Assembly Failure following Seismically Induced Fire	Extremely Unlikely	1.3×10^{-1}	8×10^{-5}	4.6×10^{-3}	3×10^{-6}	4.5×10^{-1}	0 (3×10^{-4})
Fire Involving VTR Spent Fuel Assemblies	Extremely Unlikely to Beyond Extremely Unlikely	400	5×10^{-1}	14	9×10^{-3}	1,400	1 (9×10^{-1})
VTR Fuel Assembly Drop in Experiment Hall	Beyond Extremely Unlikely	1.9×10^{-3}	1×10^{-6}	6.7×10^{-5}	4×10^{-8}	6.9×10^{-3}	0 (4×10^{-6})
VTR Seismic Event Resulting in Collapse of the Experiment Hall	Beyond Extremely Unlikely	150	2×10^{-1}	5.1	3×10^{-3}	500	0 (3×10^{-1})
Spent Fuel Handling and Treatment							
Criticality Involving Melted Spent Fuel (failed containment)	Extremely Unlikely	2.5	2×10^{-3}	1.5×10^{-1}	9×10^{-5}	4.8	0 (3×10^{-3})

Accident	*Frequency [e] (per year)*	*Impacts on Noninvolved Worker (100 meters)*		*Impacts on an MEI at 0.8 Kilometers [a]*		*Near-Term Impacts on Population within 50 Miles [d]*	
		Dose (rem)	*Probability of an LCF [b]*	*Dose (rem)*	*Probability of an LCF*	*Dose (person-rem)*	*LCFs [c]*
Spill of Melted Spent Fuel with Seismically Induced Confinement Failure	Extremely Unlikely	1.7	1×10^{-3}	5.8×10^{-2}	4×10^{-5}	5.6	0 (3×10^{-3})
Na Fire Involving Spent Fuel with Cladding and Confinement Failure	Extremely Unlikely	23	3×10^{-2}	0.80	5×10^{-4}	77	0 (5×10^{-2})
Transuranic Waste Accident Impacts							
Fire Outside Confinement (waste from fuel fabrication or spent fuel treatment)	Extremely Unlikely	1.5×10^{-4}	9×10^{-8}	5.4×10^{-6}	3×10^{-9}	5.2×10^{-4}	0 (3×10^{-7})
Fire Outside Involving a Waste Drum with 23 g Am-241	Extremely Unlikely	0.21	1×10^{-4}	7.2×10^{-3}	4×10^{-4}	0.69	0 (4×10^{-4})
Post-Irradiation Examination Accident Impacts							
Fire Involving Test Assembly (seismically induced containment failure)	Extremely Unlikely	4.0×10^{-2}	2×10^{-5}	1.4×10^{-3}	8×10^{-7}	1.3×10^{-1}	0 (8×10^{-5})
Spent Fuel Storage Accident Impacts							
Seismic Event Causes Failure of Storage Structure and Failure of Spent Fuel Storage Casks with Fuel Release	Beyond Extremely Unlikely	8	5×10^{-3}	2.8×10^{-1}	2×10^{-4}	27	0 (2×10^{-2})
Seismic Event Causes Failure of Storage Structure and Failure of Spent Fuel Storage Casks with Criticality	Beyond Extremely Unlikely	2.5	2×10^{-3}	1.5×10^{-1}	9×10^{-5}	4.8	0 (3×10^{-3})
Drop of Fuel-Loaded Cask	Extremely Unlikely	4	2×10^{-3}	1.4×10^{-1}	8×10^{-5}	13	0 (8×10^{-3})

HRS = heat removal system; LCF = latent cancer fatality; MEI = maximally exposed individual; Na = sodium; rem = roentgen equivalent man; RVACS = Reactor Vessel Auxiliary Cooling System.

[a] An MEI was assumed to be on an arm of Melton Lake 800 meters from the VTR complex at ORNL. Assumptions and methods for the evaluation of consequences are presented in Section D.1.4.

[b] For hypothetical individual doses equal to or greater than 20 rem, the probability of an LCF was doubled.

[c] Numbers of LCFs in the population are whole numbers; the statistically calculated values are provided in parentheses for when the reported result is 1 or less. The LCF value presented represents the risk of an LCF for the MEI and the number of LCFs that would be expected in the offsite population within 50 miles of the facility.

[d] Potential longer-term impacts due to chronic exposures to radionuclides remaining after the plume passage due to various pathways, including resuspension of remaining particulates and ingestion of contaminated food, were also calculated and presented in Appendix D. The food pathway could be the largest source of longer-term dose from accidents releasing fission products unless mitigated by the interdiction of the nearby food chain.

[e] Accident frequencies are generally grouped into the bins of "anticipated," "unlikely," "extremely unlikely," and "beyond extremely unlikely," with estimated frequencies of greater than 1×10^{-2}, 1×10^{-2} to 1×10^{-4}, 1×10^{-4} to 1×10^{-6}, and less than 1×10^{-6} per year, respectively.

The accident scenarios for the VTR alternative and supporting operations at ORNL are identical to those presented for the comparable facilities at INL. No new or substantially different accident scenarios were identified with the placement of the facilities at ORNL. While there are differences in the sites that could affect the probabilities of certain scenarios, particularly natural phenomena-initiate events such as wind, flooding, seismic, and volcanism, the dominant accident scenarios remain the same.

There are, however, differences in potential impacts due to population distributions around the VTR location, distances to the nearest potential offsite individual, and differences in meteorological conditions. The effects of these differences on impacts are summarized in Table 4–50 and presented in detail in Table 4–53.

Hazardous Material Impacts

Nonradiological impacts are evaluated in terms of comparison to ERPG values. ERPG values are estimates of airborne concentration thresholds above which one can reasonably anticipate observing adverse effects. The hazardous material impacts of potential facility accidents associated with the ORNL VTR alternative are shown in Appendix D.

4.11.3 Reactor Fuel Production Options

This section addresses health effects from facility accidents for VTR reactor fuel production at the INL Site and SRS. The accident scenarios for reactor fuel production at SRS are identical to those presented for the comparable facilities at INL. While there are differences in the sites that could affect the probabilities of certain scenarios, particularly natural phenomena-initiate events such as wind, flooding, seismic, and volcanism, the dominant accident scenarios remain the same.

4.11.3.1 INL Reactor Fuel Production Options

Two phases of reactor fuel production are evaluated. The first phase is a feedstock preparation capability. This phase involves the receipt of plutonium that contains high levels of impurities, e.g., americium-241 (which is present as the result of the decay of plutonium-241 in 'older' plutonium) or plutonium in other than metal form (e.g., plutonium oxide). The feedstock preparation capability would address the issues of plutonium polishing and conversion to metal. The second phase of reactor fuel production would involve the alloying of plutonium with uranium and zirconium, and fabricating fuel pins and fuel assemblies.

4.11.3.1.1 Construction/Facility Modification

Facility accidents associated with facility modifications for reactor fuel production are discussed in Section 4.10.3.1 of this VTR EIS.

4.11.3.1.2 Operations

Radiological Impacts

Potential radiological impacts on the public and a noninvolved onsite worker due to accidents during VTR fuel fabrication operations at MFC are summarized in Table 4–51 and are presented in this section. The detailed analysis of facility accidents, with the associated assumptions, is presented in Appendix D.

The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, spills, criticality, earthquake, and aircraft crash. **Table 4–54** presents the frequencies and consequences of the postulated set of accidents to the maximally exposed offsite member of the public (assumed to be on Highway 20 about 5 kilometers from the VTR complex), the offsite population residing within 50 miles of the facility, and a noninvolved worker located 330 feet from the facility. Receptor doses were calculated for the mean meteorological conditions.

Table 4–54. Accident Frequency and Radiological Impacts from VTR-Related Fuel Fabrication Activities at the Materials and Fuels Complex

Accident [f]	Frequency [c] (per year)	Impacts on an MEI at 5 Kilometers [a]		Near-Term Impacts on Population within 50 Miles [b]	
		Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs [d]
Fuel Fabrication – Accident Impacts					
Criticality while alloying the three components of the metal fuel, uranium, plutonium, and zirconium	Extremely Unlikely	3.6×10^{-3}	2×10^{-6}	1.3×10^{-1}	0 (8×10^{-5})
Fire Impingement on Fuel Material (intact containment)	Extremely Unlikely	6.4×10^{-6}	4×10^{-9}	1.1×10^{-3}	0 (7×10^{-7})
Fire Impingement on Fuel Material (seismically induced containment failure)	Extremely Unlikely to Beyond Extremely Unlikely	6.5×10^{-5}	4×10^{-8}	1.0×10^{-2}	0 (6×10^{-6})
Spill and Oxidation of Molten Pu-U Mixture while Heating or Casting with Seismically Induced Confinement Failure	Extremely Unlikely to Beyond Extremely Unlikely	1.2×10^{-2}	7×10^{-6}	2.0	0 (1×10^{-3})
Plutonium Oxide-to-Metal Conversion (3013 explosion)	Extremely Unlikely to Beyond Extremely Unlikely	0.11	6×10^{-5}	18	0 (1×10^{-2})
Beyond-Design-Basis Fire Involving a TRU Waste Drum with 450 g of PuO_2	Extremely Unlikely to Beyond Extremely Unlikely	2×10^{-3}	1×10^{-6}	3×10^{-1}	0 (2×10^{-4})
Feedstock Preparation – Accident Impacts					
Aqueous/Electrorefining Fuel Preparation (uncontrolled reaction)	Extremely Unlikely	2.0×10^{-4}	1×10^{-7}	3.4×10^{-2}	0 (2×10^{-5})
Fire Outside Involving a Waste Drum with 23 g Am-241	Extremely Unlikely	1.1×10^{-4}	7×10^{-8}	1.8×10^{-2}	0 (1×10^{-5})
Feedstock Preparation and Fuel Fabrication: Combined Beyond-Design-Basis Earthquake Accident Impacts					
Aircraft Crash into VTR Fuel Fabrication and Feedstock Preparation Facility	Beyond Extremely Unlikely	1.1	7×10^{-4}	180	0 (0.1)
Beyond-Design-Basis Earthquake Involving all VTR Fuel Fabrication and Preparation MAR	Extremely Unlikely to Beyond Extremely Unlikely	1.1	7×10^{-4}	180	0 (0.1)

Am = americium; LCF = latent cancer fatality; MAR = material-at-risk; MEI = maximally exposed individual; Pu = plutonium; PuO_2 = plutonium oxide; rem = roentgen equivalent man; TRU = transuranic; U = uranium.

[a] An MEI was assumed to be on Highway 20, 5 kilometers from the VTR complex at MFC. Assumptions and methods for the evaluation of consequences are presented in Section D.1.4.

[b] Potential longer-term impacts due to chronic exposures to radionuclides remaining after the plume passage due to various pathways, including resuspension of remaining particulates and ingestion of contaminated food, were also calculated and presented in Appendix D. The food pathway could be the largest source of longer-term dose from accidents releasing fission products unless mitigated by the interdiction of the nearby food chain.

[c] Accident frequencies are generally grouped into the bins of "anticipated," "unlikely," "extremely unlikely," and "beyond extremely unlikely," with estimated frequencies of greater than 1×10^{-2}, 1×10^{-2} to 1×10^{-4}, 1×10^{-4} to 1×10^{-6}, and less than 1×10^{-6} per year, respectively.

[d] Numbers of LCFs in the population are whole numbers; the statistically calculated values are provided in parentheses for when the reported result is 1 or less. The LCF value presented represents the risk of an LCF for the MEI and the number of LCFs that would be expected in the offsite population within 50 miles of the facility.

For the VTR fuel fabrication activities at either the INL Site or SRS, the bounding operational accident is a fire that results in heating and over pressurization of a 3013 can of plutonium oxide. Releases from other accidents such as a fire and spill involving molten uranium and plutonium while being cast into fuel would be filtered before release to the environment. During all of the VTR fuel fabrication operations, the radiological materials are either in metal form in a container designed to contain the radionuclides in virtually all accidents or in an inert glove box. As such, only controlled, filtered releases would be expected. Workers would be protected from routine accidents within the glove boxes and the ventilation system that directs glove box releases through HEPA filters and to an outside stack.

For accidents associated with the INL VTR metal preparation portion of the fuel fabrication option, the bounding accident from plutonium "polishing" operations would be an uncontrolled reaction during portions of the aqueous operations. This could release radioactive materials to the glovebox, but any releases from the glovebox or room to the environment would be filtered and have low impacts. If plutonium oxide were used as a feed material, the bounding operational event is a high-pressure rupture of a welded, DOE standard 3013, plutonium-oxide storage container. This could occur if the container were exposed to a fire that burns sufficiently long to raise the internal pressure of the container to the point of rupture. This scenario, while theoretically possible, would be extremely unlikely and normal fire prevention and mitigation practices should reduce the chance of it occurring.

In a severe seismic event, the building and glove box structures could be damaged enough that an unfiltered release could occur. Even so, most of the material not specifically being processed at the time of the earthquake would be in metal form and would not result in a substantial release even with loss of glove box and building integrity.

A beyond design-basis earthquake was also postulated that could threaten unfiltered releases of all of the MAR in the Fuel Preparation and Fabrication area, including the molten plutonium in casting, liquid plutonium in the polishing operation, and plutonium oxide in the conversion operations. In a severe seismic event, the building and glove box structures could be damaged enough that an unfiltered release could occur. Even so, most of the material not specifically being processed at the time of the earthquake would be in metal form and would not result in a substantial release even with loss of glove box and building integrity.

Hazardous Material Impacts

Nonradiological impacts are evaluated in terms of comparison to ERPG values. ERPG values are estimates of airborne concentration thresholds above which one can reasonably anticipate observing adverse effects. The hazardous material impacts of potential facility accidents associated with the INL VTR Alternative are shown in Appendix D.

4.11.3.2 SRS Reactor Fuel Production Options

This section presents the impacts from establishing the reactor fuel production at SRS. Facility construction or modifications and operations would be similar to those described in Section 4.11.3.1, but would occur in the K Area Complex at SRS.

4.11.3.2.1 Construction/Facility Modification

Facility accidents associated with facility modifications for fuel fabrication are discussed in Section 4.10.3.2 of this VTR EIS.

4.11.3.2.2 Operations

Radiological Impacts

Potential radiological impacts on the public and a noninvolved onsite worker resulting from accidents during VTR fuel fabrication at the K Area Complex at SRS are summarized in Table 4–51 and are presented in this section. The detailed analysis of facility accidents, with the associated assumptions, is presented in Appendix D.

The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, spills, criticality, earthquake, and aircraft crash. **Table 4–55** presents the frequencies and consequences of the postulated set of accidents to the maximally exposed offsite individual, the offsite population residing within 50 miles of the facility, and a noninvolved worker located 330 feet from the facility. Receptor doses were calculated for the mean meteorological conditions.

Table 4–55. Radiological Impacts from VTR-Related Fuel Fabrication Activities at K Area Complex

Accident	*Frequency [c] (per year)*	*Impacts on an MEI at the Site Boundary [a]*		*Near-Term Impacts on Population within 50 Miles [b]*	
		Dose (rem)	*Probability of an LCF*	*Dose (person-rem)*	*LCFs [d]*
Fuel Fabrication – Accident Impacts					
Criticality while alloying the three components of the metal fuel, uranium, plutonium, and zirconium	Extremely Unlikely	1.6×10^{-3}	9×10^{-7}	8.8×10^{-1}	0 (5×10^{-4})
Fire Impingement on Fuel Material (intact containment)	Extremely Unlikely	2.5×10^{-6}	2×10^{-9}	6.9×10^{-3}	0 (4×10^{-6})
Fire Impingement on Fuel Material (seismically induced containment failure)	Extremely Unlikely to Beyond Extremely Unlikely	2.5×10^{-5}	1×10^{-8}	6.8×10^{-2}	0 (4×10^{-5})
Spill and Oxidation of Molten Pu-U Mixture while Heating or Casting with Seismically Induced Confinement Failure	Extremely Unlikely to Beyond Extremely Unlikely	4.6×10^{-3}	3×10^{-6}	13	0 (8×10^{-3})
Plutonium Oxide-to-Metal Conversion (3013 explosion)	Extremely Unlikely to Beyond Extremely Unlikely	4.2×10^{-2}	2×10^{-5}	110	0 (7×10^{-2})
Beyond-Design-Basis Fire Involving a TRU Waste Drum with 450 g PuO_2	Extremely Unlikely to Beyond Extremely Unlikely	8.2×10^{-4}	5×10^{-7}	2.2	0 (1×10^{-3})
Feedstock Preparation – Accident Impacts					
Aqueous/Electrorefining Fuel Preparation (uncontrolled reaction)	Extremely Unlikely	7.9×10^{-5}	5×10^{-8}	2.2×10^{-1}	0 (1×10^{-4})
Fire Outside Involving a Waste Drum with 23 g Am-241	Extremely Unlikely	4.2×10^{-5}	3×10^{-8}	1.2×10^{-1}	0 (7×10^{-5})
Feedstock Preparation and Fuel Fabrication: Combined Beyond-Design-Basis Earthquake Accident Impacts					
Aircraft Crash into VTR Fuel Fabrication and Feedstock Preparation Facility	Beyond Extremely Unlikely	4.3×10^{-1}	3×10^{-4}	1,200	1.0
Beyond-Design-Basis Earthquake Involving all VTR Fuel Fabrication MAR	Beyond Extremely Unlikely	4.3×10^{-1}	3×10^{-4}	1,200	1.0

Am = americium; LCF = latent cancer fatality; MAR = material-at-risk; MEI = maximally exposed individual; Pu = plutonium; PuO_2 = plutonium oxide; rem = roentgen equivalent man; TRU = transuranic; U = uranium.

[a] An MEI at the nearest site boundary distance of 8.85 kilometers was used. Assumptions and methods for the evaluation of consequences are presented in Appendix D, Section D.1.4.

[b] Potential longer-term impacts due to chronic exposures to radionuclides remaining after the plume passage due to various pathways, including resuspension of remaining particulates and ingestion of contaminated food, were also calculated and

Accident	Frequency [c] (per year)	Impacts on an MEI at the Site Boundary [a]		Near-Term Impacts on Population within 50 Miles [b]	
		Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs [d]

presented in Appendix D. The food pathway could be the largest source of longer-term dose from accidents releasing fission products unless mitigated by the interdiction of the nearby food chain.

[c] Accident frequencies are generally grouped into the bins of "anticipated," "unlikely," "extremely unlikely," and "beyond extremely unlikely," with estimated frequencies of greater than 1×10^{-2}, 1×10^{-2} to 1×10^{-4}, 1×10^{-4} to 1×10^{-6}, and less than 1×10^{-6} per year, respectively.

[d] Numbers of LCFs in the population are whole numbers; the statistically calculated values are provided in parentheses for when the reported result is 1 or less.

The accident scenarios for the VTR fuel fabrication operations at SRS are identical to those presented for the comparable facilities at INL. No new or substantially different accident scenarios were identified with the placement of the facilities at SRS. While there are differences in the sites that could affect the probabilities of certain scenarios, particularly natural phenomena-initiate events such as wind, flooding, seismic, and volcanism, the dominant accident scenarios remain the same.

There are, however, differences in potential impacts due to population distributions around the VTR location, distances to the nearest potential offsite individual, and differences in meteorological conditions.

Hazardous Material Impacts

Nonradiological impacts are evaluated in terms of comparison to ERPG values. ERPG values are estimates of airborne concentration thresholds above which one can reasonably anticipate observing adverse effects. The hazardous material impacts of potential facility accidents associated with the INL VTR Alternative are shown in Appendix D.

4.11.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

This section presents the total impacts that would occur if the VTR alternative and the fuel production options were both established at the INL. The combined impacts developed earlier under the Combined INL VTR Alternative and INL Reactor Fuel Production Options are summarized in **Table 4–56**. The detailed analysis of facility accidents, with the associated assumptions, is presented in Appendix D.

