Figure 5.8-28. View From KOP 40 with the CR SMR Project and the Average Annual Plume

Figure 5.8-29. View From KOP 40 with the CR SMR Project and the Winter Plume

5.9 DECOMMISSIONING IMPACTS

The U.S. Nuclear Regulatory Commission (NRC) requires that a nuclear facility be decommissioned per NRC regulations after cessation of operations by safely removing it from service and reducing residual radioactivity to a level that permits release of the property and termination of the operating license. NRC regulation Title 10 of the Code of Federal Regulations (10 CFR) 50.82 specifies the actions that NRC and a licensee must take to decommission a nuclear power facility. The radiological criteria to be met for license termination are specified in 10 CFR 20, Subpart E.

The NRC prohibits licensees from performing decommissioning activities that result in significant environmental impacts not previously reviewed under 10 CFR 50.82. The NRC has indicated that licensees for existing reactors can rely on the information in NUREG-0586, *Generic Environmental Impact Statement (GEIS) on Decommissioning of Nuclear Facilities*, Supplement 1, to determine the environmental impacts of decommissioning existing nuclear power reactors. Supplement 1 was published in 2002 with the original NUREG-0586 published in 1988. Because decommissioning plans are required by the NRC after a decision has been made to cease operation of a licensed nuclear unit, detailed analyses of decommissioning alternatives are not prepared until cessation of operations. As such, this section addresses only general environmental impacts of decommissioning.

NRC regulation 10 CFR 50.75, which establishes the financial requirements for providing reasonable assurance that adequate funds for performing decommissioning are available at the end of facility operations, does not apply to early site permit applications.

5.9.1 NRC GEIS on Decommissioning of Nuclear Facilities

The Decommissioning GEIS (NUREG-0586, Supplement 1) describes decommissioning regulatory requirements, the decommissioning process, and environmental impacts of decommissioning of nuclear facilities. Before presenting impacts, the Decommissioning GEIS describes the NRC process for evaluating impacts. Activities and impacts that NRC considered to be within the scope of the Decommissioning GEIS include:

- Activities performed to remove the facility from service once the licensee certifies that the facility has permanently ceased operations
- Activities performed in support of radiological decommissioning, including decontamination and dismantlement of radioactive structures, systems, and components (SSCs) and any activities required to support the decontamination and dismantlement process
- Activities performed in support of dismantlement of nonradiological SSCs, such as diesel generator buildings and cooling towers
- Activities performed up to license termination and their resulting impacts as provided by the definition of decommissioning

- Human health impacts from radiological and nonradiological decommissioning activities.

The Decommissioning GEIS evaluates the environmental impact of the following three decommissioning methods:

- DECON: The equipment, structures, and portions of the facility and site that contain radioactive contaminants are removed or decontaminated to a level that permits termination of the license shortly after cessation of operations. DECON comprises four distinct periods of effort: (1) pre-shutdown planning/engineering, (2) facility deactivation and transition (no activities are conducted during this period that will affect the safe operation of the spent fuel pool), (3) decontamination and dismantlement with concurrent operations in the spent-fuel pool until the pool inventory is zero, and (4) license termination.
- SAFSTOR: The facility is placed in a safe stable condition and maintained in that state (safe storage) until it is subsequently decontaminated and dismantled to levels that permit license termination. During SAFSTOR, a facility is left intact, but the fuel is removed from the reactor vessel and radioactive liquids are drained from systems and components and then processed. Radioactive decay occurs during the SAFSTOR period, thus reducing the quantity of contaminated and radioactive material that must be disposed of during the decontamination and dismantlement of the facility at the end of the storage period.
- ENTOMB: This alternative involves encasing radioactive SSCs in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license.

As stated in the Decommissioning GEIS, decommissioning a nuclear facility that has reached the end of its useful life generally has a positive environmental impact. The air quality, water quality, and ecological impacts of decommissioning are expected to be substantially smaller than those of nuclear facility construction or operation because the level of activity and the releases to the environment are expected to be smaller during decommissioning than during construction and operation. The major environmental impact, regardless of the specific decommissioning option selected, is the commitment of small amounts of land for waste burial where the offsite disposal facility is located (onsite disposal is not considered for the DECON option). Socioeconomic impacts of decommissioning would result from the demands on, and contributions to, the community by the workers employed to decommission a nuclear facility.

The Decommissioning GEIS assesses the impacts from decommissioning reactor facilities of various types and sizes including pressurized water reactors (PWR) in the 1130 megawatt electric (MWe) to 1825 MWe range. The description of decommissioning a PWR in the original Decommissioning GEIS (NUREG-0586) states that, while SMALL, the major environmental consequence of decommissioning is the commitment of land area to the disposal of radioactive waste. Because the waste volume from decommissioning can be correlated to the size of the reactor facility as provided in Table 4-7 of Decommissioning GEIS (NUREG-0586, Supplement 1), it can be concluded that the impacts of decommissioning small PWRs at the CRN Site with a

combined electrical power of 800 MWe (Table 3.1-2, Item 16.6) are bound by the impacts of the larger reference reactor described in Decommissioning GEIS.

According to Section 5.9 of NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan*, studies of social and environmental effects of decommissioning large commercial power generating units have not identified any significant impacts beyond those considered in the Decommissioning GEIS. NUREG 1555 also describes that decommissioning experience with commercial scale nuclear power facilities has shown that the occupational exposures during the decommissioning period are comparable to those associated with refueling and facility maintenance when a facility is operational. Each potential decommissioning alternative would have radiological impacts from the transport of materials from the facility to their disposal sites. The expected impact from this transportation activity would not be significantly different from normal operations.

The NRC identified some of the differences between SMR designs and previously licensed reactors in SECY-11-0181, such as the following:

- Reduced size and quantity of components and equipment to be disposed
- Reduced area to be decontaminated (depending on the number of modules)
- Possible difficulty with accessibility for decontamination because of the small size of the components
- Possible difficulties related to the decommissioning of modules while other modules are in operation (Reference 5.9-1)

SECY-11-0181 also acknowledges the expected differences between the SMRs and large LWRs would lead to differences in the cost of decommissioning a nuclear facility.

5.9.2 Conclusions

Projected physical facility inventories associated with SMR designs are expected to be less than those for currently operating nuclear reactors due to advances in technology, the smaller size of SMR reactor facility footprints, and simplified maintenance regimes for SMRs. Based on this comparison, Tennessee Valley Authority (TVA) has concluded that the environmental impacts identified in the Decommissioning GEIS are bounding for an SMR facility constructed and operated at the CRN Site. TVA has not identified any significant new information during this environmental review that would indicate the potential for decommissioning impacts not previously reviewed. Therefore, TVA does not anticipate adverse effects from the decommissioning process for the SMRs at the CRN Site and the impact would be SMALL.

5.9.3 References

Reference 5.9-1. Johnson, Michael R., "Policy Issue Information," SECY-11-0181, December 22, 2011.

5.10 MEASURES AND CONTROLS TO LIMIT ADVERSE IMPACTS DURING OPERATION

This section summarizes the principal adverse environmental impacts of operations and controls to limit these impacts. The cause-and-effect relationships between operational environmental disturbances and the corresponding affected environmental receptors/resources are presented in Table 5.10-1. The horizontal axis on the matrix represents the principal environmental disturbances and the vertical axis depicts the environmental receptors or resources that could be affected by those disturbances. Table 5.10-1 also summarizes feasible measures and controls that have been identified for mitigating operational impacts.

The significance indicators provided in Table 5.10-1 are designated using the following descriptors: SMALL (S), MODERATE (M), or LARGE (L). The significance indicators are defined in Section 5.0. The assignment of significance levels (S, M, and L) is based on the assumption that for each impact, corresponding feasible and adequate measures and controls (or equivalents) are implemented. If a SMALL (S) significance determination is made without the implementation of measures and controls, then no additional measures and controls are identified in Table 5.10-1. A blank cell in the elements column, “Potential Environmental Disturbances and Impact Levels," denotes “no impact” of that type on the environmental resource. Each “Impact Description or Activity” attribute is assigned a number and each “Feasible and Adequate Measures and Controls” attribute is assigned a number in parenthesis that corresponds to the respective “Impact Description or Activity.”