Table 4–56. Radiological Impacts from Combined INL VTR Alternative and INL Reactor Fuel Production Options Activities

Accident	Frequency [c] (per year)	Impacts on an MEI at 5 Kilometers [a]		Near-Term Impacts on Population within 50 Miles [b]	
		Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs [d]
VTR Accident Impacts					
Test Assembly Failure following Seismically Induced Fire	Extremely Unlikely	1.8×10^{-3}	1×10^{-6}	3.3×10^{-1}	0 (2×10^{-4})
Fire involving VTR Spent Fuel Assemblies	Extremely Unlikely	8.2×10^{-2}	5×10^{-5}	13	0 (8×10^{-3})
VTR Fuel Assembly Drop in Experiment Hall	Extremely Unlikely	1.3×10^{-6}	8×10^{-10}	1.7×10^{-4}	0 (1×10^{-7})
VTR Seismic Event Resulting in Collapse of the Experiment Hall	Extremely Unlikely	7.1×10^{-2}	4×10^{-5}	13	0 (8×10^{-3})

Accident	Frequency [c] (per year)	Impacts on an MEI at 5 Kilometers [a]		Near-Term Impacts on Population within 50 Miles [b]	
		Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs [d]
Spent Fuel Handling and Treatment					
Criticality Involving Melted Spent Fuel (Failed Confinement)	Extremely Unlikely	3.9×10^{-3}	2×10^{-6}	1.3×10^{-1}	0 (8×10^{-5})
Spill of Melted Spent Fuel with Seismically Induced Confinement Failure	Extremely Unlikely	8.0×10^{-4}	5×10^{-7}	0.14	0 (9×10^{-5})
Na Fire Involving Spent Fuel with Cladding and Confinement Failure	Extremely Unlikely	1.1×10^{-2}	7×10^{-6}	2.0	0 (1×10^{-3})
Transuranic Waste Accident Impacts					
Fire Outside Confinement (waste from fuel fabrication or spent fuel treatment)	Extremely Unlikely	1.8×10^{-7}	1×10^{-10}	3.3×10^{-5}	0 (2×10^{-8})
Fire Outside Involving a Waste Drum with 23 g of Am-241	Extremely Unlikely	1.1×10^{-4}	7×10^{-8}	1.8×10^{-2}	0 (1×10^{-5})
Post-Irradiation Examination Accident Impacts					
Fire Involving Test Assembly (seismically induced containment failure)	Extremely Unlikely	5.6×10^{-3}	3×10^{-6}	0.99	0 (6×10^{-4})
Spent Fuel Storage Accident Impacts					
Seismic Event Causes Failure of Storage Structure and Failure of Spent Fuel Storage Casks with Fuel Release	Beyond Extremely Unlikely	1.3×10^{-2}	8×10^{-6}	2.3	0 (1×10^{-3})
Seismic Event Causes Failure of Storage Structure and Failure of Spent Fuel Storage Casks with Criticality	Beyond Extremely Unlikely	3.9×10^{-3}	2×10^{-6}	1.3×10^{-1}	0 (8×10^{-5})
Drop of Fuel-Loaded Cask	Extremely Unlikely	6.3×10^{-3}	4×10^{-6}	1.1	0 (7×10^{-4})
Fuel Fabrication – Accident Impacts					
Criticality while alloying the three components of the metal fuel, uranium, plutonium, and zirconium	Extremely Unlikely	3.6×10^{-3}	2×10^{-6}	1.3×10^{-1}	0 (8×10^{-5})
Fire Impingement on Fuel Material (intact containment)	Extremely Unlikely	6.4×10^{-6}	4×10^{-9}	1.1×10^{-3}	0 (7×10^{-7})
Fire Impingement on Fuel Material (seismically induced containment failure)	Extremely Unlikely to Beyond Extremely Unlikely	6.6×10^{-5}	4×10^{-8}	1.1×10^{-2}	0 (6×10^{-6})
Spill and Oxidation of Molten Pu-U Mixture while Heating or Casting with Seismically Induced Confinement Failure	Extremely Unlikely to Beyond Extremely Unlikely	1.2×10^{-2}	7×10^{-6}	2.0	0 (1×10^{-3})
Plutonium Oxide-to-Metal Conversion (3013 explosion)	Extremely Unlikely	0.11	6×10^{-5}	18	0 (1×10^{-2})
Feedstock Preparation – Accident Impacts					
Aqueous Electrorefining Fuel Preparation (uncontrolled reaction)	Extremely Unlikely	2.0×10^{-4}	1×10^{-7}	3.4×10^{-2}	0 (2×10^{-5})
Fire Outside Involving a Waste Drum with 23 g Am-241	Extremely Unlikely	1.1×10^{-4}	7×10^{-8}	1.8×10^{-2}	0 (1×10^{-5})
Feedstock Preparation and Fuel Fabrication: Combined Beyond-Design-Basis Earthquake Accident Impacts					
Aircraft Crash into VTR Fuel Fabrication and Feedstock Preparation Facility	Beyond Extremely Unlikely	1.1	7×10^{-4}	180	1 (7×10^{-1})
Beyond-Design-Basis Earthquake Involving All VTR Fuel Fabrication MAR	Extremely Unlikely to Beyond Extremely Unlikely	1.1	7×10^{-4}	180	1 (7×10^{-1})

Accident	Frequency [c] (per year)	Impacts on an MEI at 5 Kilometers [a]		Near-Term Impacts on Population within 50 Miles [b]	
		Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs [d]

Am = americium; LCF = latent cancer fatality; MAR = material-at-risk; MEI = maximally exposed individual; Na = sodium; Pu = plutonium; PuO_2 = plutonium oxide; rem = roentgen equivalent man; U = uranium.

[a] An MEI was assumed to be on Highway 20, 5 kilometers from the VTR complex at MFC.

[b] Potential longer-term impacts due to chronic exposures to radionuclides remaining after the plume passage due to various pathways, including resuspension of remaining particulates and ingestion of contaminated food, were also calculated and presented in Appendix D. The food pathway could be the largest source of longer-term dose from accidents releasing fission products unless mitigated by the interdiction of the nearby food chain.

[c] Accident frequencies are generally grouped into the bins of "anticipated," "unlikely," "extremely unlikely," and "beyond extremely unlikely," with estimated frequencies of greater than 1×10^{-2}, 1×10^{-2} to 1×10^{-4}, 1×10^{-4} to 1×10^{-6}, and less than 1×10^{-6} per year, respectively.

[d] Numbers of LCFs in the population are whole numbers; the statistically calculated values are provided in parentheses for when the reported result is 1 or less.

4.11.5 Potential Impacts of a Hypothetical Beyond Design-Basis Reactor Accident

In order to fulfill the requirements of NEPA and for VTR EIS purposes, the potential impacts are evaluated for a hypothetical beyond-design-basis reactor accident of unknown cause in which all active (heat removal system [HRS]) and passive (RVACS) cooling systems are disrupted. The hypothetical accident is chosen to envelope consequences for any accident that may be postulated as the reactor design and analysis evolves. For the sequence of events with total loss of heat removal capabilities, that is loss of both RVACS and HRS or the loss of heat sink, bulk sodium boiling and release of radionuclides from melted fuel in the reactor core is assumed. Because both the VTR reactor vessel and reactor room are not designed to withstand pressurization due to sodium bulk boiling, the confinement systems are assumed to fail.

The potential accident sequences associated with a hypothetical beyond-design-basis reactor accident that ultimately leads to loss of reactor fuel cooling, sodium boiling, fuel failure, and ultimately, release to the environment are highly speculative. Potential accident initiators are an aircraft impact or a seismic event. Many mechanisms are in place to reduce the likelihood of a large release even with a direct impact by a large aircraft or an extreme seismic event. While it may be physically possible for such releases, many reactor and safety engineers think that the likelihood or conditional probability of all the events occurring such that there would be substantial releases to the environment is negligible. As discussed in Sections D.3.3.2 to 3.3.4, many characteristics of the VTR and PRISM designs make the conditional probability of a LWR-type core melt accident with containment failure infinitesimally small following an initiating event such as direct impact by a large aircraft or a beyond-design-basis seismic event. The conditional probability of a large release following either of these initiating events is expected to range from 0.01 to 0.001 or lower than the initiating event probability. Thus, the overall probability of the hypothetical accident is expected to be beyond extremely unlikely and much less than the 10^{-6} to 10^{-7} per year range. In contrast, the current mean reactor core damage frequency for NRC regulated, commercial LWRs is 3.1×10^{-5} per year (NRC 2019). As the VTR design evolves past the conceptual design phase, additional event initiators and subsequent accident sequences may be developed but this postulated, hypothetical event is expected to provide a reasonable estimate of the impacts of such an event.

If this accident were to occur, the impacts could be high, similar but less than commercial LWRs. Potential radiological impacts and risks to the MEI and public from the hypothetical beyond design-basis accident are presented in Tables D-33 and D-34. As expected, without allowing for pre-release decay and emergency actions, the results of the MACCS modeling indicate very high doses, likely fatal doses near the reactor site. An individual at the assumed location of the MEI would receive a fatal dose if he remained at that location for the entire plume passage. Individuals, including members of the public that remained near the reactor site could receive very high, and potentially fatal doses. Over the long term and without mitigation, the projected LCFs among the population within 50 miles is 260 for INL and 8,400 for ORNL. The major difference in the projected impacts between INL and ORNL are the much larger population residing close to ORNL.

As discussed in Section D.4.9.2, the annual population risks from operation of the VTR would be at least one to two orders of magnitude smaller than that of commercial LWRs. It is important to note that the VTR risks are based on conservative assumptions and take no credit for evacuation. In contrast, the current mean reactor core damage frequency for NRC regulated, commercial LWRs is 3.1×10^{-5} per year (NRC 2019). As the VTR design evolves past the conceptual design phase, additional event initiators and subsequent accident sequences may be developed but this postulated, hypothetical event is expected to envelope the consequences from any event that may be postulated as the VTR project evolves.

If this accident were to occur, the impacts could be high. Potential radiological impacts and risks to the MEI and public from the hypothetical beyond design-basis accident are presented in Tables D–33 and D–34. The economic impacts of the hypothetical accident are discussed in Section D.4.9.4. As expected, without allowing for pre-release decay and emergency actions, the results of the MACCS modeling indicate very high and potentially lethal doses near the reactor site. An individual at the assumed location of the MEI would receive a fatal dose if exposed to the entire plume passage. Individuals, including members of the public that remained near the reactor site could receive very high, and potentially lethal doses. Over the long term and without mitigation, 260 and 8,400 LCFs are calculated for the population within 50 miles of the INL and ORNL sites, respectively. The major difference in the projected impacts between INL and ORNL is the much large population residing close to ORNL.

As discussed in Section D.4.9.2, the annual population risks from operation of the VTR would be at least one to two orders of magnitude less than for commercial LWRs. It is important to note that the VTR risks are based on conservative assumptions that do not consider decay of short-lived isotopes, mitigation to limit releases, or emergency actions such as evacuation or sheltering-in-place. Thus the potential VTR impacts are likely over stated. The NRC-evaluated risks for LWRs are based on more realistic assumptions for as-built LWRs and consider preventative and mitigation features of the LWRs, including evacuation of persons within the typical 10-mile radius emergency planning zones surrounding the LWRs. Severe accident modeling for LWRs also considers radioisotope decay for releases that occur hours or days after the reactor shuts down.

As demonstrated in Section D.4.9.3 for the hypothetical VTR accident, the VTR sited at either INL or ORNL would meet the NRC safety goals for prompt fatalities or latent cancers by a wide margin, even with the many conservative assumptions used in the accident analysis. The hypothetical, beyond-design-basis reactor accident with loss of cooling is included in this VTR EIS to provide a reasonable but bounding estimate of the potential impacts from very low probability, high consequence accidents. As the VTR design evolves past the conceptual design phase, additional event initiators and subsequent accident sequences may be developed but this postulated, hypothetical event is expected to envelope the consequences of any accident that may be postulated as the design evolves.

4.12 Human Health – Transportation Impacts

Both radiological and nonradiological transportation impacts would result from shipment of radioactive materials and waste. Only nonradiological impacts would result from shipment of nonradioactive wastes. Radiological impacts are those associated with the effects from low levels of radiation emitted during incident-free transportation and from the accidental release of radioactive materials, and are expressed as additional LCFs. Nonradiological impacts are independent of the nature of the cargo being transported, and are expressed as traffic accident fatalities resulting only from the physical forces that accidents could impart to humans.

Appendix E contains detailed descriptions of the transportation analysis and results.

Methodology and Assumptions

Transportation packages containing radioactive materials emit low levels of radiation; the amount of radiation depends on the characteristics of the transported materials. U.S. Department of Transportation (DOT) regulations require that transportation packages containing radioactive materials have sufficient radiation shielding to limit the radiation dose rate to 10 millirem per hour at a distance of 6.6 feet from the transporter.

For incident-free transportation, the potential human health impacts of the radiation field surrounding the transportation packages were estimated for transportation workers and the general population along the route (termed off-traffic or off-link). Human health impacts are also estimated for people sharing the route (termed in-traffic or on-link), at rest areas, and at other stops along the route. This EIS used the RADTRAN 6 [Radioactive Material Transportation Risk Assessment] computer code (Weiner et al. 2013, 2014) to estimate the impacts on transportation workers and the population along the route. RADTRAN 6 also was used to help estimate the impacts on an MEI (e.g., a person stuck in traffic, a gas station attendant, an inspector).

Transportation accidents involving radioactive materials present both nonradiological and radiological risks to workers and the public. Nonradiological impacts of transportation accidents include traffic accident fatalities. Radioactive material would be released during transportation accidents only when the transport package carrying the material is subjected to forces that exceed its design standard. Only a severe fire or a powerful collision, both events of extremely low probability, could lead to a transportation package of the type (Type B) used to transport highly radioactive material being damaged to the extent that there could be a significant release of radioactive material to the environment.

The radiological impact of a specific accident is expressed in terms of probabilistic risk (i.e., dose-risk). Dose risk is defined as the accident probability (i.e., accident frequency) multiplied by the accident consequences (i.e., dose). The overall radiological risk is obtained by summing the individual radiological risks from all reasonably conceivable accidents. The analysis of accident risks takes into account a spectrum of accident severities ranging from high-probability accidents of low severity (e.g., a fender bender) to hypothetical high-severity accidents having low probabilities of occurrence.

In addition to calculating the radiological risks that would result from all reasonably conceivable accidents during transportation of radioactive materials and wastes, this EIS assesses the highest consequences of a maximum reasonably foreseeable accident having a radioactive release frequency greater than 1×10^{-7} (1 chance in 10 million) per year in an urban or suburban population area along the route. This latter analysis used the RISKIND [Risks and Consequences of Radioactive Material Transport] computer code, Version 2.0, to estimate doses to individuals and populations (Yuan et al. 1995). The results of this analysis are presented in Appendix E, Section E.8.

Incident-free radiological health impacts are expressed in terms of additional LCFs. Radiological health impacts from accidents are also expressed as additional LCFs. Nonradiological accident risk is expressed as additional immediate (traffic) fatalities. LCFs associated with radiological exposure were estimated by multiplying the occupational (worker) and public dose by a dose conversion factor of 0.0006 LCFs per rem or person-rem of exposure (DOE 2003). The health impacts associated with shipment of special nuclear material and unirradiated VTR fuel were calculated assuming that all transportation packages would be transported by escorted commercial truck or NNSA secure transportation assets (STAs).

In determining transportation risks, per-shipment risk factors were calculated for incident-free and accident conditions using the RADTRAN 6 code (Weiner et al. 2013, 2014) in conjunction with the Web Transportation Routing Analysis Geographic Information System (WebTRAGIS) code (Peterson 2018), which was used to identify transportation routes in accordance with DOT regulations and other parameters. The WebTRAGIS program currently provides population density estimates along the routes based on the 2010 U.S. census data for determining population radiological risk factors. For incident-free operations, the affected population includes individuals living within 0.5 miles of each side of the road or rail line. For accident conditions, the affected population includes individuals living within 50 miles of the accident, and the MEI was assumed to be a receptor located 330 feet directly downwind from the accident. Additional details on the analytical approach and on modeling and parameter selections are provided in Appendix E. The estimated population for which incident-free and accident doses are calculated was increased to account for population growth through the year 2050.

Accident and fatality rates for commercial truck transports are used for determining traffic accident fatalities (Saricks and Tompkins 1999). Statistics specific to STA shipments, which would be used for shipment of special nuclear material, are also used for escorted commercial truck shipments (see Appendix E, Section E.7.2). The methodology for obtaining and using accident and fatality rates is provided in Appendix E, Section E.7.2, "Accident Rates."

For each alternative, transportation impacts were evaluated for the transport of the following (as applicable to each alternative):

- plutonium (weapon grade) materials from either Los Alamos National Laboratory (LANL) to SRS or INL, or from SRS to INL[6]
- plutonium (reactor grade in oxide form) materials from Europe (France, United Kingdom, or both, through Joint Base Charleston-Weapons Station in South Carolina to SRS or INL)
- TRU waste from SRS, ORNL, or the INL Site to the Waste Isolation Pilot Plant (WIPP) facility
- Unirradiated VTR Fuel from SRS to ORNL or the INL Site, or from the INL Site to ORNL
- LLW and MLLW from SRS, INL, or ORNL to offsite Federal or commercial disposal facilities; for purposes of analysis in this EIS, the disposal site was assumed to be the Nevada National Security Site (NNSS) near Las Vegas, Nevada; Energy*Solutions* near Clive, Utah; and Waste Control Specialists, near Andrews, Texas
- Low-enriched uranium (5 percent) from a commercial fuel fabrication facility (Nuclear Fuel Services, Inc. in Erwin, Tennessee) to SRS or the INL Site
- Adulterant/diluent from a commercial vendor from an assumed distance of 3,000 miles or from a DOE site to the INL Site or SRS, for dilution of plutonium wastes in critically controlled overpacks for transport to the WIPP facility
- Construction materials from commercial vendors to INL, ORNL, and SRS (nonradiological impacts only)
- Hazardous wastes from INL, SRS, and ORNL to an offsite treatment, storage, and disposal facility (nonradiological impacts only)

Route characteristics are determined for shipments to assess incident-free and transportation accident impacts related to radioactive material and waste shipments. The number of shipments of plutonium and

[6] The weapon grade plutonium would be available from LANL or SRS after the surplus pit disassembly at either site. The impacts of transporting surplus pit to either site, and its related activities are evaluated in the *Final Surplus Plutonium Disposition Supplemental Environmental Impact Statement* (DOE 2015a).

low-enriched uranium were based on the required quantities of these materials to support the VTR fuel fabrication (SRNS 2020). The compositions and the transportation packages needed for different radioactive materials are estimated using unclassified information that provides a conservative estimate that would be reflective of the material or waste being transported. All shipments were assumed to be conducted by truck. Transports of plutonium materials, low-enriched uranium, and VTR fuel assemblies were assumed to be conducted by STAs (see Appendix E, Section E.2.4, for more information regarding STA vehicle requirements). Truck routes between specific origination and destination sites are analyzed, as shown in Appendix E, Table E–1 and Figures E–2 through E–4.

As indicate above, the sources of plutonium range from domestic to foreign locations. The transportation impact analysis is based on the weapon grade (lowest risk) and European (French: the highest risk) plutonium materials, as these provide an enveloping risk for all other potential domestic plutonium that could be transported between the affected sites. Because the weapon grade plutonium could be available at either LANL or SRS sites, two sets of the analyses were performed. Tables E–6 and E–7 in Appendix E summarize the assumed destinations and estimated number of truck shipments for each type of radioactive waste or nuclear material. Both tables show similar maximum impacts, and when plutonium is available at the SRS site, then a VTR fuel fabrication option at the SRS would lead to a smaller number of shipments of weapon grade plutonium, (see Appendix E, Section E.8).

Summary of Impacts

Table 4–57 summarizes transportation impacts under each alternative for shipments of radioactive materials and waste.[7] The accident impacts presented in this table are those that could result from all reasonably conceivable impacts during transport of radioactive materials and waste. These impacts are also presented in Appendix E, Section E.8.

Table 4–57. Annual Risk of Transporting Radioactive Materials and Waste under Each Alternative [a]

Route	Number of Shipments	One-way Kilometers Traveled	Incident-Free: Crew Dose (person-rem)	Incident-Free: Crew Risk [b]	Incident-Free: Population Dose (person-rem)	Incident-Free: Population Risk [b]	Accident: Radiological Risk [b]	Accident: Non-radiological Risk [b]
INL VTR Alternative								
INL VTR and Support Facility Operations								
Transuranic (CH and RH) waste to WIPP	0.23	534	0.02		0.02	0.00001	1×10^{-6}	0.00002
Low-level (CH and RH) waste transport								
INL to Energy*Solutions*	130	66,491	2.1	0.001	1.9	0.001	2×10^{-8}	0.008
INL to NNSS	130	172,837	3.9	0.002	4.3	0.003	2×10^{-8}	0.007
INL to WCS	130	307,511	7.0	0.004	7.9	0.005	4×10^{-8}	0.01
Subtotal [c]	**130**	**308,046**	**7.0**	**0.004**	**8.0**	**0.005**	$\mathbf{2 \times 10^{-6}}$	**0.01**
INL VTR Operations plus Reactor Fuel Production options								
Total 1 = INL VTR/Support Facility Operations plus INL Reactor Fuel Production								
Total 1 – Fab only [d]-WG Pu	**187**	**444,586**	**10.3**	**0.006**	**11.5**	**0.007**	$\mathbf{2 \times 10^{-6}}$	**0.02**
Total 1 – Prep and Fab-WG Pu (Case 1)	**204**	**483,178**	**12.0**	**0.007**	**12.8**	**0.008**	$\mathbf{3 \times 10^{-6}}$	**0.02**
Total 1 – Prep and Fab-WG Pu (Case 3)	**197**	**467,181**	**11.4**	**0.007**	**12.3**	**0.007**	$\mathbf{3 \times 10^{-6}}$	**0.02**
Total 1 – Fab only-RG Pu [e]	**195**	**461,142**	**10.5**	**0.006**	**12.2**	**0.007**	$\mathbf{9 \times 10^{-6}}$	**0.02**
Total 1 – Prep and Fab-RG Pu (Case 1)	**415**	**963,636**	**29.8**	**0.02**	**28.2**	**0.02**	$\mathbf{2 \times 10^{-5}}$	**0.04**
Total 1 – Prep and Fab-RG Pu (Case 3)	**325**	**757,965**	**22.0**	**0.01**	**21.7**	**0.01**	$\mathbf{1 \times 10^{-5}}$	**0.03**

[7] This table is based on the assumption that the weapon grade plutonium is sourced from LANL. For the impacts, where weapon grade plutonium is available at SRS, See Table E–7, in Appendix E.

			Incident-Free				*Accident*	
			Crew		*Population*			
Route	*Number of Shipments*	*One-way Kilometers Traveled*	*Dose (person-rem)*	*Risk* [b]	*Dose (person-rem)*	*Risk* [b]	*Radiological Risk* [b]	*Non-radiological Risk* [b]
Total 2 = INL VTR/Support Facility Operations plus SRS Reactor Fuel Production								
Total 2 – Fab only-WG Pu	**202**	**520,996**	**11.2**	**0.007**	**12.3**	**0.007**	**3×10^{-6}**	**0.02**
Total 2 – Prep and Fab-WG Pu (Case 1)	**219**	**550,768**	**12.6**	**0.008**	**13.4**	**0.008**	**3×10^{-6}**	**0.02**
Total 2 – Prep and Fab-WG Pu (Case 3)	**212**	**534,622**	**11.9**	**0.007**	**12.8**	**0.008**	**3×10^{-6}**	**0.02**
Total 2 – Fab only-RG Pu	**203**	**679,460**	**14.5**	**0.009**	**15.3**	**0.009**	**4×10^{-6}**	**0.03**
Total 2 – Prep and Fab-RG Pu (Case 1)	**423**	**1,001,621**	**30.4**	**0.02**	**27.9**	**0.02**	**1×10^{-5}**	**0.05**
Total 2 – Prep and Fab-RG Pu (Case 3)	**333**	**794,028**	**22.4**	**0.01**	**21.1**	**0.01**	**6×10^{-6}**	**0.04**
ORNL VTR Alternative								
ORNL VTR and Support Facility Operations								
Transuranic (CH and RH) waste to WIPP	0.23	487	0.02	0.00001	0.02	0.00001	2×10^{-6}	0.00003
Low-level (CH and RH) waste transport								
ORNL to Energy*Solutions*	130	408,852	9.3	0.006	11.1	0.007	7×10^{-8}	0.02
ORNL to NNSS	130	450,619	10.2	0.006	11.7	0.007	2×10^{-8}	0.02
ORNL to WCS	130	255,208	5.8	0.004	7.3	0.004	5×10^{-8}	0.01
Sub-Total [c]	**130**	**451,106**	**10.2**	**0.006**	**11.8**	**0.007**	**2×10^{-6}**	**0.02**
ORNL VTR Operations plus Reactor Fuel Production Options								
Total 1 – Fab only-WG Pu	**202**	**616,966**	**13.2**	**0.008**	**15.0**	**0.009**	**3×10^{-6}**	**0.03**
Total 1 – Prep and Fab-WG Pu (Case 1)	**219**	**676,042**	**15.3**	**0.009**	**16.8**	**0.01**	**3×10^{-6}**	**0.03**
Total 1 – Prep and Fab-WG Pu (Case 3)	**212**	**660,045**	**14.7**	**0.009**	**16.3**	**0.01**	**3×10^{-6}**	**0.03**
Total 1 – Fab only-RG Pu	**210**	**654,006**	**13.8**	**0.008**	**16.2**	**0.01**	**9×10^{-6}**	**0.03**
Total 1 – Prep and Fab-RG Pu (Case 1)	**430**	**1,156,500**	**33.1**	**0.02**	**32.1**	**0.02**	**2×10^{-5}**	**0.05**
Total 1 – Prep and Fab-RG Pu (Case 3)	**340**	**950,829**	**25.3**	**0.02**	**25.7**	**0.02**	**1×10^{-5}**	**0.04**
Total 2 – Fab only-WG Pu	**202**	**617,072**	**14.4**	**0.009**	**15.9**	**0.01**	**3×10^{-6}**	**0.03**
Total 2 – Prep and Fab-WG Pu (Case 1)	**219**	**646,844**	**15.8**	**0.009**	**17.1**	**0.01**	**3×10^{-6}**	**0.03**
Total 2 – Prep and Fab-WG Pu (Case 3)	**212**	**630,698**	**15.1**	**0.009**	**16.5**	**0.01**	**3×10^{-6}**	**0.03**
Total 2 – Fab only-RG Pu	**203**	**775,536**	**17.7**	**0.01**	**19.0**	**0.01**	**4×10^{-6}**	**0.04**
Total 2 – Prep and Fab-RG Pu (Case 1)	**423**	**1,097,697**	**33.6**	**0.02**	**31.5**	**0.02**	**1×10^{-5}**	**0.06**
Total 2 – Prep and Fab-RG Pu (Case 3)	**333**	**890,104**	**25.6**	**0.02**	**24.8**	**0.01**	**6×10^{-6}**	**0.05**
INL Reactor Fuel Production Option								
STA transport								
All STA routes (with U.S. WG Pu)	13	34,530	0.29	0.0002	0.9	0.0006	5×10^{-7}	0.0007
All STA routes (with European RG Pu) [e]	21	51,086	0.49	0.0003	1.7	0.001	7×10^{-6}	0.001
Low-level waste transport								
INL to NNSS	15	19,943	0.40	0.0002	0.4	0.0002	2×10^{-9}	0.0008
INL to Energy*Solutions*	15	7,672	0.15	0.00009	0.2	0.0001	2×10^{-9}	0.0009
INL to WCS	15	35,482	0.71	0.0004	0.7	0.0004	4×10^{-9}	0.002
Transuranic waste transport								
INL to WIPP (Secondary waste)	4	9,141	0.35	0.0002	0.3	0.0002	8×10^{-8}	0.0004
INL to WIPP (POCs) Fab only [d]-WG Pu	13	29,708	1.13	0.0007	0.9	0.0006	2×10^{-7}	0.001
INL to WIPP (diluted PuO_2 in CCOs) [f] – Fab only- WG Pu	12	27,679	0.87	0.0005	0.7	0.0004	2×10^{-7}	0.001
INL to WIPP (Diluted PuO_2 in CCOs) [g]– Fab only-WG Pu	10	23,530	0.87	0.0005	0.7	0.0004	2×10^{-7}	0.001
INL to WIPP – Prep and Fab-WG Pu (Case 1)	42	95,980	3.65	0.002	3.0	0.002	8×10^{-7}	0.004
INL to WIPP – Prep and Fab-WG Pu (Case 3)	35	79,983	3.04	0.002	2.5	0.002	5×10^{-7}	0.003

Route	Number of Shipments	One-way Kilometers Traveled	Incident-Free				Accident	
			Crew		Population			
			Dose (person-rem)	Risk [b]	Dose (person-rem)	Risk [b]	Radiological Risk [b]	Non-radiological Risk [b]
INL to WIPP – Prep and Fab-RG Pu (Case 1)	245	559,881	21.28	0.01	17.6	0.01	9×10^{-6}	0.02
INL to WIPP – Prep and Fab-RG Pu (Case 3)	155	354,211	13.47	0.008	11.1	0.007	5×10^{-6}	0.01
Total reactor fuel production transport								
Total – Fab only-WG Pu	**57**	57	136,540	3.34	0.002	3.5	0.002	1×10^{-6}
Total – Prep and Fab-WG Pu (Case 1)	**74**	**175,132**	**4.99**	**0.003**	**4.9**	**0.003**	$\mathbf{1 \times 10^{-6}}$	**0.007**
Total – Prep and Fab-WG Pu (Case 3)	**67**	**159,136**	**4.38**	**0.003**	**4.4**	**0.003**	$\mathbf{1 \times 10^{-6}}$	**0.006**
Total – Fab only-RG Pu [e]	**65**	**153,096**	**3.54**	**0.002**	**4.3**	**0.003**	$\mathbf{8 \times 10^{-6}}$	**0.005**
Total – Prep and Fab-RG Pu (Case 1)	**285**	**655,590**	**22.83**	**0.01**	**20.2**	**0.01**	$\mathbf{2 \times 10^{-5}}$	**0.03**
Total – Prep and Fab-RG Pu (Case 3)	**195**	**449,919**	**15.01**	**0.009**	**13.7**	**0.008**	$\mathbf{1 \times 10^{-5}}$	**0.02**
VTR Fuel Assemblies to ORNL	**15**	**49,804**	**0.05**	**0.00003**	**0.2**	**0.0001**	$\mathbf{5 \times 10^{-8}}$	**0.001**
SRS Reactor Fuel Production Option								
STA transport								
All STA routes (with U.S. WG Pu)	13	21,976	0.3	0.0002	0.9	0.0005	7×10^{-7}	0.0006
All STA routes (with European RG Pu)	14	4,593	0.04	0.00002	0.12	0.00007	5×10^{-7}	0.0001
Low-level waste transport								
SRS to NNSS	15	58,343	1.2	0.0007	1.1	0.0007	6×10^{-9}	0.003
SRS to Energy*Solutions*	15	53,578	1.1	0.0006	1.1	0.0007	1×10^{-9}	0.003
SRS to WCS	15	32,723	0.7	0.0004	0.7	0.0004	6×10^{-10}	0.002
Transuranic waste transport								
SRS to WIPP (secondary waste)	4	9,226	0.4	0.0002	0.1	0.00005	2×10^{-8}	0.0006
SRS to WIPP (POCs) Fab only [d]-WG Pu	13	29.986	1.2	0.0007	1.0	0.0006	2×10^{-7}	0.002
SRS to WIPP (diluted PuO_2 in CCOs) [f] – Fab only WG Pu	12	27,893	0.9	0.0005	0.8	0.0005	2×10^{-7}	0.002
SRS to WIPP (diluted PuO_2 in CCOs) [g] – Fab-WG Pu	10	23,255	0.9	0.0005	0.8	0.0005	2×10^{-7}	0.001
SRS to WIPP – Prep and Fab-WG Pu (Case 1)	42	96,876	3.74	0.002	3.15	0.002	8×10^{-7}	0.006
SRS to WIPP – Prep and Fab-WG Pu (Case 3)	35	80,730	3.06	0.002	2.55	0.002	8×10^{-7}	0.004
SRS to WIPP – Prep and Fab-RG Pu (Case 1)	245	565,113	21.81	0.01	18.39	0.01	8×10^{-6}	0.03
SRS to WIPP – Prep and Fab-RG Pu (Case 3)	155	357,520	13.80	0.008	11.63	0.007	4×10^{-6}	0.02
Total reactor fuel production transport								
Total – Fab only-WG Pu	**57**	**156,650**	**4.2**	**0.003**	**4.2**	**0.002**	$\mathbf{2 \times 10^{-6}}$	**0.008**
Total – Prep and Fab-WG Pu (Case 1)	**74**	**186,422**	**5.52**	**0.003**	**5.28**	**0.003**	$\mathbf{2 \times 10^{-6}}$	**0.01**
Total – Prep and Fab-WG Pu (Case 3)	**67**	**170,276**	**4.84**	**0.003**	**4.67**	**0.003**	$\mathbf{2 \times 10^{-6}}$	**0.008**
Total – Fab only-RG Pu) [e]	**58**	**315,114**	**7.49**	**0.004**	**7.18**	**0.004**	$\mathbf{2 \times 10^{-6}}$	**0.02**
Total – Prep and Fab-RG Pu (Case 1)	**278**	**637,275**	**23.37**	**0.01**	**19.73**	**0.01**	$\mathbf{8 \times 10^{-6}}$	**0.04**
Total – Prep and Fab-RG Pu (Case 3)	**188**	**429,682**	**15.36**	**0.009**	**12.97**	**0.008**	$\mathbf{5 \times 10^{-6}}$	**0.03**
VTR Fuel Assemblies to INL	**15**	**56,300**	**0.06**	**0.00004**	**0.21**	**0.0001**	$\mathbf{6 \times 10^{-8}}$	**0.001**
VTR Fuel Assemblies to ORNL	**15**	**9,316**	**0.010**	**0.000006**	**0.041**	**0.00002**	$\mathbf{2 \times 10^{-8}}$	**0.0002**

Case 1 = aqueous plutonium processing; Case 3 = pyro-chemical plutonium processing; CCO = criticality control overpack; CH = contact-handled; Fab = fuel fabrication; NNSS = Nevada National Security Site; POC = pipe overpack container; Prep and Fab = feedstock preparation (processing) and fuel fabrication; RG = reactor grade (European) feed; RH = remote-handled; SRS = Savannah River Site; STA = Secure Transportation Asset; VTR = Versatile Test Reactor; WCS = Waste Control Specialists; WG = weapon grade feed; WIPP = Waste Isolation Pilot Plant.

Route	Number of Shipments	One-way Kilometers Traveled	Incident-Free				Accident	
			Crew		Population			
			Dose (person-rem)	Risk [b]	Dose (person-rem)	Risk [b]	Radiological Risk [b]	Non-radiological Risk [b]

[a] For each shipment category, the cited values are annual impact values. The reactor fuel production facilities are to be operational three years before the start of the VTR. The VTR requires about 110 driver fuel assemblies (a full load plus one year of refueling needs) prior to start of its operation.

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

[c] This subtotal reflects the maximum risk from transporting the LLW/MLLW to either NNSS, EnergySolutions, or WCS

[d] Fabrication only is used for the clean weapon grade plutonium feed materials.

[e] Includes impacts from transporting the reactor grade (European [French or United Kingdom]) plutonium materials, which are assumed to be transported to SRS for repackaging and then transported to INL, if applicable.

[f] Includes impacts from transport of two shipments of adulterants from an assumed distance of 4,800 kilometers (3,000 miles) to the INL Site or SRS for dilution of plutonium in CCOs.

[g] Includes impacts from transport of a shipment every 5 years of a diluent from a DOE site to the INL Site or SRS for dilution of plutonium in CCOs.

Notes: Totals may differ from the sum of individual entries due to rounding.
All STA routes is the sum of the plutonium and low-enriched uranium transports.
Annual waste shipment numbers could be less than one.
To convert kilometers to miles, multiply by 0.62137.
Bolded entries are sums.

Appendix E, Section E.9 provides the impacts from transporting construction materials and hazardous wastes related to construction and operations. **Table 4–58** summarizes the impacts from transporting these materials.

The results in Tables 4–57 and 4–58 are discussed further in Sections 4.12.1 and 4.12.2. Route-specific impacts are presented in Appendix E, Table E–5.

Table 4–58. Estimated Total Impacts from Hazardous Waste and Construction Material Transport

Number of Shipments	Total Distance Traveled (two-way kilometers)	Number of Accidents	Traffic Fatality Risk
INL VTR Alternative			
18,460	24,300,000	14	0.6
ORNL VTR Alternative			
23,786	31,548,000	17	0.7
INL VTR Fuel Production Options			
0.0 [a]			
SRS VTR Fuel Production Options			
2,454	490,800	0.4	0.02

[a] INL existing facilities do not require major construction to accommodate the equipment (e.g., glove boxes) for the fuel production activities.

Note: To convert kilometers to miles, multiply by 0.62137.
Source: INL 2020f, SRNS 2020.

4.12.1 INL VTR Alternative

Under the INL VTR Alternative, transportation impacts from radioactive and nonradioactive (hazardous and construction wastes) generated in support of the facility construction and operation activities to various locations are summarized.

As shown in Table 4–57, under this alternative, there would be 187 to 423 truck shipments of radioactive materials and waste, annually. This includes 15 shipments of unirradiated VTR fuel assemblies to INL, if the SRS VTR fuel production option is used. These types of transports would occur for about 63 years, 3 years of fuel production prior to the start of VTR operation and 60 years of VTR operation afterward.

Impacts of Incident-Free Transportation

Crew[8] – The highest annual crew dose of about 30 person rem and an expected LCF of 0.018 would occur if the foreign (European) plutonium fuel were to be used along with the aqueous feedstock preparation as part of the VTR fuel production at INL. Assuming that the same individual crew would be responsible for all shipments for a period of 20 years, the transport of radioactive materials, waste, and unirradiated VTR fuel likely would not result in any LCFs among crew members.

Public – The highest cumulative annual population dose of about 28 person-rem and an expected LCF of 0.017 amongst the exposed population would occur if the foreign plutonium fuel were to be used along with the aqueous feedstock preparation as part of the VTR fuel production at INL. Given the various transport routes and the exposed population groups along these routes, the cumulative dose to the general population over the 63 years likely would not result in any LCFs from transport of radioactive materials, waste, and unirradiated VTR fuel.

Impacts of Transportation Accidents

As described previously, two sets of analyses were performed for the evaluation of radiological transportation accident impacts: impacts of maximum reasonably foreseeable accidents (accidents having radioactive release probabilities greater than 1×10^{-7} [1 chance in 10 million] per year), and impacts of all conceivable accidents (total transportation accidents).

For maximum reasonably foreseeable transportation accidents probabilities were calculated for all route segments (i.e., rural, suburban, and urban), and maximum consequences were determined for those route shipments having a likelihood-of-release frequency exceeding 1 in 10 million per year. For the INL VTR Alternative, the maximum reasonably foreseeable transportation accident having the highest consequence would involve truck transport of plutonium (assumed to be in powder form)[9] to SRS for the VTR fuel production (see Appendix E, Table E–9), if a weapon grade plutonium is used, and to the INL Site for fuel production if the European (French fuel) is used.

The maximum reasonably foreseeable probability of a truck accident involving the weapon grade material would be up to 2.5×10^{-6} per year in a rural area, or 1 chance in 400,000 each year; and that for the European fuel would be 1.2×10^{-7} per year in a suburban area, or 1 chance in 8.3 million each year. The consequences of the truck transport accident in terms of population dose would be about 348 person-rem, resulting in 0 (0.21) additional LCFs among the exposed population for the weapon grade fuel, and for the European fuel would be about 61,500 person rem, resulting in 37 additional LCF among the exposed population. Considering the likelihood of these accidents, the maximum expected additional LCF among the exposed population would be 0 (0.0000044), annually.

Estimates of total transportation accident dose-risks for all projected accidents involving all materials and waste shipments, regardless of material or waste type, and unirradiated VTR fuel assemblies likely would not result in any LCFs. Transport activities under this alternative would result in 4 (3.8) nonradiological fatalities due to traffic accidents, over 63 years of operation. For comparison, in the United States in 2017 there were over 37,133 traffic fatalities due to all vehicular crashes (DOT 2019). The incremental increase

[8] Crew are the truck drivers; assumed to be two drivers per transport.
[9] European plutonium is in oxide form, and there is a potential that domestic weapon grade plutonium would also be in oxide form, as well. The assumption that all source materials would be in oxide form maximizes the accident risk. Therefore, the assumption that all feedstock plutonium is in oxide for transportation analysis envelopes the accident risks.

in risk to the general population from shipments associated with the VTR program would therefore be very small.

Impacts of Construction Materials and Hazardous Waste Transport

As shown in Table 4–58, the impacts from transporting construction materials to the INL Site and hazardous waste from the INL Site to an offsite disposal or recycle facility would result in 1 (0.6) traffic fatalities.

4.12.2 ORNL VTR Alternative

Under the ORNL VTR Alternative, transportation impacts from radioactive and nonradioactive (hazardous and construction wastes) generated in support of the facility construction and operation activities to various locations are summarized.

As shown in Table 4–57, under this alternative, there would be 202 to 430 truck shipments of radioactive materials and waste, annually. This includes 15 shipments of unirradiated VTR fuel assemblies to ORNL from either INL, or SRS.

Impacts of Incident-Free Transportation

Crew – The highest annual crew dose of about 34 person rem and an expected LCF of 0.020 would occur if the foreign plutonium fuel were to be used along with the aqueous feedstock preparation as part of the VTR fuel production at SRS. Assuming that the same individual crew is responsible for all shipments for a period of 20 years, the transport of radioactive materials, waste, and unirradiated VTR fuel likely would not result in any LCFs among crew members.