The feasible and adequate measures and controls described in Table 5.10-1 are considered reasonable from a practical, engineering, and economic view; many are based on statutes and regulatory requirements or are generally accepted practices within the utility industry. Therefore, these measures and controls are not expected to present an undue hardship on the applicant. Based on a review of the operational impacts described in this chapter, some general feasible and adequate measures and controls for reducing adverse impacts at the Clinch River Nuclear (CRN) Site include:

- An environmental safety and health plan has been prepared and is followed.
- Operational employees receive appropriate training on environmental compliance and safety procedures.
- Safety data sheets are required for applicable hazardous materials at the CRN Site. Operational employees are trained on the appropriate use of hazardous materials.
- Hazardous materials are used in accordance with applicable federal, state, and local laws and regulations and Tennessee Valley Authority (TVA) procedures.
- Hazardous wastes are treated, stored, and disposed of in accordance with the Resource Conservation and Recovery Act (RCRA), and other applicable federal, state, and local laws and regulations and TVA procedures. Operational employees are trained on the appropriate handling and disposal of hazardous wastes.

- As appropriate, a safety/environmental officer oversees and inspects operational activities.
- Operational activities are performed in accordance with applicable local, state, and federal ordinances, laws, and regulations and TVA procedures intended to prevent or minimize adverse environmental effects of operational activities on air, water, and land, and on plants, animals, workers and the public.
- Operational activities comply with applicable environmental laws, regulations, permits, and licenses, which place controls on how activities are performed.
- Operational activities are performed in compliance with applicable corporate environmental, safety, and operational procedures, which place controls on how activities are performed.

More specific mitigation measures are detailed in Table 5.10-1.

Table 5.10-1 (Sheet 1 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.1 Land Use Impacts															
5.1.1 The Site and Vicinity							S		S					1. Restriction of use of the land for most purposes other than those involving siting of utility projects. 2. Offsite disposal of waste.	(1) Land already designated for plant operations. (1) Limit disturbance of vegetation to the area within the site designated for CRN Site construction. (1-2) Minimize potential impacts through best management practices (BMPs) and TVA procedures. (2) Disposal of waste in accordance with applicable regulations and TVA procedures.
5.1.2 Transmission Corridors and Offsite Areas							S		S					1. Project implementation restricts use of land for most purposes other than those involving utility right-of-way (ROW) activities. 2. Continued impact to land from maintenance of the existing transmission line ROWs.	(1) To the extent feasible, avoid any additional disturbances of land in ROWs. (1-2) Inspect vegetation within and adjacent to ROW on a regular basis to assist in planning corrective and routine maintenance in accordance with TVA's "A Guide for Environmental Protection and Best Management Practices for TVA Transmission Construction and Maintenance Activities." (2) Limit continued vegetation removal to the minimal amount needed to support the transmission line ROW.
5.1.3 Historic Properties							S							1. Potential to adversely affect historic and archaeological properties in areas of ground disturbance and maintenance.	(1) Conduct operations in compliance with the Programmatic Agreement.

Table 5.10-1 (Sheet 2 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.2 Water Related Impacts															
5.2.1 Hydrological Alterations and Plant Water Supply		S				S								1. Minor localized influence from cooling water system. 2. Small adverse impact on hydrological characteristics of CRN Site. 3. Stormwater discharge into nearby water bodies.	(1) Design diffuser to meet the objectives of maximizing thermal and chemical mixing while minimizing scour and hydrologic modifications. (2) Incorporate the hydrologic function of Stream S01 (displaced by cooling system intake) in conveying stormwater from the CRN Site into the stormwater management system for the CRN Site. (3) Manage stormwater in accordance with a site-specific Integrated Pollution Prevention Plan.
5.2.2 Water Use Impacts						S		S		S	S	S		1. Water loss primarily as a result of evaporative loses and drift from cooling towers 2. Effects to water users, including biota, from discharge of blowdown with small quantities of water treatment chemicals and other liquid effluents into reservoir.	(1) Design cooling towers to limit drift and evaporative water loss. (1) Control water availability through TVA's reservoir operating policy and construction of the Melton Hill dam by-pass. (2) Limit wastewater discharges and comply with Tennessee Department of Environment and Conservation (TDEC) National Pollutant Discharge Elimination System (NPDES) permit. (2) Minimize potential of hazardous materials/waste spills or releases through training and rigorous compliance with RCRA and applicable regulations and TVA procedures.