Public – The highest cumulative annual population dose of about 32 person-rem and an expected LCF of 0.019 amongst the exposed population would occur if the foreign plutonium fuel were to be used along with the aqueous feedstock preparation as part of the VTR fuel production at SRS. Given the various transport routes and the exposed population groups along these routes, the cumulative dose to the general population over the 63 years likely would not result in any LCFs from transport of radioactive materials, waste, and unirradiated VTR fuel.

Impacts of Transportation Accidents

As described previously, two sets of analyses were performed for the evaluation of radiological transportation accident impacts: impacts of maximum reasonably foreseeable accidents (accidents having radioactive release probabilities greater than 1×10^{-7} [1 chance in 10 million] per year), and impacts of all conceivable accidents (total transportation accidents).

Maximum reasonably foreseeable transportation accident probabilities were calculated for all route segments (i.e., rural, suburban, and urban), and maximum consequences were determined for those route shipments having a likelihood-of-release frequency exceeding 1 in 10 million per year. For the ORNL VTR Alternative, the maximum reasonably foreseeable transportation accident having the highest consequence would involve truck transport of plutonium (assumed to be in powder form) to SRS for the VTR fuel production (see Appendix E, Table E–9), if a weapon grade plutonium is used, and to the INL Site for fuel production if the European (French fuel) is used.

The maximum reasonably foreseeable probability of a truck accident involving the weapon grade material would be up to 2.5×10^{-6} per year in a rural area, or 1 chance in 400,000 each year; and that for the European fuel would be 1.2×10^{-7} per year in a suburban area, or 1 chance in 8.3 million each year. The consequences of the truck transport accident in terms of population dose would be about 348 person-rem, resulting in 0 (0.21) additional LCFs among the exposed population for the weapon grade fuel, and for the European fuel would be about 61,500 person rem, resulting in 37 additional LCF among the exposed population. Considering the likelihood of these accidents, the maximum expected additional LCF among the exposed population would be 0 (0.0000044), annually.

Estimates of total transportation accident dose-risks for all projected accidents involving all materials and waste shipments, regardless of material or waste type, and unirradiated VTR fuel assemblies likely would not result in any LCFs. Transport activities under this alternative would result in 4 (3.8) nonradiological fatalities due to traffic accidents, over 63 years of operation. For comparison, in the United States in 2017 there were over 37,133 traffic fatalities due to all vehicular crashes (DOT 2019). The incremental increase in risk to the general population from shipments associated with the VTR program would therefore be very small.

Impacts of Construction Materials and Hazardous Waste Transport

As shown in Table 4–58, the impacts from transporting construction materials to ORNL and hazardous waste from ORNL to an offsite disposal or recycle facility would result in 1 (0.7) traffic fatalities.

4.12.3 Reactor Fuel Production Options

Two options for the location of fuel fabrication facility are considered: at the INL Site and at SRS. Each fuel option includes plutonium fuel feedstock preparation. The processing cases considered include, Aqueous, Pyro-chemical plus a small aqueous, and Pyro-chemical only, see Appendix B to this VTR EIS, for details. The transportation impacts are enveloped by the Aqueous (Case-1) and the Pyro-chemical (Case-3) processes.

4.12.3.1 INL Reactor Fuel Production

Under this option, the impact of transporting the needed source materials (e.g., Pu, U, Zr, steel, NA, etc.) to the INL Site for the fabrication of the VTR fuel assemblies along with the generated waste transports to the disposal facilities, and the needed equipment and construction materials for the facility operation are evaluated.

As shown in Table 4–57, under this option, there would be 57 to 285 truck shipments of radioactive materials and waste annually, for the INL VTR Alternative. There would be additional 15 shipments for transport of VTR fuel under the VTR ORNL Alternative

Impacts of Incident-Free Transportation

Crew – The highest annual crew dose of about 23 person rem and an expected LCF of 0.01 would occur if the foreign plutonium fuel were to be used along with the aqueous feedstock preparation as part of the VTR fuel production at INL. Assuming that the same individual crew is responsible for all shipments for a period of 20 years, the transport of radioactive materials and waste associated with this option likely would result in no LCFs among crew members.

Public – The highest cumulative annual population dose of about 20 person-rem and an expected LCF of 0.01 amongst the exposed population would occur if the foreign plutonium fuel were to be used along with the aqueous feedstock preparation as part of the VTR fuel production at INL. Given the various transport routes and the exposed population groups along these routes, the cumulative dose to the general population associated with this option likely would result in no LCFs from transport of radioactive materials and waste.

Impacts of Transportation Accidents

For radioactive materials and waste shipped under this option, the maximum reasonably foreseeable offsite truck transportation accident having the highest consequence would involve truck transport of plutonium (assumed to be in powder form) to the INL Site (see Appendix E, Table E–9). The maximum reasonably foreseeable probability of a truck accident involving this material would be up to 1.9×10^{-6} per year in a rural area, or 1 chance in about 500,000 each year for the weapon grade; and 1.2×10^{-7} per year in a suburban area, or 1 chance in 8.3 million each year, for the European fuel. The consequences of the truck transport accident in terms of population dose would be about 286 person-rem, resulting in 0 LCFs (0.17) among the exposed population for the weapon grade fuel. For the European fuel, the consequences would be about 61,500 person rem, resulting in 37 additional LCF among the exposed population. Considering the likelihood of these accidents, the maximum expected additional LCF among the exposed population would be 0 (0.0000044), annually.

Estimates of total transportation accident dose-risks for all projected accidents involving all materials and waste shipments, regardless of material and waste type likely would result in no LCFs. Transport activities under this alternative would result in 2 (1.9) nonradiological fatalities due to a traffic accident, over 63 years. For comparison, in the United States in 2017 there were over 37,133 traffic fatalities due to all vehicular crashes (DOT 2019). The incremental increase in risk to the general population from shipments associated with the VTR program would therefore be very small.

Impacts of Construction Materials and Hazardous Waste Transport

As shown in Table 4–58, the impacts from transporting construction materials to the INL Site and hazardous waste from the INL Site to an offsite disposal or recycle facility would result in no traffic fatalities.

4.12.3.2 SRS Reactor Fuel Production

Under this option, the impact of transporting the needed equipment, construction materials, and source materials (e.g., plutonium, uranium, zirconium, steel, sodium) to SRS for the fabrication of the VTR fuel assemblies is evaluated. The option also evaluates generated waste transportation to disposal facilities.

As shown in Table 4–57, under this alternative, there would be 57 to 278 truck shipments of radioactive materials and waste. Transport of the fabricated VTR fuel assemblies would add 15 truck shipments to the INL Site or ORNL, annually,

Impacts of Incident-Free Transportation

Crew – The highest annual crew dose of about 23 person rem and an expected LCF of 0.01 would occur if the foreign plutonium fuel were to be used along with the aqueous feedstock preparation the VTR fuel production at SRS. Assuming that the same individual crew is responsible for all shipments for a period of 20 years, the transport of radioactive materials and waste associated with this option likely would result in no LCFs among crew members.

Public – The highest cumulative annual population dose of about 20 person-rem and an expected LCF of 0.01 amongst the exposed population would occur if the foreign plutonium fuel were to be used along with the aqueous feedstock preparation and the VTR fuel production at INL. Given the various transport routes and the exposed population groups along these routes, the cumulative dose to the general population associated with this option likely would result in no LCFs from transport of radioactive materials and waste.

Impacts of Transportation Accidents

For radioactive materials and waste shipped under this option, the maximum reasonably foreseeable offsite truck transportation accident having the highest consequence would involve truck transport of plutonium (assumed to be in powder form) to the INL Site (see Appendix E, Table E–9). The maximum reasonably foreseeable probability of a truck accident involving this material would be up to 2.5×10^{-6} per year in a rural area, or 1 chance in 400,000 each year. The consequences of the truck transport accident in terms of population dose would be about 348 person-rem, resulting in 0 (0.21) LCFs among the exposed population.

Estimated total transportation accident dose-risks for all projected accidents involving all materials and waste shipments, regardless of material and waste type likely would not result in any LCFs. Transport activities under this alternative would result in 3 (2.6) nonradiological fatalities due to traffic accidents, over 63 years. For comparison, in the United States in 2017 there were over 37,133 traffic fatalities due to all vehicular crashes (DOT 2019). The incremental increase in risk to the general population from shipments associated with the VTR program would therefore be very small.

Impacts of Construction Materials and Hazardous Waste Transport

As shown in Table 4–58, the impacts from transporting construction materials to SRS and hazardous waste from SRS to an offsite disposal or recycle facility would result in no traffic fatalities.

4.12.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

This section presents the total impacts that would occur if the VTR and the fuel production capability were both established at INL. The combined impacts developed earlier under the Combined INL VTR Alternative and the INL Reactor Fuel Production Option are summarized in Table 4–57 under the INL VTR Alternative in conjunction with the entries designated as "Total-1."

As shown in Table 4–57, under this alternative, there would be 187 to 415 truck shipments of radioactive materials and waste, annually. These types of transports would occur for about 63 years, 3 years of fuel production prior to the start of VTR operation and 60 years of VTR operation.

Impacts of Incident-Free Transportation

Crew – The highest annual crew dose of about 30 person rem and an expected LCF of 0.018 would occur if the foreign (European) plutonium fuel were to be used along with the aqueous feedstock preparation. Assuming that the same individual crew is responsible for all shipments for a period of 20 years, the transport of radioactive materials and waste likely would not result in any LCFs among crew members.

Public – The highest cumulative annual population dose of about 28 person rem and an expected LCF of 0.017 amongst the exposed population would occur if the foreign plutonium fuel were to be used along with the aqueous feedstock preparation. Given the various transport routes and the exposed population groups along these routes, the cumulative dose to the general population over the 63 years likely would not result in any LCFs from transport of radioactive materials or waste.

Impacts of Transportation Accidents

As described previously, two sets of analyses were performed for the evaluation of radiological transportation accident impacts: impacts of maximum reasonably foreseeable accidents (accidents having radioactive release probabilities greater than 1×10^{-7} [1 chance in 10 million] per year), and impacts of all conceivable accidents (total transportation accidents).

For maximum reasonably foreseeable transportation accidents probabilities were calculated for all route segments (i.e., rural, suburban, and urban), and maximum consequences were determined for those route shipments having a likelihood-of-release frequency exceeding 1 in 10 million per year. For the INL VTR Alternative, the maximum reasonably foreseeable transportation accident having the highest consequence would involve truck transport of plutonium (assumed to be in powder form) to the INL Site for the VTR fuel production (see Appendix E, Table E–9). The maximum reasonably foreseeable probability of a truck accident involving this material would be up to 1.9×10^{-6} per year in a rural area, or 1 chance in about 500,000 each year for the weapon grade; and 1.2×10^{-7} per year in a suburban area, or 1 chance in 8.3 million each year, for the European fuel. The consequences of the truck transport accident in terms of population dose would be about 286 person-rem, resulting in 0 LCFs (0.17) among the exposed population, for the weapon grade, and for the European fuel would be about 61,500 person rem, resulting in 37 additional LCF among the exposed population. Considering the likelihood of these accidents, the maximum expected additional LCF among the exposed population would be 0 (0.0000044), annually.

Estimates of total transportation accident dose-risks for all projected accidents involving all materials and waste shipments, regardless of material or waste type, and unirradiated VTR fuel assemblies likely would not result in any LCFs. Transport activities under this alternative would result in 3 (2.52) nonradiological fatalities due to traffic accidents, over 63 years of operation. For comparison, in the United States in 2017 there were over 37,133 traffic fatalities due to all vehicular crashes (DOT 2019). The incremental increase in risk to the general population from shipments associated with the VTR program would therefore be very small.

Impacts of Construction Materials and Hazardous Waste Transport

As shown in Table 4–58, the impacts from transporting construction materials to the INL Site and hazardous waste from the INL Site to an offsite disposal or recycle facility would result in 1 (0.6) traffic fatalities.

4.13 Traffic

This section discusses the potential effects to roadway and railroad networks that could occur from the construction and operation of the VTR, as well as the associated infrastructure, including construction of the Post-Irradiation Examination and Spent Nuclear Fuel Storage facilities (where applicable).

Table 4–59 summarizes the overall environmental impacts on traffic for the INL and ORNL VTR Alternatives and INL and SRS Reactor Fuel Production Options.

Table 4–59. Summary of Environmental Consequences on Traffic

Resource Area	***VTR Alternatives***	
	INL VTR	***ORNL VTR***
Traffic	***Construction***: The average increases in daily traffic at the INL Site during construction is not expected to exceed existing LOS of offsite roads, and no upgrades or improvements to onsite roads are anticipated. A maximum of 1,300 construction personnel would arrive during peak construction, with an overall average of about 640 construction personnel over the entire construction period.	***Construction***: The average increases in daily traffic at the ORNL Site during construction is not expected to exceed existing LOS of offsite roads, and no upgrades or improvements to onsite roads are anticipated. The construction of the Hot Cell Facility will result in about 30 percent higher traffic volumes at ORNL compared to INL. A maximum of about 1,700 construction personnel would arrive during peak construction, with an overall average of about 830 construction personnel over the entire construction period. Truck traffic would be directed specifically to avoid the main roadway through the center of campus.
	Operations: Operations at each facility are expected to result in an increase of about 218 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 LOS of offsite roads, and no upgrades or improvements to onsite roads are anticipated.	***Operations:*** Operations at each facility are expected to result in an increase of about 300 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 LOS of offsite roads, and no upgrades or improvements to onsite roads are anticipated.

<table>
<tr><th rowspan="2"></th><th colspan="2">Reactor Fuel Production Options</th></tr>
<tr><th>INL Reactor Fuel Production</th><th>SRS Reactor Fuel Production</th></tr>
<tr><td rowspan="6">Traffic</td><td colspan="2">Feedstock Preparation</td></tr>
<tr><td>Construction: The increase in traffic from both material shipments and construction workers are not expected to exceed existing LOS of offsite roads at either site, and no upgrades or improvements to onsite roads are anticipated Construction workers would average a total of 6 over the 3-year construction period, with a maximum of 18 workers during peak construction.</td><td>Construction: The increase in traffic from both material shipments and construction workers are not expected to exceed existing LOS of offsite roads at either site, and no upgrades or improvements to onsite roads are anticipated. This option would require approximately 120 new employees at SRS.</td></tr>
<tr><td colspan="2">Operations: The increase in traffic from new (300 at either of the two sites) combined with existing employee traffic is not expected to exceed existing LOS of offsite roads at either site, and no upgrades or improvements to onsite roads are anticipated to be needed. The increase in workforce would be about 2 percent at the INL Site and about 3 percent at SRS.</td></tr>
<tr><td colspan="2">Fuel Fabrication</td></tr>
<tr><td>Construction: The increase in traffic from both material shipments and construction workers are not expected to exceed existing LOS of offsite roads at either site, and no upgrades or improvements to onsite roads are anticipated Construction workers would average a total of 6 over the 3-year construction period, with a maximum of 18 workers during peak construction.</td><td>Construction: The increase in traffic from both material shipments and construction workers are not expected to exceed existing LOS of offsite roads at either site, and no upgrades or improvements to onsite roads are anticipated. This option would require approximately 120 new employees at SRS.</td></tr>
<tr><td>Operations: Approximately 70 new employees would be required to support fuel fabrication activities. The increase in traffic from new combined with existing employee traffic is not expected to exceed existing LOS of offsite roads at either site, and no upgrades or improvements to onsite roads are anticipated to be needed. The increase in workforce would be about 2 percent at the INL Site.</td><td>Operations: Approximately 300 new employees would be required to support fuel fabrication activities. The increase in traffic from new combined with existing employee traffic is not expected to exceed existing LOS of offsite roads at either site, and no upgrades or improvements to onsite roads are anticipated to be needed. The increase in workforce would be about 3 percent at the SRS Site.</td></tr>
<tr><th></th><th colspan="2">Combined INL VTR Alternative and INL Reactor Fuel Production Options</th></tr>
<tr><td rowspan="2">Traffic</td><td colspan="2">Construction: If all three options were to occur at INL (VTR, Feedstock Preparation, and Fuel Fabrication), the total number of new commuters (construction workers and employees) to INL would be approximately 1,400 during peak construction.</td></tr>
<tr><td colspan="2">Operations: If all three options were to occur at INL (VTR, Feedstock Preparation, and Fuel Fabrication), the total number of new employees required would be approximately 600.</td></tr>
</table>

LOS = Level of Service.

4.13.1 INL VTR Alternative

The following sections present the impacts from establishing the VTR at the INL Site. The impacts would include construction and operation of the VTR and facility modifications and incremental operational impacts for performing post-irradiation examination of test items. Facility modifications and incremental operational impacts for preparing SNF for long-term storage and disposal and construction and operation of a new long-term storage facility near ZPPR are also presented.

4.13.1.1 Construction/Facility Modification

Materials

From site mobilization to startup (about 60 months), an estimated 15,500 deliveries are anticipated, including a combination of standard delivery and flatbed tractor-trailer trucks. Estimated quantities of materials for VTR construction are included in Appendix B, Table B–8.

It is assumed that manufactured goods (permanent equipment) transported to the INL Site, including specialty components, would arrive via the Port of Wilmington, North Carolina, and be transported by truck to the INL Site, a distance of about 2,500 miles. The primary route from Wilmington to the INL Site would include Interstates 40 west, 24 west, 57 north, 64 west, 70 west, 29 north, 80 west, and 84 west; U.S. Routes 74 west and 26 west; and Nebraska State Route 2 west. It is assumed that about 35 percent of the 15,500 estimated deliveries (5,400 to 5,500 total) would be brought via this route.

Aggregates and other materials would be brought in from local sources located about 50 miles or less from the INL Site. It is assumed that about 65 percent of the 15,500 estimated deliveries (10,000 to 10,100) would come from these local sources.

Since the bulk of the routes involved include U.S. and Interstate Highways, it is anticipated that the addition of 16 trucks per day, on average, to these roadways would result in negligible to minor impacts on traffic volumes.

No other expected modes of transportation would be anticipated, except for the reactor vessel module. The reactor vessel module is about 1,200 tons and 20 feet in diameter. Shipment would likely require multiple modes of transport (road and/or rail). This will not be known until a transportation study is completed.

Personnel

The estimated number of persons commuting to/from site each day during construction is depicted in **Figure 4–1** and would range from less than 100 persons initially to a maximum of about 1,300 persons during peak construction. Figure 4–1 includes craft labor personnel and non-manual personnel for the Phase 2 EPC contractor and subcontractor personnel. Figure 4–1 does not include BEA or DOE non-manual personnel. For estimation purposes, it is assumed that the workers commuting to the INL Site would be split evenly between Idaho Falls, Idaho (about 50 miles east of the INL Site) via U.S. Route 20; and Blackfoot, Idaho (about 40 miles southeast of the INL Site) via U.S. Route 26.

The base work schedule is expected to be:

- Four (4) workdays per week (Monday – Thursday); 10 hours per day; day shift only; no work on scheduled holidays
- Overtime would be used for critical items identified in the schedule and for schedule recovery. Overtime is Friday, Saturday, and Sunday. The estimated order of magnitude of overtime as a portion of the overall scheduled work is 10 percent.

As indicated in Table 4–3, it is estimated that the maximum number of workers onsite during the peak construction period would be 1,300. Within that total, the rough estimated range for peak craft personnel at the construction site is anticipated to be 500 to 750.

Overall, using a high-end scenario (i.e., all workers commute separately), the average number of worker annual commuter trips during construction would be about 10,000, ranging from about 3,050 in 2022 to a peak of 12,600 in 2024. The addition of about 640 vehicles commuting to the site daily, on average, during construction would have a minor impact on local traffic conditions, increasing traffic to the site by about 17 percent compared to current baseline traffic volumes. Traffic would increase by about 33 percent during peak construction in 2024 as compared to current conditions.