Table 5.10-1 (Sheet 3 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels: Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor	Impact Description or Activity	Feasible and Adequate Measures and Controls
5.3 Cooling System Impacts															
5.3.1 Intake System		S				S		S		S				1. Hydrodynamic force induced by intake system near the intake structure. 2. Some fish killed by impingement and entrainment. 3. Minor aquatic impact resulting from consumption of water from the Clinch River arm of the Watts Bar Reservoir.	(1) To the extent practical, design pumps, machinery, and screens to reduce hydrodynamic impacts. (2) Minimize withdrawals with closed-loop cooling cycle and reduce impingement and entrainment with low through-screen velocity at intake. (2) Minimize impingement and entrainment of organisms through compliance with Section 316(b) of the Clean Water Act (CWA) (implemented by the NPDES permit). (3) Design cooling water system to minimize water losses and reduce intake flows.
5.3.2 Discharge System		S			S	S				S		S		1. Small localized increase in surface water temperature from thermal plume resulting from water discharged to the reservoir. 2 Small impact on aquatic organisms from potential minor erosion or sedimentation near the discharge point. 3. Minor impact on aquatic organisms from thermal plume. 4. Small impact on aquatic organisms from small turbidity effect near the discharge structure.	(1) Compliance with state water quality standards and TVA procedures associated with thermal discharges. (1,3) Minimize the thermal discharge to the Clinch River arm of the Watts Bar Reservoir with closed loop cooling system. (2) To the extent practical, employ and position discharge structure so as to reduce erosion/sedimentation effects on aquatic organisms. (4) To the extent practical, design and position discharge structure so as to reduce turbidity effects on aquatic organisms.

Table 5.10-1 (Sheet 4 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.3.2 Discharge System (continued)														5. Small impact on benthic organisms from small amount of bottom scouring near the discharge structure. 6. Discharges of chemicals in blowdown water.	(5) To the extent practical, design and position discharge structure so as to reduce scouring effects on benthic organisms. (6) Monitor chemical concentrations to comply with the Biocide/Corrosion Treatment Plan submitted as part of the application for a TDEC NPDES permit.
5.3.3 Heat-Discharge System	S		S	S			S	S					S	1. Water vapor plume in the atmosphere from cooling towers release. 2. Contamination of soil from small amounts of waste salts and other chemicals from cooling towers in the atmosphere (drift deposition). 3. Minor increase in humidity in the CRN Site vicinity from cooling towers. 4. Minor impact on humans and terrestrial organisms from cloud shadowing. 5. Consumption of water from the reservoir due to cooling towers drift and evaporative losses. 6. Obscuring of view by water vapor plume. 7. Minor effect on wildlife near the cooling towers from operating noise.	(1) To the extent practical, design cooling towers using Best Available Technology to reduce evaporative losses and noise.