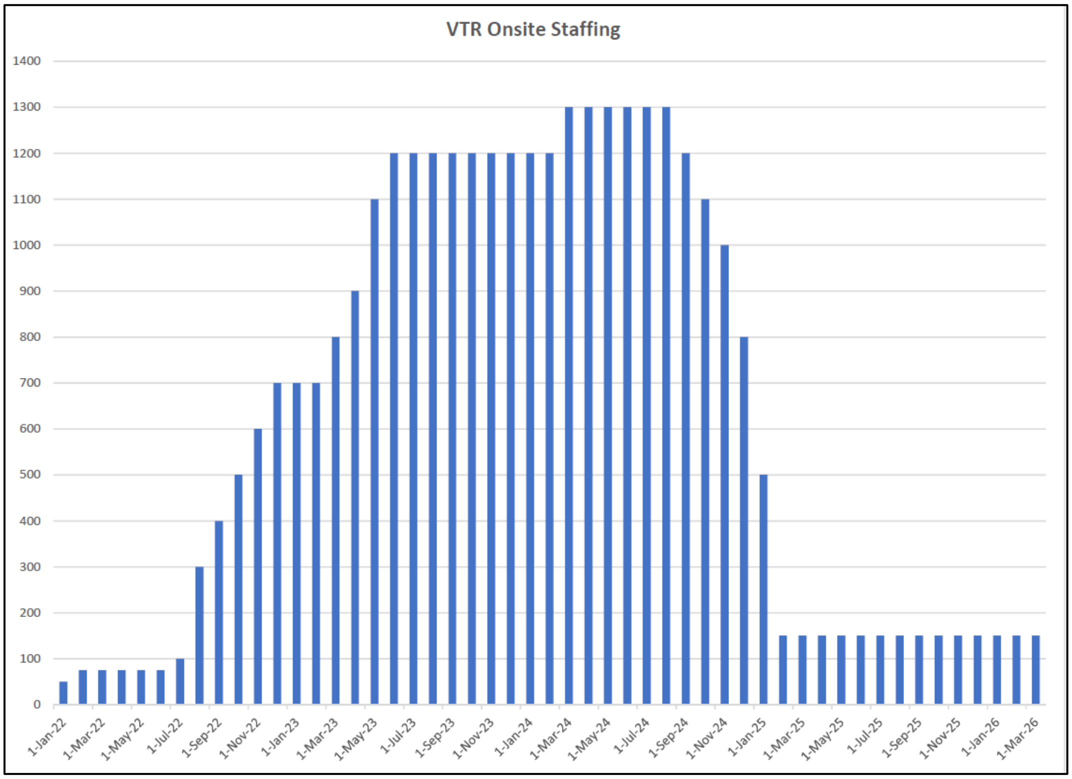

Figure 4–1. Estimated Number of Persons Commuting To/From Idaho National Laboratory Each Day During Construction

Waste

From site mobilization to startup (about 60 months), an estimated 2,250 waste shipments are anticipated. Of the 2,250 shipments, about 115 shipments would be hazardous waste. All waste shipments would be transported via road. The INL Site has onsite facilities for the disposal of nonhazardous waste. Estimated quantities of waste requiring shipment during construction are included in Appendix B, Table B–10.

No construction activities are anticipated. Any new handling equipment built would be handled by current MFC personnel. Likewise, no radioactive or hazardous waste generation is anticipated.

A new spent fuel storage facility would be constructed within the PIDAS in the open space near ZPPR. The facility would consist of a concrete pad, enclosed by a steel frame and siding weather enclosure.

4.13.1.2 Operations

It is anticipated that an individual cycle re-load could require two shipments, so annual shipment quantities would be six shipments. Initial core loading (maximum 66 assemblies) could require 10 shipments.

The number of new employees commuting to the site each day to support VTR operations is about 218.

Operations – Test Assembly Examination Facility

Waste shipments from post-irradiation examination activities would involve discarded material from fuel assemblies and experiments. LLW items associated with cask operations and operator personal protective equipment (PPE) would also be anticipated. Together they would be about one shipment of TRU waste and two shipments of LLW per year (i.e., about one 36-gallon can ([5-gallon overpack] of RH-TRU waste and three 4 × 4 × 4 boxes of LLW).

4.13.2 ORNL VTR Alternative

The following sections present the impacts from establishing the VTR at ORNL. The impacts would include establishment of a new PIDAS for the VTR complex and construction and operation of the VTR. Impacts would also result from construction and operation of a hot cell facility for performing post-irradiation examination of test items and for preparing SNF for long-term storage and disposal, extension of existing infrastructure to the VTR complex, and construction and operation of a long-term storage facility.

4.13.2.1 Construction/Facility Modification

Materials

From site mobilization to startup (about 60 months), an estimated 20,150 deliveries are anticipated, including a combination of standard delivery and tractor-trailer trucks. Estimated quantities of materials for VTR construction are included in Appendix B, Table B–8.

It is assumed that about 35 percent of the 20,150 estimated deliveries (7,000 to 7,100 total) would be transported from distant locations. Since most of these routes would be over U.S. and Interstate Highways, the addition of 16 trucks per day, on average, to these roadways would result in negligible impacts on traffic volumes.

Aggregates and other materials would be brought from local sources. It is assumed that about 65 percent of the 20,150 estimated deliveries (13,000 to 13,100) would come from these local sources. Construction materials from both distant and local sources would largely travel on the same roads in the region. The preferred route for access to the proposed project location by construction vehicles is to exit State Route 62 onto Bethel Valley Road, then use EGCR Access Road to Melton Valley Drive to the site. This would minimize the amount of traffic along Bethel Valley Road further south and to lessen traffic impacts through the most developed portion of the area. The addition of 16 trucks per day, on average, on these regional and local roadways would result in negligible to minor impacts on traffic volumes.

No other expected modes of transportation would be anticipated, except for the reactor vessel module. The reactor vessel module is about 1,200 tons and 20 feet in diameter. Shipment would likely require multiple modes of transport (road and/or rail). This will not be known until a transportation study is completed.

Personnel

The estimated number of persons commuting to and from site each day during construction, depicted in Figure 4–1, would range from less than 100 persons initially to a maximum of approximately 1,700 persons during peak construction. Figure 4–1 includes craft labor personnel and non-manual personnel for the Phase 2 EPC contractor and subcontractor personnel. Figure 4–1 does not include contractor (UTB) or DOE non-manual personnel. For estimation purposes, it is assumed that the workers commuting to ORNL would originate from Knoxville, the nearest urbanized area/population center. Depending on their exact work location at ORNL, commuters would have the option of taking Interstate 40 west to State Route 162 west to State Route 62 west to Bethel Valley Road; or Interstate 40 west to State Route 95 north to Bethel Valley Road.

The base work schedule is expected to be:

- Four workdays per week (Monday – Thursday); 10 hours per day; day shift only; no work on scheduled holidays
- Overtime would be used for critical items identified in the schedule and for schedule recovery. Overtime is Friday, Saturday, and Sunday. The estimated order of magnitude of overtime as a portion of the overall scheduled work is 10 percent.

As indicated in Table 4–3, it is estimated that the maximum number of workers onsite during the peak construction period would be 1,700. Within that total, the rough estimated range for peak craft personnel at the construction site is anticipated to be 500 to 750.

Overall, using a high-end scenario (i.e., all workers commute separately), the average number of worker annual commuter trips during construction would be about 10,000, ranging from about 3,400 in 2022 to a peak of 13,000 in 2024. The addition of about 660 vehicles commuting to the site daily, on average, during construction would have a minor impact on local traffic conditions, increasing traffic to the site by about 15 percent compared to current baseline traffic volumes. Traffic would increase by about 30 percent during peak construction in 2024 as compared to current conditions.

Waste

From site mobilization to completion of startup (about 60 months), a rough estimate is about 2,925 waste shipments. Of the 2,925 shipments, it is estimated that about 115 shipments would be hazardous waste. All waste shipments would be transported via road. Estimated quantities of waste requiring shipment during construction are included in Appendix B, Table B-10.

4.13.2.2 Operations

An average of 40 trucks per week making deliveries of material. Most of these carriers would be making deliveries as well as receiving tendered material for outgoing shipments.

It is anticipated that an individual cycle re-load could be shipped in two shipments, so annual shipment quantities would be six shipments while initial core loading (maximum 66 assemblies) could be shipped in 10 shipments.

The number of new employees commuting to the site each day to support VTR operations is about 200. An additional 100 new employees will also be required to support hot cell operations.

Waste shipments from post-irradiation examination activities would involve discarded material from fuel assemblies and experiments. However, this will likely include less than 5 shipments per year and will have a negligible effect on traffic.

4.13.3 Reactor Fuel Production Options

4.13.3.1 INL Reactor Fuel Production Options

The following sections present the impacts from establishing the fuel production capability at the INL Site. Impacts would be from facility construction or modifications to offer the necessary technologies for fabricating a U-Pu-Zr metal fuel for the VTR. Two options are evaluated.

The fuel fabrication option assumes that uranium and plutonium feedstock would be received in forms that could be used directly for creating the U-Pu-Zr alloy from which the fuel would be fabricated. The feed materials would include plutonium without high levels of impurities, such as americium-241.

Under the feedstock preparation option, capabilities would be installed to handle a wide variety of plutonium feedstock. Gloveboxes and equipment would be installed to remove impurities from the plutonium, to polish plutonium by removing ingrowth isotopes (e.g., americium-241), and to convert plutonium to a metal form (e.g., reducing plutonium oxide to metal). These steps would yield a plutonium metal that would then be used to create the U-Pu-Zr alloy and fabricate the VTR fuel.

4.13.3.1.1 INL Feedstock Preparation Option

Construction/Facility Modification

Construction materials anticipated in support of the project include new gloveboxes and process equipment. Planners anticipate two deliveries per new piece of process equipment plus one delivery of supporting supplies. These deliveries would yield 3 deliveries per each piece of equipment or station (5 new stations) resulting in 15 deliveries during construction. Other equipment and delivery needs are anticipated to arrive in existing freight schedules.

Onsite work would typically be performed by a small construction crew focused in installing facility modifications as well as new equipment hookups. Average construction worker requirements for these activities would be about six workers over 2 years. Peak construction numbers for equipment installation and facility modifications would be as many as 18 workers at any given time (with an average of 6 over 3 years).

Operations

Radioactive material feedstock for fuel fabrication is anticipated to be received in batches supporting continual fuel production schedules. Feedstock shipments would be anticipated to average three per operating year. Estimated quantities of materials for construction are included in Appendix B, Table B–8.

The number of new employees commuting to the site each day to support VTR feedstock preparation if performed at the INL Site is 70.

4.13.3.1.2 INL Fuel Fabrication Option

Construction/Facility Modification

Construction materials anticipated in support of the project include new gloveboxes and process equipment. Planners anticipate two deliveries per new piece of process equipment plus one delivery of supporting supplies. These deliveries would yield 3 deliveries per each piece of equipment or station (5 new stations) resulting in 15 deliveries during construction. Other equipment and delivery needs are anticipated to arrive in existing freight schedules.

Onsite work would typically be performed by a small construction crew focused in installing facility modifications as well as new equipment hookups. Average construction worker requirements for these activities would be about six workers over 2 years. Peak construction numbers for equipment installation and facility modifications would be as many as 18 workers at any given time (with an average of 6 over 3 years).

Operations

The number of new employees commuting to the site each day to support VTR fuel fabrication operations if performed at the INL Site is 300.

4.13.3.2 SRS Reactor Fuel Production Options

The following sections present the construction impacts from establishing the fuel production options at SRS. Impacts would be from facility construction or modifications to offer the necessary technologies for fabricating a U-Pu-Zr metal fuel for the VTR. Two options are evaluated.

The fuel fabrication option assumes that uranium and plutonium feedstock would be received in forms that could be used directly for creating the U-Pu-Zr alloy from which the fuel would be fabricated. The feed materials would include plutonium without high levels of impurities, such as americium-241.

Under the feedstock preparation option, capabilities would be installed to handle a wide variety of plutonium feedstock. Gloveboxes and equipment would be installed to remove impurities from the plutonium, to polish plutonium by removing ingrowth isotopes (e.g., americium-241), and to convert plutonium to a metal form (e.g., reducing plutonium oxide to metal). These steps would yield a plutonium metal that would then be used to create the U-Pu-Zr alloy and fabricate the VTR fuel.

4.13.3.2.1 SRS Feedstock Preparation Option

Construction/Facility Modification

Waste

In order to prepare the existing building to support reactor fuel production, D&R would be required. D&R activities would generate large amounts of materials and waste for offsite shipment. The main items that would require removal include larger AC and DC motors, motor control centers, moderator storage and overflow tanks, and several hundred feet of process, cooling, and effluent piping (24-, 36-, 42-, and 48-inch diameter). Other tanks, equipment, and piping would also require removal from these areas. All waste shipments would be transported via road. Estimated quantities of waste requiring shipment during construction are included in Appendix B, Table B–43 and B–48.

In addition, stainless steel drums would be required to drain the contents of three heavy water tanks, which could contain up 58,760 gallons of heavy water; the actual current volume of heavy water contained within the tanks is unknown. Based on a total capacity of 58,760 gallons of heavy water, it would require up to about 1,780 drums (33 gallons per drum) to completely drain all three tanks prior to removing the tanks. Assuming 24 drums per shipment (stacked two high), this process would require about 75 shipments of new stainless steel drums to the facility. Due to uncertainty in the actual heavy water content of the existing tanks, additional work is required to identify the actual number of new heavy water drums that may be required for draining of existing K Area Complex equipment.

The relocation of an additional about 2,000 heavy water drums to another storage location at SRS would be required to facilitate installation of VTR fuel fabrication equipment. Based on an assumption of 24 drums per shipment, it is estimated that it would require 158 shipments to completely remove the estimated quantity of drums (about 3,780 total) from the K Area Complex.

Materials

While no “new” construction is proposed, renovation activities at the site would be required. These construction activities would require the transport of structural components (concrete, steel rebar, aggregates, rebar, etc.), stainless steel drums (for emptying the contents of three heavy water tanks, and fabrication process components (gloveboxes, furnaces, gloveboxes, furnaces, ducting, air balance equipment, filtration equipment, and other equipment). All waste shipments would be transported via road.

Major infrastructure to be provided includes material control and accountability equipment, analytical support for process control, electrical switchgear for furnace power supply, and exhaust ventilation. Redundant exhaust fans and HEPA filtration would be required for both glovebox and room exhaust. In addition, fire suppression equipment, high volume air monitoring, and new National Incident Management System are required.

During renovation, it is anticipated that 2 deliveries per new piece of process equipment plus 1 delivery of supporting supplies yields 3 deliveries per each piece of equipment or station (5 new stations) would be required, resulting in 15 deliveries. Other equipment and delivery needs are anticipated to arrive in existing freight schedules.

It is assumed that manufactured goods (permanent equipment) transported to SRS, including specialty components, would arrive via the Port of Wilmington, North Carolina, and be transported by truck to SRS, a distance of about 500 miles. The primary route from Wilmington to SRS would include Interstate 95 south to Interstate 20 west to U.S Route 1 south. It is assumed that about 35 percent of the estimated deliveries would be brought via this route.

Aggregates and other materials would be brought in from local sources located about 50 miles or less from SRS. It is assumed that about 65 percent of the estimated deliveries would come from these local sources.

Personnel

The construction staff is expected to top out at 120 full-time employees working five, 10-hour days a week. This will include 100 craft and 20 non-manual employees.

Operations

Materials Shipments (Incoming)

Radioactive material feedstock for feedstock preparation is anticipated to be received in batches supporting continual fuel production schedules. Feedstock shipments would be anticipated to average three per operating year.

Waste Shipments (Outgoing)

New waste shipments from proposed feedstock preparation activities would involve the typical nonhazardous wastes from worker activities. LLW items associated with glovebox operations, crucible scraps, cleaning rags and operator PPE are also anticipated. Estimated quantities of waste requiring shipment during construction are included in Appendix B, Table B–46.

Personnel

The number of new employees commuting to the site each day to support VTR feedstock preparation, if performed at SRS, is about 300.

4.13.3.2.2 SRS Fuel Fabrication Option

Construction/Facility Modification

The construction staff is expected to top out at 120 full-time employees working five, 10-hour days a week. This will include 100 craft and 20 non-manual employees.

Operations

Waste Shipments (Outgoing)

New waste shipments from proposed fuel fabrication activities would involve the typical nonhazardous waste from worker activities. LLW items associated with glovebox operations, casting mold scraps, cleaning rags and operator PPE are also anticipated. Estimated quantities of waste requiring shipment during construction are included in Appendix B, Table B–50.

Personnel

The number of new employees commuting to the site each day to support VTR fuel fabrication, if performed at SRS, is about 300.

4.13.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

This section presents the total impacts that would occur at the INL Site if the VTR alternative and the fuel production options were all established at the site. It is a short summary of the combined impacts developed earlier under the Combined INL VTR Alternative and the INL Reactor Fuel Production Options.

The impacts on traffic from construction and operation of facilities under the INL VTR Alternative are anticipated to be minor. The added impacts on traffic from the INL Feedstock Preparation and Fuel Fabrication Options, if executed, are anticipated to be negligible.

4.14 Socioeconomics

Socioeconomic impacts result from the direct employment of construction and operations workers and the impacts on regional economic characteristics, population, housing, and community resources within the ROI. An important consideration in assessing potential impacts of the proposed facilities is the number of workers, families, and children who might move into the ROI (in-migrate), either temporarily or permanently, with construction and operation of the proposed facilities. Impacts on population are described in terms of total number of in-migrants (and their families) arriving in the region in the peak year of construction and first year of operation. The resulting population influx would have the potential to substantially affect the housing market in the ROI, with potential increases in demand for both rental and owner-occupied housing units. It could also increase demand for educational services and for other public services such as police and fire protection and health services. Finally, the increases in jobs and income from construction and operation of the proposed facilities would have both direct and indirect impacts on the local and regional economy. To the extent these increases would help reduce existing unemployment levels and boost the economy, they are considered to be beneficial.

The following analysis evaluates projected socioeconomic impacts relative to population, housing, labor, income, other economic characteristics, and community services within several project regions. In particular, this section discusses the potential impacts on socioeconomics of the VTR alternatives and reactor fuel production options. The INL, ORNL, and SRS ROIs for socioeconomics would include the counties within which the majority of onsite employees at each DOE facility reside, including the host counties and adjacent counties or nearby counties containing the largest population centers. The impacts analysis considers aspects of the social and economic environment that are sensitive to change and that may be adversely or beneficially affected by activities associated with the Proposed Action. Adverse impacts on socioeconomic resources would occur if any of the alternatives had the potential to cause the following:

- Alter local economies on a substantial basis without the capacity to absorb a decrease or increase,

  Changes housing characteristics (types of units, occupancy, housing values, etc.) or residential development patterns in a substantial way,

- Alters population growth or demographic patterns in a way that changes the overall character of communities,
- Displaces populations, residents, or businesses to accommodate construction,
- Requires an amount of public or private resources (time and/or money) that interferes with the performance of other local government functions or the viability of proposed projects, and
- Induces growth without adequate supporting community services (e.g., education, public health, and safety).

Staffing estimates used in the socioeconomic analysis are derived from Appendix B (Detailed Project Information) and are consistent with the onsite staffing estimates used in the human health impact assessment (see Section 4.10), although the socioeconomic analysis focuses on that portion of the projected workforce that would not be local but rather would in-migrate into each site's ROI.

Table 4–60 presents a summary of the potential environmental consequences on socioeconomics for the INL and ORNL VTR Alternatives and the INL and SRS Reactor Fuel Production Options. A more detailed summary of site-specific impacts on each of the main socioeconomic resource areas is included in Tables 4–62 (INL), 4–64 (ORNL), 4–65 (SRS), and 4–66 (Combined, INL).

Table 4–60. Summary of Environmental Consequences on Socioeconomics

	VTR Alternatives	
Resource Area	***INL VTR***	***ORNL VTR***
Socioeconomics	*Construction*: Negligible adverse impact; small and beneficial economic impact. In the peak year of construction (civil/structural in the 2023-2025 timeframe), construction of the VTR at the INL Site would create direct employment of 1,300 (660 annual) construction workers and generate another 660 indirect jobs in the region. 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 (80 percent) and their families would be about 2,787 persons. This is considered relatively small – representing less than 1 percent of the population in the ROI – and would have no major adverse impacts on the region in terms of population, employment, income levels, housing, or community services (Table 4–66).	*Construction*: Negligible adverse impact; small and beneficial economic impact. In the peak year of construction (civil/structural in the 2023-2025 timeframe), construction of the VTR at ORNL would create direct employment of 1,598 (858 annual) construction workers and generate another 1,185 indirect jobs (peak) in the region (636 indirect annual jobs). The increase in jobs and income from construction would have a short-term potential beneficial impact on the area. The population influx associated with an in-migrating workforce (30 percent) and their families would be 1,214 persons. This 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 (Table 4–68).
	Operations: No adverse impact. Operation of the VTR at the INL Site would create annual direct employment of 218, \$20.9 million in annual income, an additional 373 indirect jobs, and \$10.6 million in income annually. The increase in jobs and income would have a potential beneficial impact on the local and regional economy.	*Operations*: No adverse impact. Operation of the VTR at ORNL would create annual direct employment of 300, \$24.3 million in annual income, an additional 520 indirect jobs, and \$22.4 million in income annually. The increase in jobs and income would have a potential beneficial impact on the local and regional economy.
	The population influx associated with an in-migrating workforce (30 percent) and their families would be about 190 persons. In-migration would require less than 5 percent of vacant owner-occupied housing during facility operations (or less than 1 percent of total vacant housing units in the ROI). These numbers are considered relatively small and would have no major adverse impacts on the region in terms of population, housing, or community services (see Table 4–66).	The population influx associated with an in-migrating workforce (30 percent) and their families would be about 230 additional persons. In-migration would require less than 1 percent of vacant owner-occupied housing during facility operations. These numbers are considered relatively small and would have no major adverse impacts on the region in terms of population, employment, income levels, housing, or community services (see Table 4–68).