Table 5.10-1 (Sheet 5 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.3.4 Impacts to Members of the Public	S		S	S							S		S	1. Small increase in the background noise level from heat dissipation system. 2. Small impact to humans from increased humidity, vapor, and mineral emissions from the cooling towers. 3. Small cumulative socioeconomic impact on the surrounding region from evaporative and drift water loss. 4. Obscuring of view by water vapor plume. 5. Growth of etiologic agents (including organisms formerly referred to as thermophilic microorganisms) in the water cooling system.	(1) To the extent practical, use pumps and machinery that reduce noise levels. (2) Treat cooling water to reduce salt and mineral impurities. (3 and 4) Design cooling towers to reduce evaporative and drift water loses. (3) If necessary, initiate a water conservation program. (5) Periodically monitor and test water for etiologic agents (thermophilic microorganisms) according to programs such as the Centers for Disease Control’s Surveillance for Waterborne-Disease Outbreaks—United States.
5.4 Radiological Impacts of Normal Operations															
5.4.1 Exposure Pathways			S		S	S						S		1. Releases of radionuclides in gaseous effluents. 2. Releases of radionuclides in liquid effluents. 3. Exposure of humans to direct radiation and radioactive effluents.	(1-5) Doses from planned releases of radiation less than the limits prescribed under Title 10 of the Code of Federal Regulations (10 CFR) 20.1301and Title 40 of the Code of Federal Regulations (40 CFR) 190. (1-5) Implement a Radiological Environmental Monitoring Program to monitor specified exposure pathways. (1-5) Minimize effluent discharges in accordance with applicable regulations.

Table 5.10-1 (Sheet 6 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.4 Radiological Impacts of Normal Operations															
5.4.1 Exposure Pathways (continued)														4. Exposure of terrestrial species and habitats to direct radiation and radioactive effluents. 5. Exposure of aquatic species and habitats to direct radiation and radioactive effluents.	
5.4.2 Radiation Dose Modeling														NA	NA
5.4.3 Impacts to Members of the Public			S		S	S	S					S		1. Small incremental radiation dose to members of the public from the small modular reactors. 2. Radiation doses to members of the public from breathing, swimming, eating, drinking water, and contact with contaminated soil.	(1-2) Measure radiation doses to the public from liquid effluent releases to the reservoir and gaseous releases to the atmosphere. Calculated doses to the public are within the design objectives of 10 CFR 50 Appendix I and within regulatory limits of 40 CFR 190. (1-2) Implement a Radiological Environmental Monitoring Program to monitor specified exposure pathways. (1-2) Releases of radiation within regulatory limits. Calculated doses to the public are within the design objectives of 10 CFR 50 Appendix I and within regulatory limits of 40 CFR 190.

Table 5.10-1 (Sheet 7 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.4.4 Impacts to Biota other than Members of the Public			S		S	S			S	S		S		1. Radiation doses to biota via breathing, direct contact with contaminated water or soil, and ingestion.	(1) Although there are no acceptance criteria specifically for biota, there is no scientific evidence that chronic doses below 100 mrad/day are harmful to plants or animals. Calculated biota doses are less than 0.1 mrad/day. (1) As appropriate, erect barriers to restrict access to contaminated soil or water. (1) Monitor organisms to determine exposure to radiation.
5.5 Environmental Impacts of Waste															
5.5.1 Nonradioactive-Waste-System Impacts			S		S	S	S		S	S				1. Discharge of relatively low concentrations of hazardous nonradioactive emissions and effluents to the air, reservoir, and soil column as part of routine operations. 2. Generation and disposal of hazardous nonradioactive waste (e.g., waste paints, solvents, etc.) in licensed hazardous waste landfills. 3. Generation and disposal of nonhazardous waste (e.g., concrete, scrap metal, etc.) in licensed landfills.	(1) Release hazardous air emissions according to limits imposed by the Clean Air Act (CAA) Amendments of 1977, as amended, 41 USC 7401 et seq, the CAA regulations (40 CFR 50-99), and TVA procedures. (1) Release hazardous water effluents according to limits imposed by the CWA/Federal Water Pollution Control Act (FWPCA) and NPDES program and permit requirements, and TVA procedures. (2) Manage, treat, and dispose of hazardous waste according to RCRA regulations and TVA procedures. (1 and 2) Carefully monitor hazardous waste.