	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Socioeconomics	**Fuel Fabrication**	
	Construction: Negligible adverse impact; small and beneficial economic impact. VTR fuel fabrication process would be located in existing buildings (FMF and ZPPR) and could use existing infrastructure with modifications. Construction workforce requirements would be minimal (peak of 18 and annual workforce of 6). Given the small staffing requirements, no population influx associated with in-migrating workers would be expected and there would be no adverse socioeconomic impacts from project construction or operation on the local housing market or community services in the ROI.	*Construction*: Negligible adverse impact; small and beneficial economic impact. Fuel fabrication would be performed in an existing facility in the K Area Complex, but construction activities would be associated with the build-out of the equipment locations within 105-K Building and the new infrastructure required (e.g., material storage areas, special nuclear material measurement equipment, analytical support). Workforce requirements include 120 workers (annual peak). Given the small projected construction workforce, it is assumed there would be minimal to no in-migration of any maintenance or operations personnel, and therefore no adverse effects on the ROI in terms of population, employment, income levels, housing, or community services.
	Operations: No adverse impact. Annual operations workforce of 300 FTEs but, only 70 FTEs would be new hires. Given the small staffing requirements, minimal to no population influx associated with in-migrating workers would be expected, and there would be no adverse socioeconomic impacts from project construction or operation on the local housing market or community services in the ROI.	*Operations*: No adverse impact. Projected operations workforce would be 300 with no in-migration of workers. Therefore, the Project would have negligible effect on population growth. As a result, there would be no adverse effects on the ROI in terms of population, employment, income levels, housing, or community services.
	Discussion: For both sites, the increase in jobs and income from plant construction and operation, however small, would have a long-term small and beneficial impact on the economy of each area. Employee spending would create an additional positive induced effect on the economy and generate additional State and local revenues. The positive economic impacts would be expected to be slightly greater at SRS because of the larger workforce requirements compared to INL.	
	Feedstock Preparation	
	No adverse impact. Feedstock preparation activities could be required to prepare the plutonium for fuel fabrication. These activities would require a separate, but similar construction and operations workforce as that estimated for fuel fabrication, with the exception of the INL Site where feedstock preparation activities would require up to 300 workers for operations, similar to operations projected at the INL Site for fuel fabrication). The majority of these workers are expected to be available locally, with minimal worker in-migration or population influx to the ROI. Therefore, no adverse effects would be expected on the ROI in terms of housing, schools, or community services. The potential increase in employment and income would be considered a beneficial impact on the local and regional economies.	
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Socioeconomics	*Construction*: The incremental increase in the reactor fuel production workforce as compared to the VTR workforce analyzed for the INL VTR Alternative would be very small, even if the feedstock preparation workforce is added in, and the combined workforce requirements for the VTR and reactor fuel production activities would be essentially as described above for the INL VTR Alternative. *Operations*: The incremental increase in the reactor fuel production workforce as compared to the VTR workforce analyzed for the INL VTR Alternative would be small, even with the feedstock preparation activities are added in, given the assumptions made regarding a small in-migrating workforce. The combined workforce requirements for the VTR and reactor fuel production activities would be essentially as described above for the INL VTR Alternative.	

4.14.1 INL VTR Alternative

4.14.1.1 Construction/Facility Modification

Construction at the INL Site would include construction of the VTR and a spent fuel storage pad at MFC. DOE would use existing, co-located facilities at INL's MFC (with modifications as necessary) for the post-irradiation examination of test assemblies and the treatment or conditioning of SNF to prepare it for storage and eventual disposal. **Table 4–61** shows that projected staffing for project construction is tied primarily to the VTR itself. VTR activities associated with construction requirements for test assembly examination would be encompassed by current activities at INL. No additional plant staff would be required during construction and any changes to resource requirements would be minimal.

Table 4–61. Projected Organization Staffing at INL

Estimated Workforce				
	Construction			***Operation***
Organization	***Peak***	***Average Annual***	***Total***	***Annual***
VTR	1,300	650	3,200	200
Hot Cell Building (no new hires)	0	0	0	0
Spent Fuel Treatment Facility	10	10	10	18
Total	**1,310**	**660**	**3,210**	**218**

Staffing estimates are obtained from Appendix B (Detailed Project Information) of this EIS.

In the peak year of construction (civil/structural in the 2023-2025 timeframe), construction of the VTR at the INL Site would create direct employment of 1,310 (660 annual) construction workers and generate another 890 indirect jobs in the region, including jobs relating to suppliers (provide materials and supplies) and induced jobs (jobs in goods and services where construction workers spend their money). They would also generate $40.6 million in income annually during construction from direct and indirect jobs (up to $81.2 million during peak year). These are based on the following multipliers: 1.68 for construction employment and 1.45 for labor income (Idaho Policy Institute et al. 2019).

The total peak employment (direct and indirect) requirement of 2,200 direct and indirect jobs represents 1.4 percent of the projected ROI workforce in 2018 (157,398); the direct employment of 1,310 construction workers represents 11.4 percent of the construction workforce in the ROI (11,470), and 1.8 percent of construction workforce in the State of Idaho (72,421) in 2018. The ROI had a low unemployment rate of 1.4 percent in 2018. While the estimated project construction workforce under the INL VTR Alternative is low compared to the total labor force in the ROI, it does represent over 10 percent of the total construction workforce in the ROI and would require some specialty crafts and skill sets that may not be found locally. It is assumed that 20 percent of the construction workforce would be found within the ROI at the time construction starts, and 80 percent is assumed to in-migrate into the ROI (about 1,050 for peak). This would result in a population influx of about 2,810 additional persons, representing less than 1 percent (0.87 percent) of the population in the ROI in 2018 (322,434). This population increase is based on the conservative assumption that every new household would have 2.68 people, based on the average household size in Idaho (between 2014 and 2018) – where the average household occupant can also include one person living alone (Census 2020a).

These numbers, as summarized in **Table 4–62**, are considered relatively small and would have no major adverse impacts on the ROI in terms of population, employment, income levels, housing, or community services. The increase in jobs and income would be considered a potential beneficial impact on the area.

Table 4–62. Effects of VTR on Socioeconomics within INL's ROI

Impact Category	***VTR Staffing Requirements***	
	Construction (annual)	***Operation (annual)***
Employment (Number of jobs)		
Direct	1,310 (peak); 660 (average) 3,200 total (based on 51-month construction period)	218
Indirect	890 (peak) 450 (average)	373
Total	2,200 (peak) 1,110 (annual)	591
Income ($ in millions) [a]		
Direct	$56 (peak) $28.4 (annual)	$20.9
Indirect	$25.2 (peak) $12.8 (annual)	$10.6
Total	$81.2 (peak) $41.2 (annual)	$31.5
Population (# new residents)	2,810 Including up to 715 additional children which is 1 percent [65,268] increase in school children in ROI	190 46 additional children Less than 0.1 percent increase in school children in ROI
Housing (# units required)	1,040 (9.7 percent of total vacant rental units (10,692) and 8.9 percent of total vacant housing units in ROI in 2017) (11,706 rental and owned)	65 (3.3 percent of vacant owner-occupied housing units in ROI in 2017 – 1,984) Or under 1 percent of total vacant housing units in ROI in 2017
Public finances (Percent impacts on expenditures)		
Cities and Counties	< 1	< 1
Schools	< 1	< 1
Public Service Employment (# new employees)		
Local government employees	0	0
Teachers	0	0

[a] Based on average salary of $43,040 for construction worker (BLS 2020d), and $95,768 average base salary of INL employee in FY 2017 (INL 2018d).

The percentage of housing units that would be required for an in-migrating construction workforce would be around 10 percent, which represents the peak workforce and are compared to the number of total vacant housing units in the ROI in 2017. The increase would represent less than 1 percent of the total housing market in the ROI in 2017. Such impacts would be short-term in nature, and the number of housing units in the ROI would be expected to be higher at the start of construction in 2024. Therefore, these numbers indicate there would be sufficient housing available to accommodate the in-migrating workforce, assuming there are no other major strains on the housing market. The analysis includes a conservative assumption that 80 percent of the construction workforce would relocate to the ROI (a lower percentage would result in fewer impacts). Beneficial impacts would be due to increased jobs, tax revenue, and income. The small population influx would not be expected to have adverse impacts existing schools and community services. In addition, increased tax revenues could be utilized to offset increased strains on community services and recreational facilities by funding enhancements to appropriate services and facilities if and where needed.

4.14.1.2 Operation

Tables 4–61 and 4–62 also show that projected staffing for project operation as they relate to the VTR and VTR activities associated with test assembly examination (no new hires required) and spent fuel treatment and storage operation. Operation of the VTR at the INL Site would create annual direct employment of

218 and $20.9 million in annual income and an additional 373 indirect jobs and about $10.6 million in income annually. The indirect impacts are based on the following multipliers: 2.71 for employment and 1.51 for labor income (INL 2018d).

Similar to the construction workforce, it is assumed that some of the special skill sets required for VTR operation would not be found locally. It is conservatively assumed that about 30 percent of plant maintenance (nuclear pipeline craftsmen pipefitters) and operations (reactor operators) personnel, or about 65 workers, would in-migrate to the area at the beginning of operations and all would bring their families. This would result in a population influx of about 175 additional persons, based on an average household size in Idaho of 2.68 persons (includes singles as described for construction in Section 4.14.1.1) (Census 2020a). In-migration would have a small effect on population growth and would require less than 5 percent of vacant owner-occupied housing during facility operations (or less than 1 percent of total vacant housing units in the ROI). No significant impact on public finances would occur because of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI.

These numbers are considered relatively small and therefore would have no major adverse impacts on the ROI in terms of population, employment, income levels, housing, or community services.

The potential increase in jobs and income from plant operation would be a long-term beneficial impact on the economy of the area, similar to the short-term beneficial impacts from project construction. As indicated in Section 3.1.14 and further summarized below, INL significantly impacts Idaho's economy. An increase in INL employment associated with the Proposed Action would further benefit the local, regional, and State economy. For purposes of comparison the 218 projected operations workforce personnel would represent about 3.2 percent of the 6,836 directly employed INL workers in 2020.

In addition to the increases in employment and income, overall economic activity generated by the manufacture and construction activities at the INL Site would increase. As reported in the 2017 INL Economic Summary Report (INL 2018d), for every $100 in direct economic activity at INL, an additional $93 of activity is created or sustained throughout the State's economy (outlier multiplier of 1.93). In FY2017, INL operations added $1.94 billion in Idaho's gross economic output, including just over $1 billion in INL direct spending); this represented more than 2.9 percent of Idaho's total output or gross State product. These impacts also would result in increased tax revenues for the local, regional, and State governments in Idaho. These would include local property taxes annually over the construction period. Added revenues from sales, excise individual, and corporate income taxes would further increase tax revenues in the State.

In summary, construction and manufacture activities from the project would increase eastern Idaho employment and labor income and generate increases in economic output in the region. Annual operations of the project would provide ongoing additions of about 590 jobs (direct and indirect) to the eastern Idaho region and over $31.5 million in labor income annually for the life of the project. The project's ongoing operations and maintenance activities would result in increases in overall economic output and tax revenues throughout the region and in Idaho would increase.

In addition to increased employment, labor income, economic output and tax revenues stemming from the construction and operation of the project, the facility would provide an ongoing stabilizing force to the eastern Idaho economy. Given the nature of personnel hired for plant operations, for example, the project would add to the highly skilled workforce already at the INL Site. In short, the added economic benefits to the region, added tax revenues, and other benefits stemming from the sustained presence of the facility are anticipated to be beneficial contributors to the quality of life in the communities surrounding the facility and across Idaho.

4.14.2 ORNL VTR Alternative

4.14.2.1 Construction/Facility Modification

The major structures for the VTR component at ORNL would be the same as those described under the INL VTR Alternative, and construction of the VTR itself at ORNL would have the same staffing requirements. However, there would be additional staffing requirements associated with site preparation work required to clear and level the selected site, and construction of the hot cell building (post irradiation examination and spent fuel treatment facilities) and spent fuel pad; the new hot cell building would only be required at ORNL.

In addition, 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 (roads, utilities, security, etc.) to support construction and operation of the VTR.

Table 4–63 shows the projected staffing for VTR and associated construction activities at ORNL.

Table 4–63. Projected Organization Staffing at ORNL

Estimated Workforce				
	Construction			*Operation*
Organization	*Peak*	*Average Annual*	*Total*	*Annual*
VTR	1,300	650	3,200	200
Hot Cell Building (combined test assembly examination and spent fuel storage and treatment facility)	290	200	985	100
Fuel Storage Pad	8	8	8	0
Total	**1,598**	**858**	**4,193**	**300**

Note: Staffing estimates are pulled from Appendix B (Detailed Project Information) of this EIS. Estimate does not include 16 workers estimated for site clearing and excavation work during the first 10 months of project construction, given their minimal impact compared to that occurring during peak construction year(s).

In the peak year of construction (civil/structural in the 2023-2025 timeframe), construction of the VTR at ORNL would create direct employment of 1,598 (858 annual) construction workers and generate another 1,185 indirect jobs (peak) in the region (636 indirect annual jobs), including jobs relating to suppliers (provide materials and supplies) and induced jobs (jobs in goods and services where construction workers spend their money). They would also generate $62.7 million in income annually during construction from direct and indirect jobs (up to $116.8 million during peak year). These are based on the following regional multipliers for the industry employment and earnings: 1.742 for construction employment and 1.6998 for labor income developed from Bureau of Economic Analysis's Regional Input-Output Modeling System (NRC 2019).

The total employment requirement of 2,783 direct and indirect jobs (peak) represents less than 1 percent (0.9 percent) of the projected ROI workforce in 2018 (320,327). The estimated 1,598 direct construction employment represents about 9 percent of the construction workforce in the ROI (17,922) and less than 1 percent (0.7 percent) of the construction workforce in the State of Tennessee in 2018 (226,412). The ROI had a low unemployment rate of 3.1 percent in 2018. Table 4–63 shows the projected construction staffing for the project. While the estimated project construction workforce under the ORNL alternative is low compared to the total labor force in the ROI, it represents over 5 percent of the total construction workforce in the ROI and would require some specialty crafts and skill sets that may not be found locally. It is assumed that 70 percent of the construction workforce would be found within the ROI at the time construction starts, and 30 percent is assumed to in-migrate into the ROI (480 for peak). This would result in a population influx of about 1,214 additional persons, representing less than 1 percent (0.19 percent) of the population in the ROI in 2018 (647,965). This population increase is based on the conservative assumption that every new household would have 2.53 people, based on the average household size in Tennessee (from 2014 through 2018) – where the average household occupant can also include one person living alone (Census 2020a).

These numbers, as summarized in **Table 4–64**, are considered relatively small and would have no major adverse impacts on the ROI in terms of population, employment, income levels, housing, or community services. A comparison to the in-migrating construction workforce (direct jobs) and the available rental housing in 2018 would indicate a low impact on the local rental housing market (2.2 percent increase in vacant rental units during peak construction period). Additional demand on housing could come from an in-migrating workforce resulting from the indirect jobs created. However, this number is expected to be low and any combined impacts on available housing would be minor, especially if you add in the number of vacant owner-occupied units and assuming additional housing units would be available at the time of peak construction. The increase in jobs and income would be considered a potential beneficial impact on the area. Construction activities from the Project would provide increases in East Tennessee employment and labor income, and generate increases in economic output and tax revenues in the region. Over the longer term, increased tax revenues also could be utilized to offset increased strains on local housing by funding enhancements to appropriate supplies/markets.

Table 4–64. Effects of VTR Project on Socioeconomics at the ROI for the ORNL Site

	VTR Staffing Requirements	
Impact Category	***Construction (annual)***	***Operation (annual)***
Employment (number of jobs)		
Direct	1,598 (peak); 858 (annual) 51-month period	300
Indirect	1,185 (peak); 636 (annual)	520
Total	2,783 (peak); 1,494 (annual)	820
Income ($ in millions) [a]		
Direct	$68.7 (peak); $36.9 (annual)	$24.3
Indirect	$48.1 (peak); $25.8 (annual)	$21.9
Total	$116.8 (peak); $62.7 (annual)	$46.7
Population (# new residents)	1,214 0.19 percent increase in population ROI, including about 260 additional children which is 0.3 percent increase in school children in ROI	230 20 additional children Essentially 0 percent increase in school children in ROI
Housing (# units required)	480 (2.9 percent of total vacant rental units in ROI in 2018 (16,827), or 2.1 percent of total vacant units in the ROI in 2018 (22,491 rental and owned)	90 (1.6 percent of vacant owner-occupied housing units in ROI in 2018), (5,664); or less than 1 percent of total vacant units in the ROI in 2018 (29,166)
Public Finances (percent impacts on expenditures)		
Cities and Counties	< 1	< 1
Schools	< 1	< 1
Public Service Employment (# new employees)		
Local government employees	0	0
Teachers	0	0

[a] Based on average salary of $43,000 for construction worker (BLS 2020d), and $81,000 average base salary of DOE-related employee in Oak Ridge in FY 2017 (DOE 2018g).

4.14.2.2 Operation

Operation of the VTR facility itself at ORNL would be the same as that described for INL. However, ORNL would have additional staffing requirements associated with the following activities:

- Single facility for test assembly examination and spent fuel treatment and
- Facility for storage.

Tables 4–63 and 4–64 also show the projected staffing for project operation as it relates to the VTR and VTR activities associated with test assembly examination and spent fuel treatment and storage operation; operation of the fuel storage pad would be drawn from existing facility staff. Operation of the VTR at ORNL would create annual direct employment of 300 and $24.3 million in annual income. An additional 520 indirect jobs and $22.4 million in income annually would be created. The indirect impacts are based on the following multipliers: 2.73 for employment and 1.90 for labor income (DOE 2018g).

Similar to the construction workforce, it is assumed that some of the special skill sets required for VTR operation would not be found locally. It is conservatively assumed that about 30 percent of plant maintenance (nuclear pipeline craftsmen pipefitters) and operations (reactor operators) personnel, or about 90 workers, would in-migrate to the area at the beginning of operations and all would bring their families. This would result in a population influx of about 230 additional persons, based on an average household size in Tennessee of 2.53 persons (including singles, as described for construction in Section 4.14.2.1) (Census 2020a).

In-migration would have a small effect on population growth and would require less than 1 percent of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur because of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI.

These numbers are considered relatively small and would have no major adverse impacts on the ROI in terms of population, employment, income levels, housing, or community services (see also Table 4–64).

Similar to construction, the increase in jobs and income for plant operation would be a long-term beneficial impact on the economy of the area. As indicated in Section 3.2.14 and further summarized below, ORR, including ORNL, drives a significant impact on Tennessee's economy. An increase in ORNL employment associated with the Proposed Action would further benefit the local, regional and State economy; for purposes of comparison the 300 projected operations workforce personnel would represent about 2.4 percent of the 12,530 directly employed ORR workers in 2018, or 6.8 percent of the 4,400 directly employed at ORNL workers in 2018 (OREM 2019).

In addition to the increases in employment and income, overall economic activity generated by the manufacture and construction activities at ORNL site would increase. As reported in the 2017 DOE's Economic Impact in Tennessee (DOE 2018g), the total economic impact from DOE and its major contractors' activities (contribution to State GDP and income benefits) – based on 2017 ORNL employment levels – was nearly $5.6 billion. This included about nearly $3.4 billion because of direct and indirect effects of DOE expenditures and nearly $2.2 billion in total personal income generated by DOE-related activities in the State. DOE and contractor spending exceeded $943 million on procurement of raw materials, services, and supplies from Tennessee businesses, and more than $1.1 billion on non-payroll expenditures (direct procurement spending). Noteworthy regarding DOE and contractor spending is that the majority of it occurred in Anderson, Knox, and Roane Counties within the ROI.

Project impacts also would result in increased tax revenues for the local, regional, and State governments in Tennessee. These would include local property taxes annually over the construction period. Added revenues from sales, excise individual, and corporate income taxes would further increase tax revenues in the State.

In summary, construction and manufacture activities from the project would provide increases in East Tennessee employment and labor income, and generate increases in economic output in the region. Annual operations of the project would produce ongoing additions of 748 jobs to East Tennessee and nearly $42.2 million in labor income annually over the life of the project. The project's ongoing operations and maintenance activities would result in increases in overall economic output and tax revenues throughout the region and in Tennessee would increase.