Table 5.10-1 (Sheet 8 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.5.1 Nonradioactive-Waste-System Impacts (continued)														4. Effluent and stormwater discharge. 5. Air emissions from equipment.	(3) Generate and dispose of nonhazardous nonradioactive waste according to applicable local, state, and federal regulations, including the Solid Waste Disposal Act, as amended, 42 U.S. Code (USC) 6901 et seq., and 40 CFR 261, *Identification and Listing of Hazardous Waste*, and TVA procedures. (1-3) Perform inspections for compliance with applicable waste management laws and regulations and TVA procedures. (1-3) As appropriate, train employees to follow applicable procedures and waste regulations.
5.5.2 Mixed Waste Impacts			S		S	S	S					S		1. Discharge of mixed waste emissions and effluents to the air, reservoir, or soil column as part of routine operations. 2. Disposal of mixed waste in licensed mixed waste landfills. 3. Potential chemical hazard and occupational exposure to radiological materials during handling and storage.	(1) Manage and release hazardous air constituents in accordance with the CAA regulations (40 CFR 50-99) and TVA procedures. (1) Manage and release hazardous water constituents in accordance with the CWA and TVA procedures. (1-3) Manage, treat, and dispose of hazardous waste constituents according to RCRA regulations, and TVA procedures. (1-3) Manage and dispose of radioactive constituents according to applicable regulations and TVA procedures. (1-3) As appropriate, train employees to follow applicable waste management procedures and regulations and TVA procedures.

Table 5.10-1 (Sheet 9 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.5.2 Mixed Waste Impacts (continued)															(1-3) Carefully monitor mixed waste. (1-3) Perform inspections for compliance with applicable waste management laws and regulations and TVA procedures. (1-3) Limit mixed waste generation through source reduction, recycling, and treatment options. (1-3) Develop and follow a waste management plan. (1-3) Develop and follow a waste minimization plan to reduces the amount of waste that is generated. (1-3) Adopt as low as reasonably achievable program and train employees on implementation of this program, as appropriate.
5.6 Transmission System Impacts															
5.6.1 Terrestrial Ecosystems									S					1. Impact on terrestrial ecology from continued maintenance involving clearing of vegetation along the existing ROWs. 2. Potential for some erosion following vegetative clearing and/or excavation operations. 3. Application of herbicides. 4. Operation of noisy equipment that produce air emissions.	(1-5) Minimize potential impacts through compliance with permitting requirements, BMPs, and TVA procedures. (1-2) As appropriate, train employees on how to perform work in a manner that reduces adverse environmental impacts; to the extent feasible, avoid any additional disturbances to sensitive terrestrial or wetland habitats/species. (1, 3) Identify sensitive areas requiring restrictions on types of vegetation maintenance.

Table 5.10-1 (Sheet 10 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.6.1 Terrestrial Ecosystems (continued)															(2) As practical, reseed cleared areas to limit erosion using non-invasive species/native plants, per TVA procedures. (3) Use licensed operators to apply herbicides. (3) Comply with the TDEC General Permit for Pesticide Discharges (includes herbicides) (4) As practical, use noise suppression/mufflers on vehicles/machinery and maintain vehicles to reduce emissions.
5.6.2 Aquatic Ecosystems		S			S	S	S			S				1. Impact on aquatic biota from continued maintenance involving clearing of vegetation along ROWs near water bodies. 2. Potential for some erosion and subsequent runoff of sediment into water bodies. 3. Migration of herbicides into water bodies. 4. Potential discharge or spills of herbicides that pollute the aquatic ecosystem.	(1-4) Minimize potential impacts through compliance with permitting requirements, BMPs, and TVA procedures. (1-4) Identify Streamside Management Zones requiring restrictions on the type of vegetation management activities performed. (1) To the extent feasible, avoid any additional disturbances to sensitive aquatic habitats/species. (2) As practical, reseed cleared areas to limit erosion using non-invasive species/native plants, per TVA procedures. (3) Use licensed operators to apply herbicides. (3) Comply with the TDEC General Permit for Pesticide Discharges (includes herbicides). (4) As appropriate, train employees on herbicides procedures to minimize the risk of spills or discharges.