In addition to increased employment, labor income, economic output and tax revenues stemming from the construction and operation of the project, the facility would create an ongoing stabilizing force to the East Tennessee economy. Given the nature of personnel hired for plant operations, for example, the project would add to the highly skilled workforce already at the ORNL site. In short, the added economic benefits to the region, added tax revenues, and other benefits stemming from the sustained presence of the facility are anticipated to be beneficial contributors to the quality of life in the communities surrounding the facility and across Tennessee.

4.14.3 Reactor Fuel Production Options

4.14.3.1 INL Reactor Fuel Production Options

Under the INL reactor fuel production options, the VTR fuel production would be located in existing buildings (primarily FCF, FMF, and ZPPR) and could use existing infrastructure with modifications. Construction workforce requirements would be minimal. There are sufficient engineering and startup organizations to staff these needs, and fabrication is specifically planned to allow transport to the site from other states if needed. VTR activities associated with fuel fabrication construction at the INL Site would require a peak workforce (on site at one time, but not FTEs) of 18 workers and an annual workforce of 6 workers during an about 3-year construction period (Appendix B, Table B–35); and an annual operations workforce of 300 FTEs, although 230 of these workers are expected to be drawn from the existing workforce already onsite at INL. Only 70 FTEs would be considered new hires with the potential to impact existing socioeconomic resources in the region (Appendix B, Table B–38). It is expected that all construction workers and 90 percent of the 70 new hires for the operational workforce would be pulled from the local area (6 workers would in-migrate) (INL 2020f; Nelson 2020).

In addition, depending on the source, some feedstock may require special preparation to put it in a form that can be fabricated. At this level of scope development, the estimated construction workforce associated with feedstock preparation would be the same as that for fuel fabrication, with a total peak workforce of 36 and annual workforce of 12 during the 3-year construction period for both fuel fabrication and feedstock preparation activities. Given the small staffing requirements for construction, no in-migrating workers and associated population influx would be expected, and there would be no adverse socioeconomic impacts from project construction on the local housing market or community services in the ROI.

With respect to operations, the number of workers required for feedstock preparation at the INL Site is estimated at 300, which would bring the total operations workforce to 370 for both fuel fabrication and feedstock preparation activities. It is estimated that the majority of workers would be local hires or taken from existing jobs at INL, and a small percentage of workers (10 percent or 37) would in-migrate and bring their families. Based on an average household size of 2.68, the total population influx would be about 100 persons. This represents 0.01 percent of the total ROI population.

Given the relatively small staffing requirements and projected population influx, no adverse socioeconomic impacts would be expected from project construction or operation on the local housing market or community services in the ROI. The potential increase in jobs and income would be considered a small and beneficial impact on the local economy. The combined impacts of fuel fabrication, feedstock preparation, and VTR construction and operation are addressed in Section 4.14.5.

4.14.3.2 SRS Reactor Fuel Production Options

Construction

Under the SRS Reactor Fuel Production Options, no new facilities would be constructed at SRS. Fuel fabrication would be performed in an existing facility in the K Area Complex. All equipment necessary to support fuel alloying and homogenization, fuel slug casting, fuel pin assembly, and fuel assembly fabrication would be located on two below ground levels within the building. The only construction activities would be the build-out of the equipment locations within 105-K Building and the removal of existing equipment. However, new infrastructure would be required, including material storage areas, special nuclear material measurement equipment, analytical support, and other infrastructure services such as glovebox and room ventilation and electrical distribution. The space needed for support facilities are expected to be substantial. At least one and possibly two of the adjacent 108-K buildings could be needed for these support operations. Construction is assumed to require 3 years (SRNS 2020).

VTR activities associated with fuel fabrication construction at SRS would require a larger workforce than at INL, as follows: 120 (peak and annual average), for a total of 360 workers over a 3-year construction period (see Appendix B, Table B–41). The majority of workers would be local. In addition, the direct employment would generate another 76 indirect jobs in the region. They would also generate about $8.3 million annually during the period of construction from direct and indirect jobs. The employment totals are based on a regional multiplier for the (construction) industry employment of 1.63 (DOE 2015a, 2020a). Earnings are based on the number of direct and indirect employees, the average construction worker's salary of $43,620 in Georgia and South Carolina (BLS 2020d), and a 2018 per capita income of $40,886 for the ROI (BEA 2019a).

Regarding the potential need for feedstock preparation, the number of workers required for construction for feedstock preparation activities at this level of scope development would be considered equivalent to that of fuel fabrication (120). It is assumed that the majority of these workers also would be local. The total employment (direct and indirect) requirement of 196 jobs related to fuel fabrication, or 392 with feedstock preparation activities, represents a very small percentage (0.08 percent to 0.16 percent) of the ROI workforce in 2018, and 1.3 percent to 2.6 percent of the of the construction workforce in the ROI. The ROI had a relatively low unemployment rate of 4.1 percent in 2018. **Table 4–65** shows the projected construction staffing for the project.

Socioeconomic projections assume 10 percent of the 240 combined fuel production options' workforce, or 24 construction workers, would in-migrate to the SRS area and bring their families. The total population influx would be about 65 persons, based on an average household size of 2.63 in South Carolina. This is about 0.01 percent of the total ROI population in 2018. Given the relatively small staffing requirements and projected population influx, no adverse socioeconomic impacts would be expected from project operation on the local housing market or community services in the ROI. The potential increase in jobs and income would be considered a small and beneficial impact on the local economy.

Table 4–65. Effects of VTR Project-Fuel Fabrication and Feedstock Preparation on Socioeconomics at the Region of Influence for Savannah River Site

Impact Category	*Fuel Fabrication Staffing Requirements* Construction (annual) Fuel Fabrication/Fuel Fabrication and Feedstock Preparation	*Fuel Fabrication Staffing Requirements* Operation (annual) Fuel Fabrication/Fuel Fabrication and Feedstock Preparation
Employment (number of jobs)		
Direct	120 / 240 3-year period	300 / 600
Indirect	76 / 152	360 / 715
Total	196 / 392	660 / 1,315
Income ($ in millions) [a]		
Direct	$5.2 / $10.5	$25.5 / $51.0
Indirect	$3.1 / $6.2	$14.7 / $29.2
Total	$8.3 / $16.6	$40.2 / $80.2
Population (# new residents)	Negligible	Negligible
Housing (# units required)	Negligible	Negligible
Public finances (Percent impacts on expenditures)		
Cities and Counties	< 1	< 1
Schools	< 1	< 1
Public Service Employment (# new employees)		
Local government employees	0	0
Teachers	0	0

[a] Based on average salary of $43,620 for construction worker in GA/SC (BLS 2020d); $40,886 per capita income in ROI used for indirect workers salary (BEA 2019a); and $85,000 average worker salary at SRS (Noah et al. 2011).

Operation

Based on the projected staffing requirements, the potential socioeconomic impacts from operating the fuel fabrication facility would be small. Operational activities would create a maximum of 300 direct jobs during the first year of operation (2026) and about $25.5 million in income annually, starting in 2028. Up to an additional 360 indirect jobs and another $14.7 million in income annually during operations from indirect jobs would be possible. This is based on an employment multiplier (operations) of 2.19 (DOE 2020); see also Table 4–65. The total additional employment (direct and indirect workers) associated with the Project would be very small (about 0.1 percent of the total civilian workforce in the ROI) and have negligible impact on the SRS ROI labor force, based on levels in 2018.

It is further assumed that there would be no in-migration of any maintenance or operations personnel at the beginning of operations and therefore the project would have negligible effect on population growth. As a result, there would be no adverse effects on the ROI in terms of population, employment, income levels, housing, or community services.

Similar to construction, the increase in jobs and income from plant operation, however small, would have a small, beneficial long-term impact on the economy of the area. As indicated in Chapter 3, Section 3.14.3, SRS significantly influences the economy of both Georgia and South Carolina. An increase in SRS employment associated with the Proposed Action would further benefit the local, regional, and State economy. SRS employees' spending would create an additional positive effect on the economy and generate additional State and local revenues and taxes.

The inclusion of feedstock preparation activities would increase the workforce by an additional 300 workers, bringing the total combined workforce to 600. Similar to the analysis for INL, it is assumed that all new hires would be local or pulled from existing jobs at SRS, and no workers would migrate into the area.

Combining the fuel fabrication and feedstock preparation workforce would result in a total employment (direct and indirect) requirement of just over 1,300 workers. However, this higher number would still represent a very small percentage (0.6 percent) of the total ROI workforce in 2018. The ROI had a relatively low unemployment rate of 4.1 percent in 2018. Table 4–65 shows the projected operations staffing for the project. In addition, given the expectation that all hires would be local, the socioeconomic impacts from project operation on the local housing market or community services in the ROI would be expected to be negligible. The potential increase in jobs and income would be considered a small and beneficial impact on the local economy.

4.14.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

4.14.4.1 Construction/Facility Modification

Table 4–66 shows the combined construction workforce requirements for VTR alternative and reactor fuel production at INL. The fuel fabrication activities assume that feedstock preparation would be required to provide a bounding analysis, and the workforce estimates reflect this. The incremental increase in the fuel fabrication/feedstock preparation workforce (36 peak, 12 annual average), as compared to the VTR workforce analyzed in Section 4.14.2, is very small, and the combined workforce requirements for the VTR and fuel fabrication activities would be essentially the same as those analyzed just for the VTR in Section 4.14.2. There would be no major adverse impacts on the ROI in terms of population, employment, income levels, housing, or community services from the combined set of construction activities. Section 4.14.1.1 describes the change in housing requirements during construction. The increase in jobs and income would be considered a small and beneficial impact on the area.

4.14.4.2 Operation

Table 4–66 shows the combined operations workforce requirements for VTR and fuel fabrication activities at INL. The incremental increase in the fuel fabrication and feedstock preparation workforce (about 600 total, 370 of which would be new hires), as compared to the VTR workforce analyzed in Section 4.14.2, would result in minimal in-migration of workers and their families. Most new hires would be from the local area. Therefore, the impacts of the combined workforce on the ROI, with respect to population, housing, and community services would be essentially the same as those analyzed for the VTR alone in Section 4.14.2. There would be no major adverse impacts on the ROI in terms of population, employment, income levels, housing, or community services from the combined set of activities. The increase in jobs and income would be considered a small and beneficial impact on the area.

Table 4–66. Combined Effects of VTR and Fuel Fabrication/Feedstock Preparation Activities on Socioeconomics within the Idaho National Laboratory Region of Influence

Impact Category	*VTR and Fuel Fabrication - Feedstock Preparation Staffing Requirements*	
	Construction (annual)	*Operation (annual)*
Employment (number of jobs)		
Direct	1,340 (peak); 672 (average) 3,200 total (based on 51-month construction period)	590 (new workers)[b]
Indirect	910 (peak); 457 (annual)	1,010
Total	2,250 (peak); 1,130(annual)	1,600
Income ($ in millions) [a]		
Direct	$57.7(peak year); $28.9 (annual)	$56.5

Impact Category	VTR and Fuel Fabrication - Feedstock Preparation Staffing Requirements	
	Construction (annual)	Operation (annual)
Indirect	$26 (peak); $13 (annual)	$28.8
Total	$83.7 (peak); $41.9(annual)	$85.3
Population (# new residents)	2,787 (peak) Including up to 700 additional children which is just over a 1 percent(65,268) increase in school children in ROI	290 75 additional children Less than 0.1 percent increase in school children in ROI
Housing (# units required)	1,040 (about 9.7 percent of total vacant rental units (10,692) and about 8.9 percent of total vacant housing units in ROI in 2018) (11,706 rental and owned)	102 (5.1 percent of vacant owner-occupied housing units in ROI in 2018) (1,984); and less than 1 percent of total vacant housing units in ROI in 2018
Public finances (Percent impacts on expenditures)		
Cities and Counties	< 1	< 1
Schools	< 1	< 1
Public Service Employment (# new employees)		
Local government employees	0	0
Teachers	0	0

[a] Based on average salary of $43,040 for construction worker (BLS 2020d), and $95,768 average base salary of INL employee in FY 2017 (INL 2018fd).

[b] 590 new workers but an additional 230 fuel fabrication workers would be drawn from the existing workforce at the INL Site, which results in a total of 820 workers.

4.15 Environmental Justice

This section discusses impacts on environmental justice populations within the respective 50-mile radius of the MFC at the INL Site, ORNL, and K Area at SRS. The 50-mile radius was selected because it is consistent with the ROI for air emissions and because it includes portions of the counties that constitute the respective ROIs for socioeconomics as described in Sections 3.1.15, 3.2.15, and 3.3.15.

Executive Order 12898 established the need to identify and address disproportionately high and adverse human health or environmental effects of Federal activities on environmental justice populations. CEQ (1997) defines disproportionately high and adverse human health or environmental effects as:

- Health or environmental effects that may be measured in risks and rates that are significant or above generally accepted norms;
- Risk or rate of hazard exposure by a minority, low-income population, or Native American Tribe to an environmental hazard that is significant and appreciably exceeds, or is likely to appreciably exceed, the risk or rate to the general population or other appropriate comparison group;
- Health or environmental effects that occur in a minority population, low-income population, or Native American Tribe affected by cumulative or multiple adverse exposures from environmental hazards; or
- Impact on the natural or physical environment that significantly and adversely affects a minority population, low-income population, or Native Americans.

To have disproportionately high and adverse human health or environmental effects on minority and low-income populations from the project, minority or low-income populations would need to be concentrated in geographic areas with high risk of exposure to radiation, hazardous chemicals, or potential accidents. Areas considered include geographic areas downwind from air emissions, or areas in close proximity to pollution sources. Additionally, high risk or exposure could occur through subsistence consumption of contaminated vegetation, fish, or wildlife. Impacts on Native American populations could occur from interrelated impacts (e.g., ecological, cultural, and traditional use areas) to the natural or physical environment.

Sections 3.1.14, 3.2.14, and 3.3.14 describe the existing environmental justice characteristics for the ROIs for each of the respective project locations, including census units for minority, low-income populations, and Native American Tribes. **Table 4–67** provides a summary of environmental consequences on Environmental Justice.

Table 4–67. Summary of Environmental Consequences on Environmental Justice

Resource Area	***VTR Alternatives***	
	INL VTR	***ORNL VTR***
Environmental Justice	*Construction:* No disproportionately high and adverse impacts on minority or low-income populations are expected. *Operations:* No disproportionately high and adverse impacts on minority or low-income populations are expected.	*Construction:* Same as INL VTR construction. *Operations:* Same as INL VTR operation.
	Discussion: Construction or operations of the VTR would not result in any disproportionately high and adverse human health or environmental effects on any minority or low-income populations. Increased risks of minority, low-income individuals, or Native American populations exposed to radiation would be negligible. There would be no other impacts on the natural or physical environment that would result in significant and adverse impacts on minority or low-income populations.	
	Reactor Fuel Production Options	
	INL Reactor Fuel Production	***SRS Reactor Fuel Production***
Environmental Justice	**Feedstock Preparation**	
	Construction: No disproportionately high and adverse impacts on minority or low-income populations are expected. *Operations:* No disproportionately high and adverse impacts on minority or low-income populations are expected.	*Construction:* Same as INL feedstock preparation construction. *Operations:* Same as INL feedstock preparation operation.
	Fuel Fabrication	
	Construction: Same as INL feedstock preparation construction. *Operations:* Same as INL feedstock preparation operation.	*Construction:* Same as INL feedstock preparation construction. *Operations:* Same as INL feedstock preparation operation.
	Discussion: Construction or operations for either feedstock preparation or fuel fabrication would not result in any disproportionately high and adverse human health or environmental effects on any minority or low-income populations. Increased risks of minority, low-income individuals, or Native American populations exposed to radiation would be negligible. There would be no other impacts on the natural or physical environment that would result in significant and adverse impacts on minority or low-income populations.	
	Combined INL VTR Alternative and INL Reactor Fuel Production Options	
Environmental Justice	*Construction:* No disproportionately high and adverse impacts on minority, low-income, or Native American populations are expected. *Operations:* No disproportionately high and adverse impacts on minority, low-income, or Native American populations are expected.	

4.15.1 INL VTR Alternative

In accordance with DOE Orders, environmental sampling is performed at several locations on the INL Site, at the INL Site boundary, and at various distances from the INL Site. Environmental sampling is also conducted at locations at Blackfoot and on the Fort Hall Indian Reservation to monitor for possible impacts on the Shoshone-Bannock Tribes. Potential pathways for contaminants to reach humans are sampled and monitored, and include air, water, precipitation, soil, agricultural products, and wildlife as it relates to ingestion (INL 2018a). To address possible impacts from consumption, including subsistence consumption, DOE routinely samples game species residing on the INL Site as well as regional agriculture products. Large game animals (pronghorn, mule deer, and elk) are sampled whenever they are killed from vehicle collisions on site or at the INL Site boundary. Waterfowl are also collected at ponds on the INL Site and at a location offsite (i.e., the American Falls Reservoir in 2017), and sampled. Data from monitoring programs are reported and published annually. Monitoring locations for milk, potatoes, and wheat products include traditional use areas of the Shoshone-Bannock Tribes and are located near Blackfoot and Fort Hall (INL 2018a).

4.15.1.1 Construction/Facility Modification

No disproportionately high or adverse impacts on environmental justice populations are anticipated during construction. The short-term socioeconomic impacts during any construction activities would be positive and not result in any disproportionately high and adverse effects on minority populations, low-income, or Native American populations. Regarding human health, there would be no additional radiological risks to the public during construction. Regarding other health or environmental effects, construction would occur about 2 miles from the nearest identified environmental justice block group, which is at such distance that is not anticipated to result in significant adverse effects to these populations. Therefore, no disproportionately high and adverse effects on minority, low-income, or Native American populations would be expected during construction of the VTR at the INL Site.

4.15.1.2 Operations

As discussed in Sections 4.10, routine operations under operations of the VTR alternative at the INL Site would pose no significant health risks to the public. **Table 4–68** shows the annual impacts on the total and subset populations within 5, 10, 20, and 50 miles of the facilities at the INL Site used under this alternative.

Table 4–68. Comparison of Annual Doses to Average Individual of Minority and Low-Income Populations Near the INL Site During VTR Operations in 2050 (millirem)

Population Group	***Within 5 Miles***	***Within 10 Miles***	***Within 20 Miles***	***Within 50 Miles***
Average Individual of the Total Population	0.0019	7.9×10^{-4}	4.5×10^{-4}	1.2×10^{-4}
Nonminority Individual	0.0016	8.7×10^{-4}	4.9×10^{-4}	1.2×10^{-4}
Average Individual of Total Minorities	0.0020	5.2×10^{-4}	3.3×10^{-4}	1.1×10^{-4}
White - Hispanic/Latino Individual	0.0019	9.1×10^{-4}	5.2×10^{-4}	1.4×10^{-4}
Black/African American Individual [a]	ND	ND	3.7×10^{-4}	1.3×10^{-4}
American Indian or Alaska Native Individual [b]	ND	ND	5.2×10^{-4}	1.6×10^{-4}
Other Minority Individual [a, b]	ND	5.5×10^{-4}	3.6×10^{-4}	1.2×10^{-4}
Non-low-income Individual	0.0019 0.0016	8.2×10^{-4}	4.6×10^{-4}	1.2×10^{-4}
Low-income Individual	ND	5.1×10^{-4}	3.5×10^{-4}	1.1×10^{-4}

ND = No dose; there are no recorded individuals of this population group within this radial distance

[a] Includes persons who also indicated Hispanic or Latino origin.

[b] Other Minority includes all combined individuals of Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, or Two or More Races.

Note: Dose calculations are based on 2050 population projections.

Impacts are summarized as follows:

- Within all radial distances, the annual dose for any racial or ethnic minority individual does not exceed more than 1.2×10^{-4} millirem than that of the average nonminority individual. This difference is so small that it represents no appreciable change in the risk to the exposed individual of developing a latent fatal cancer.
- The annual dose to the average low-income individual does not exceed the annual dose for the non-low-income individual at any radius.

Impacts on the Shoshone-Bannock Tribes on the Fort Hall Reservation, and their use on the INL Site of sacred and traditional-use areas, natural landscapes, water, and ecological resources that are of special significance to them are further evaluated in this EIS in Section 4.6.

Considering the above analysis and the very low levels of risk exposure by each minority or low-income population compared to non-minority or non-low-income populations, operations of the VTR at the INL Site would not result in disproportionately high and adverse impacts on minority or low-income populations near the INL Site. Environmental sampling would continue to occur at the INL Site to ensure operations, including from the VTR, do not impact offsite populations.