Table 5.10-1 (Sheet 11 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.6.3 Impacts to Members of the Public	S			S			S			S			S	1. Effects on humans from noise from vehicles and equipment operated near inhabited or residential areas. 2. Potential electromagnetic fields effects of underground transmission line. 3. Potential for electric shock. 4. Continued aesthetics effects from maintenance of the transmission line ROW.	(1-4) Minimize potential impacts through compliance with permitting requirements, BMPs, and TVA procedures. (1) Minimize night and weekend maintenance operations to reduce noise impacts. (2) Use mitigation measures to decrease the electromagnetic fields related to the underground transmission line. (3) Maintain vertical clearance from the ground for overhead transmission lines and safety procedures to prevent direct contact with underground transmission line.
5.7 Uranium Fuel Cycle Impacts															
5.7.1 Uranium Fuel Cycle Impacts			S	S	S	S	S	S				S		1. Commitment of land for uranium processing facilities. 2. Consumption of cooling water during uranium oxide (UO_2) fuel fabrication. 3. Electrical energy used to power uranium processing facilities. 4. Management of hazardous and radioactive air emissions and effluents from the gaseous diffusion plant. 5. Management of hazardous, mixed, and radioactive waste.	(1) Construct plant according the BMPs. (3) As feasible, use energy efficient equipment/processes and introduce energy conservation program. (4) Discharge air emissions per CAA regulations (40 CFR 50-99). (4) Discharge water effluents per CWA/FWPCA and NPDES permit specifications. (4) Incorporate best available pollution control technology. (4) Treat and monitor emissions and effluents. (5) Manage hazardous constituents according to RCRA regulations.

Table 5.10-1 (Sheet 12 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.7.1 Uranium Fuel Cycle Impacts (continued)														6. Occupational radioactive dose to workers. 7. Transportation dose to workers and public. 8. Management of waste from operations, decontamination and decommissioning. Note: The Activities in this column and the Measures and Controls in the next column apply to operations and facilities that are not under the control of TVA.	(5) Manage radioactive constituents according to applicable regulations. (5) Implement waste minimization plan. (2, 5) Consider use of a more efficient enrichment technology. (3, 4, and 5) Consider centrifuge process over gaseous diffusion process that could significantly reduce energy requirements and environmental impacts. (3, 4, and 5) Consider use of new technologies with less fuel loading to reduce emissions, energy, and water usage. (6-7) As appropriate, monitor and train employees in radiation procedures/regulations pursuant to 10 CFR 20, 40 CFR 190, and 10 CFR 20.1301. (8) Prepare a detailed decontamination and decommissioning plan.
5.7.2 Transportation of Radioactive Materials												S		1. Occupational and public exposures to radioactive materials from incident-free transportation.	(1) Minimize shipments of unirradiated fuel, irradiated fuel, and radioactive waste (maximize packaging/shipping efficiency). (1) Maximize plant efficiency (reduce fuel needs). (1) Implement waste minimization procedures.

Table 5.10-1 (Sheet 13 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.8 Socioeconomic Impacts															
5.8.1 Physical Impacts of Station Operation	S		S				S						S	1. Potential episodic and limited noise impacts to workers and nearby residents. 2. Effects on humans from air pollutant and thermal emissions.	(1) As appropriate, train and appropriately protect workers to reduce the risk of potential exposure to noise. (1) Tests of emergency warning sirens with advance notification to the public. (2) Operate air emissions sources, and monitor release of air emissions, in accordance with state and federal regulations, air permit requirements and TVA procedures. (2) Include efficient drift eliminators to minimize drift emissions from cooling towers. (2) Manage thermal discharge from cooling water system in accordance with requirements of TDEC NPDES permit and TVA procedures.
5.8.2 Social and Economic Impacts of Station Operation				S							S		S	1. Traffic congestion impacts in the vicinity of the CRN Site due to operations traffic. 2. Potential ability of infrastructure and schools to accommodate influx of residents and students without additional facilities, services, or teachers. 3. Beneficial impact on economy and tax revenue.	(1) Offset operational and refueling event impacts to level of service for these roads by constructing the roadway improvements designed to accommodate the larger traffic volumes associated with construction traffic. (2) Offset demand associated with increased population with increased revenue from property taxes and sales taxes on workforce expenditures. (3) Maintain public access to boat ramps. (3) Maintain water quality so as not to impact fishing.