4.15.2 ORNL VTR Alternative

Similar to at the INL Site, environmental sampling is performed at several locations on the ORNL, at the ORNL boundary, and at various distances from the ORNL per DOE Orders. Potential pathways for contaminants to reach humans are sampled and monitored, and include air, water (surface water and groundwater), precipitation, agricultural products, and fish and wildlife as it relates to ingestion (ORO 2019). To address possible impacts from consumption, DOE routinely samples game species residing on ORNL as well as regional agriculture products. Game animals (i.e., white-tailed deer, turkey) and waterfowl (i.e., Canada geese) are collected and sampled. Data from monitoring programs are reported and published annually (ORO 2019).

4.15.2.1 Construction/Facility Modification

Impacts for construction/facility modification at ORNL would be similar to what is described in Section 4.15.1.1 for the INL Site, and no disproportionately high or adverse impacts on environmental justice populations are anticipated. Regarding human health, there would be no additional radiological risks to the public during construction. Regarding other health or environmental effects, construction would occur about 3 miles from the nearest identified environmental justice block group, which is at such distance that is not anticipated to result in significant adverse effects to these populations. Therefore, no disproportionately high and adverse effects on minority or low-income populations would be expected during construction of the VTR at ORNL.

4.15.2.2 Operations

As discussed in Sections 4.10, routine operations under the VTR alternative at ORNL would pose no significant health risks to the public. **Table 4–69** shows the annual impacts on the total and subset populations within 5, 10, 20, and 50 miles of the facilities at ORNL used under this alternative.

Table 4–69. Comparison of Annual Doses to Average Individuals of Minority and Low-Income Populations Near ORNL During VTR Operations in 2050 (millirem)

Population Group	*Within 5 Miles*	*Within 10 Miles*	*Within 20 Miles*	*Within 50 Miles*
Average Individual of the Total Population	0.0028	0.0012	6.2×10^{-4}	3.6×10^{-4}
Nonminority Individual	0.0028	0.0012	6.3×10^{-4}	3.7×10^{-4}
Average Individual of Total Minorities	0.0028	0.0013	6.0×10^{-4}	3.1×10^{-4}
White – Hispanic/Latino Individual	0.0022	0.0013	6.9×10^{-4}	4.2×10^{-4}
Black/African American Individual [a]	0.0036	0.0014	5.0×10^{-4}	3.3×10^{-4}
American Indian or Alaska Native Individual [b]	0.0052	0.0012	5.4×10^{-4}	2.7×10^{-4}
Other Minority Individual [a, b]	0.0027	0.0013	6.3×10^{-4}	2.8×10^{-4}
Non-low-income Individual	0.0027	0.0012	6.2×10^{-4}	3.6×10^{-4}
Low-income Individual	0.0033	0.0015	6.3×10^{-4}	3.4×10^{-4}

[a] Includes persons who also indicated Hispanic or Latino origin.
[b] Other Minority includes all combined individuals of Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, or Two or More Races.
Note: Dose calculations are based on 2050 population projections.

Impacts are summarized as follows:

- Within the 5-mile radius, the annual dose to an average individual of the American Indian or Alaska Native population would be about 0.0024 millirem higher than that of the average nonminority individual. Annual doses for the average individual of the Black/African American population would be about 8.1×10^{-4} millirem higher than that of the average nonminority individual. These differences represent a negligible increased risk to the exposed individual of developing a latent fatal cancer (respectively, 1×10^{-9}, or 1 chance in 1 billion; and 5×10^{-10}, or 1 chance in 2 billion, annually).
- Within the 10-mile radius, the annual dose to an average individual of the Black/African American population would be about 1.6×10^{-4} millirem higher than that of the average nonminority individual. These differences represent a negligible increased risk to the exposed individual of developing a latent fatal cancer (9×10^{-11}, or 1 chance in 11.1 billion)
- In all other instances where average individual dose for any racial or ethnic group exceeds that of non-minorities, the exceedance would be no more than 8.2×10^{-5} millirem, which does not represent an appreciable change in the risk to the exposed individual of developing a latent fatal cancer.
- For low-income populations, the annual doses to the average low-income individual is 6×10^{-4} millirem higher within 5 miles, and 2.6×10^{-4} millirem higher within 10 miles of the non-low-income average individual. These differences represent a negligible increased risk to the exposed individual of developing a latent fatal cancer (respectively, 4×10^{-10}, or 1 chance in 2.5 billion; and 2×10^{-10}, or 1 chance in 5 billion, annually). Within 20 miles, the annual dose to the average low-income individual is 2.1×10^{-6} millirem higher than the average non-low-income individual, which does not represent an appreciable change in the risk to the exposed individual of developing a latent fatal cancer. Within 50 miles, the annual dose to the average low-income individual does not exceed the annual dose for the non-low-income individual.

Considering the above analysis and the very low levels of risk exposure by each minority or low-income population compared to non-minority or non-low-income populations, operations of the VTR at ORNL would not result in disproportionately high and adverse impacts on minority or low-income populations near ORNL. Environmental sampling would continue to occur at ORNL to ensure operations, including from the VTR, do not impact offsite populations.

4.15.3 Reactor Fuel Production Options

4.15.3.1 INL Reactor Fuel Production Options

4.15.3.1.1 INL Feedstock Preparation Option

Construction/Facility Modification

Impacts for construction/facility modification for a feedstock preparation facility at the INL Site would be similar to those described in Section 4.15.1.1 for VTR construction at the INL Site. No disproportionately high or adverse impacts on environmental justice populations are anticipated. Regarding human health, there would be no additional radiological risks to the public during construction. Construction activities would occur within existing facilities directly adjacent to the proposed VTR construction site (i.e., about 2 miles from the nearest identified environmental justice block group), and no new land disturbance would occur that would result in substantial health or environmental effects. Therefore, no disproportionately high and adverse effects on minority populations, low-income, or Native American populations would be expected during construction for the feedstock preparation at the INL Site.

Operations

As discussed in Section 4.10, routine operations of feedstock preparation at the INL Site would pose no significant health risks to the public. **Table 4–70** shows the annual impacts on the total and subset populations within 5, 10, 20, and 50 miles of the facilities at the INL Site utilized under this alternative.

Table 4–70. Comparison of Annual Doses to Average Individuals of Minority and Low-Income Populations Near the INL Site During Feedstock Preparation in 2050 (millirem)

Population Group	*Within 5 Miles*	*Within 10 Miles*	*Within 20 Miles*	*Within 50 Miles*
Average Individual of the Total Population	5.6×10^{-4}	2.4×10^{-4}	1.4×10^{-4}	3.2×10^{-5}
Nonminority Individual	5.6×10^{-4}	2.5×10^{-4}	1.4×10^{-4}	3.1×10^{-5}
Average Individual of Total Minorities	5.9×10^{-4}	2.0×10^{-4}	1.2×10^{-4}	3.5×10^{-5}
White - Hispanic/Latino Individual	5.9×10^{-4}	2.7×10^{-4}	1.5×10^{-4}	3.7×10^{-5}
Black/African American Individual [a]	ND	ND	1.1×10^{-4}	3.4×10^{-5}
American Indian or Alaska Native Individual [b]	ND	ND	1.5×10^{-4}	4.3×10^{-5}
Other Minority Individual [a, b]	ND	1.7×10^{-4}	1.1×10^{-4}	3.3×10^{-5}
Non-low-income Individual	5.6×10^{-4}	2.5×10^{-4}	1.4×10^{-4}	3.3×10^{-5}
Low-income Individual	ND	1.6×10^{-4}	1.1×10^{-4}	2.9×10^{-5}

ND = No dose; there are no recorded individuals of this population group within this radial distance.
[a] Includes persons who also indicated Hispanic or Latino origin.
[b] Other Minority includes all combined individuals of Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, or Two or More Races.
Note: Dose calculations are based on 2050 population projections.

Impacts are summarized as follows:

- In all instances where average individual dose for any racial or ethnic group exceeds that of non-minorities, the exceedance would be no more than 3.2×10^{-5} millirem, which does not represent an appreciable change in the risk to the exposed individual of developing a latent fatal cancer.
- The annual dose to the average low-income individual does not exceed the annual dose for the non-low-income individual at any radial distance.

Considering the above analysis and the very low levels of risk exposure by each minority or low-income population compared to non-minority or non-low-income populations, operations of a feedstock preparation scenario at the INL Site would not result in disproportionately high and adverse impacts on minority or low-income populations near the INL Site. Environmental sampling would continue to occur at the INL Site to ensure operations, including from feedstock preparation, do not impact offsite populations.

4.15.3.1.2 INL Fuel Fabrication Option

Construction/Facility Modification

Impacts for construction/facility modification for a fuel fabrication at the INL Site would be the same as described for the feedstock preparation facility. There would be no differences in human health impacts, and facility modification would occur within the same footprint as for the feedstock preparation. Therefore, no disproportionately high and adverse effects on minority, low-income, or Native American populations would be expected during construction.

Operations

Fuel fabrication operations at the INL Site would present a comparable but slightly higher increase in risk to what is described for operations of feedstock preparation. **Table 4–71** shows the annual impacts on the total and subset populations within 5, 10, 20, and 50 miles of the facilities at the INL Site utilized under this alternative.

Table 4–71. Comparison of Annual Doses to Average Individuals of Minority and Low-Income Populations Near the INL Site During Fuel Fabrication in 2050 (millirem)

Population Group	*Within 5 Miles*	*Within 10 Miles*	*Within 20 Miles*	*Within 50 Miles*
Average Individual of the Total Population	6.4×10^{-4}	2.0×10^{-4}	8.5×10^{-5}	1.5×10^{-5}
Nonminority Individual	6.4×10^{-4}	2.2×10^{-4}	9.0×10^{-5}	1.4×10^{-5}
Average Individual of Total Minorities	6.8×10^{-4}	1.6×10^{-4}	7.6×10^{-5}	1.6×10^{-5}
White – Hispanic/Latino Individual	6.8×10^{-4}	2.3×10^{-4}	9.5×10^{-5}	1.7×10^{-5}
Black/African American Individual [a]	ND	ND	6.7×10^{-5}	1.5×10^{-5}
American Indian or Alaska Native Individual [b]	ND	ND	8.6×10^{-5}	1.9×10^{-5}
Other Minority Individual [a, b]	ND	1.3×10^{-4}	6.6×10^{-5}	1.5×10^{-5}
Non-low-income Individual	6.4×10^{-4}	2.1×10^{-4}	8.7×10^{-5}	1.5×10^{-5}
Low-income Individual	ND	1.2×10^{-4}	6.6×10^{-5}	1.3×10^{-5}

ND = No dose; there are no recorded individuals of this population group within this radial distance.
[a] Includes persons who also indicated Hispanic or Latino origin.
[b] Other Minority includes all combined individuals of Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, or Two or More Races.
Note: Dose calculations are based on 2050 population projections.

Impacts are summarized as follows:

- In all instances where average individual dose for any racial or ethnic group exceeds that of non-minorities, the exceedance would be no more than 4.5×10^{-5} millirem, which does not represent an appreciable change in the risk to the exposed individual of developing a latent fatal cancer.
- The annual dose to the average low-income individual does not exceed the annual dose for the non-low-income individual at any radial distance.

Considering the above analysis and the very low levels of risk exposure by each minority or low-income population compared to non-minority or non-low-income populations, operations of a fuel fabrication option at the INL Site would not result in disproportionately high and adverse impacts on minority or low-income populations near the INL Site. Environmental sampling would continue to occur at the INL Site to ensure operations, including from fuel fabrication, do not impact offsite populations.

4.15.3.2 SRS Reactor Fuel Production Options

Similar to at the INL Site, environmental sampling is performed at several locations on the SRS, at the SRS boundary, and at various distances from the SRS per DOE Orders. Potential pathways for contaminants to reach humans are sampled and monitored, and include air, surface water, drinking water, precipitation, vegetation, soil and stream sediment, agricultural products, and fish and wildlife as it relates to ingestion (SRNS 2019a). To address possible impacts from consumption, DOE routinely samples game species residing on ORNL as well as regional agriculture products. Game animals (i.e., white-tailed deer, turkey) and waterfowl (i.e., Canada geese) are collected and are sampled. Data from monitoring programs are reported and published annually (SRNS 2019a).

4.15.3.2.1 SRS Feedstock Preparation Option

Construction/Facility Modification

No disproportionately high or adverse impacts on environmental justice populations are anticipated during construction for feedstock preparation at SRS. Impacts would be similar to those described for construction required for feedstock preparation at the INL Site (i.e., similar socioeconomic and human health impacts). Construction would occur about 5 miles from the nearest identified environmental justice block group, which is at such distance that is not anticipated to result in significant adverse effects to these populations. Therefore, no disproportionately high and adverse effects on minority, low-income, or Native American populations would be expected during construction.

Operations

As discussed in Section 4.10, routine operations of a feedstock preparation facility at SRS would pose no significant health risks to the public. **Table 4–72** shows the annual impacts on the total and subset populations within 10, 20, and 50 miles of the facilities at SRS used under this option.

Table 4–72. Comparison of Annual Doses to Average Individuals of Minority and Low-Income Populations Near SRS During Feedstock Preparation in 2050 (millirem)

Population Group	*Within 10 Miles*	*Within 20 Miles*	*Within 50 Miles*
Average Individual of the Total Population	4.3×10^{-4}	1.2×10^{-4}	4.7×10^{-5}
Nonminority Individual	4.3×10^{-4}	1.1×10^{-4}	4.4×10^{-5}
Average Individual of Total Minorities	4.3×10^{-4}	1.3×10^{-4}	5.0×10^{-5}
White – Hispanic/Latino Individual	4.4×10^{-4}	9.8×10^{-5}	4.3×10^{-5}
Black/African American Individual [a]	4.4×10^{-4}	1.3×10^{-4}	5.2×10^{-5}
American Indian or Alaska Native Individual [b]	3.5×10^{-4}	1.3×10^{-4}	5.0×10^{-5}
Other Minority Individual [a, b]	3.4×10^{-4}	1.0×10^{-4}	4.1×10^{-5}
Non-low-income Individual	4.3×10^{-4}	1.1×10^{-4}	4.6×10^{-5}
Low-income Individual	4.5×10^{-4}	1.4×10^{-4}	5.1×10^{-5}

[a] Includes persons who also indicated Hispanic or Latino origin.
[b] Other Minority includes all combined individuals of Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, or Two or More Races.
Note: Dose calculations are based on 2050 population projections.

Within all radial distances, the annual dose for any racial or ethnic minority individual does not exceed more than 2.5×10^{-5} millirem than that of the average nonminority individual. This difference is so small that it represents no appreciable change in the risk to the exposed individual of developing a latent fatal cancer. The annual dose for any low-income individual is comparably small and the difference between low-income and non-low-income individual does not represent an appreciable change in the risk to the exposed individual of developing a latent fatal cancer.

Considering the above analysis and the very low levels of risk exposure by each minority or low-income population compared to non-minority or non-low-income populations, operations of a feedstock preparation option at SRS would not result in disproportionately high and adverse impacts on minority or low-income populations near SRS. Environmental sampling would continue to be conducted at SRS to ensure operations, including from feedstock preparation, do not impact offsite populations.

4.15.3.2.2 SRS Fuel Fabrication Option

Construction/Facility Modification

Impacts for construction/facility modification for a fuel fabrication facility at SRS would be similar to as described for the feedstock preparation facility. There would be no differences in human health impacts, and facility modification would occur within the same footprint as for the feedstock preparation facility. Therefore, no disproportionately high and adverse effects on minority or low-income populations would be expected during construction.

Operations

Operations of a fuel fabrication facility at SRS would present a smaller increase in risk than as described for operations of a feedstock preparation facility. Therefore, no disproportionately high and adverse effects on minority or low-income populations would be expected during operations.

4.15.4 Combined INL VTR Alternative and INL Reactor Fuel Production Options Impacts

As discussed in Section 4.10, routine operations under operations of the Combined INL VTR Alternative and INL Reactor Fuel Production Options would pose no significant health risks to the public. **Table 4–73** shows the annual impacts on the total and subset populations within 5, 10, 20, and 50 miles of the facilities at the INL Site utilized under this alternative.

Table 4–73. Comparison of Annual Doses to Average Individuals of Minority and Low-Income Populations Near the INL Site During Combined INL VTR Alternative and INL Reactor Fuel Production in 2050 (millirem)

Population Group	Within 5 Miles	Within 10 Miles	Within 20 Miles	Within 50 Miles
Average Individual of the Total Population	0.0031	0.0012	6.7×10^{-4}	1.7×10^{-4}
Nonminority Individual	0.0031	0.0013	7.2×10^{-4}	1.7×10^{-4}
Average Individual of Total Minorities	0.0028	8.7×10^{-4}	5.3×10^{-4}	1.6×10^{-4}
White – Hispanic/Latino Individual	0.0033	0.0014	7.7×10^{-4}	1.9×10^{-4}
Black/African American Individual [a]	ND	ND	5.5×10^{-4}	1.7×10^{-4}
American Indian or Alaska Native Individual [b]	ND	ND	7.6×10^{-4}	2.3×10^{-4}
Other Minority Individual [a, b]	ND	8.5×10^{-4}	5.3×10^{-4}	1.7×10^{-4}
Non-low-income Individual	0.0031	0.0013	6.8×10^{-4}	1.7×10^{-4}
Low-income Individual	ND	8.0×10^{-4}	5.3×10^{-4}	1.6×10^{-4}

ND = No dose; there are no recorded individuals of this population group within this radial distance.

[a] Includes persons who also indicated Hispanic or Latino origin.

[b] Other Minority includes all combined individuals of Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, or Two or More Races.

Note: Dose calculations are based on 2050 population projections.

Impacts are summarized as follows:

- Within the 5-mile radius, the annual dose to an average individual of the White – Hispanic/Latino population would be about 1.7×10^{-4} millirem higher than that of the average nonminority individual. This difference represents a negligible increased risk to the exposed individual of developing a latent fatal cancer (1×10^{-10}, or about 1 chance in 10 billion, annually).
- In all other instances where the average individual dose for any racial or ethnic group exceeds that of non-minorities, the exceedance is no more than 7.3×10^{-5} millirem, which does not represent an appreciable change in the risk to the exposed individual of developing a latent fatal cancer.
- The annual dose to the average low-income individual does not exceed the annual dose for the non-low-income individual for any radius.

Considering the above analysis and the very low levels of risk exposure by each minority or low-income population compared to non-minority or non-low-income populations, operations of the combined INL VTR, feedstock preparation, and fuel fabrication alternative at the INL Site would not result in disproportionately high and adverse impacts on minority or low-income populations near the INL Site. Environmental sampling would continue to be conducted at the INL Site to ensure operations, including from this alternative, do not impact offsite populations.

4.16 No Action Alternative

As described in Chapter 2, Section 2.3, under the No Action Alternative, DOE would not construct and operate a VTR and associated facilities. DOE would continue to make use of the limited capabilities and availabilities of existing facilities, both domestic and foreign for testing in the fast-neutron-flux spectrum. Domestic reactor facilities that could be used include the ORNL HFIR, the INL ATR, and their associated post-irradiation examination and SNF management facilities. The HFIR and ATR reactors and fuel fabrication facilities would continue to be used as they currently exist consistent with their current programs. DOE would not construct new facilities or modify any existing reactors, post-irradiation examination, SNF management, or reactor fuel production facilities. Conditions at INL, ORNL, and SRS would remain as described in Chapter 3 for each of the 15 resource areas.

4.17 Deactivation, Decommissioning, and Demolition

Following the completion of operations and shutdown of the VTR and associated facilities, the first disposition activity is to deactivate the facilities. The purpose of deactivation is to place potentially contaminated nuclear, radiological, and radioactive facilities in safe shutdown conditions. Safe shutdown minimizes risks by protecting workers, the public, and the environment. Safe shutdown is economical to monitor and is maintained for the period of time until the facilities are decommissioned and demolished. Decommissioning includes decontamination and dismantling facilities to the ultimate end state of demolition. During decommissioning, hazardous and radioactive materials and contamination are removed or fixed in place to ensure protection of workers, public health and safety, and the environment. Demolition is construction in reverse and includes the recycling of demolition materials to the extent practical and the disposal of non-recyclable materials. The specifics of deactivation, decommissioning, and demolition of the VTR and associated facilities are decades in the future. Therefore, this discussion reflects the general process and not the specifics which are not ripe for evaluation at this time given the length of proposed operations and the potential for changes in future DOE Program needs.

4.18 Mitigation Measures

No potential adverse impacts were identified that would require additional mitigation measures beyond those required by regulation or achieved through design features or BMPs. However, the Action Alternatives and Options have the potential to affect one or more resource areas. If during implementation, mitigation measures above and beyond those required by regulations would be identified to reduce impacts, they will be developed, documented, and executed.