Table 5.10-1 (Sheet 14 of 14)
Summary of Measures and Controls to Limit Adverse Operational Impacts

Environmental Resources (Section Reference)	Potential Environmental Disturbances and Impact Levels													Impact Description or Activity	Feasible and Adequate Measures and Controls
	Noise	Erosion/Sedimentation	Air Disturbance/ Emissions	Traffic	Hazardous Materials/ Wastes	Surface and Ground Water	Land-Use/Disturbances	Water Use Consumption	Terrestrial Disturbances	Aquatic Disturbances	Socioeconomic Changes	Rad Exposure	Aesthetics/Dust/Odor		
5.8.2 Social and Economic Impacts of Station Operation (continued)														4. Limitation of recreational activities (i.e., fishing, boating, hunting, etc.) along the CRN Site shoreline.	
5.8.3 Environmental Justice Impacts	S		S	S			S	S			S			1. No disproportionately high adverse impacts to minority populations.	NA

Note:
NA = Not Applicable

5.11 CUMULATIVE IMPACTS RELATED TO STATION OPERATION

Impacts associated with facility operations are discussed in Chapter 5. Section 5.11 contains a summary of potential cumulative environmental impacts associated with operation of the Clinch River (CR) Small Modular Reactor (SMR) Project. The term cumulative impact is defined in the regulations of the Council on Environmental Quality (CEQ) implementing the National Environmental Policy Act (NEPA) (Title 40 of the Code of Federal Regulations [40 CFR] 1508.7) as follows:

> "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

The purpose of this section is to identify federal, state, local or other activities within the CR SMR Project region that could have cumulative impacts in conjunction with the proposed action. Potential impacts would include measurable changes to the analyzed resources which would not occur if the CR SMR Project were not constructed.

The geographic areas considered for the cumulative impacts of the CR SMR Project operations phase are the same as the resource based geographic areas of interest provided in Section 4.7. As indicated in Section 3.9, operation of the first SMR is projected to commence in early 2026. At that time, additional SMRs would still be under construction. Full operation of all SMR units of the facility is projected to begin in mid-2027.

For the purposes of this cumulative impacts assessment, the operational phase is considered separately from the construction phase, essentially assuming construction is complete and the CR SMR Project is fully operational. Cumulative impacts of CR SMR Project operations when added to other past, present, or reasonably foreseeable future actions are discussed below.

5.11.1 Past, Present, and Reasonably Foreseeable Future Projects

A summary of past, present, and reasonably foreseeable projects that could have a cumulative effect upon the geographic area of interest are provided in Section 4.7, Table 4.7-1. The table includes activities on the Oak Ridge Reservation (ORR), local industrial development, highway improvements, aviation projects, Tennessee Valley Authority's (TVA) generation projects (nuclear, fossil, and hydro), and local infrastructure improvements. The geographic areas of interest for each analyzed resource, as defined in Section 4.7 and Section 5.11, are provided in Table 5.11-1.

5.11.2 Cumulative Land Use Impacts

Subsection 4.7.2 summarizes the geographic and temporal scope of the cumulative analysis; the cumulative impacts associated with the past, present, and reasonably foreseeable future

projects on land use; and the incremental contribution of preconstruction and construction activities to those cumulative impacts. This subsection addresses the incremental contribution of SMR operation to those cumulative impacts.

As discussed in Subsection 4.7.2, much of the Clinch River Nuclear (CRN) Site peninsula was under preparatory activities for the Clinch River Nuclear Breeder Reactor Project (CRBRP) in 1982 and 1983. CRBRP preparations ceased in 1983. The site was stabilized, major excavations backfilled, and vegetation planted. Planned use of this previously changed area by the proposed CRN SMR Project is consistent with the broader land use of the CRBRP; thus minimizing land use changes and the impact from the proposed CRN SMR Project.

As discussed in Section 5.1, impacts of the operation of the SMRs on land use and prime farmlands at the CRN Site and in the vicinity would be SMALL. Although project construction would permanently impact land use and soils on the CRN Site and in the Barge/Traffic Area, there would be no further impacts as a result of CR SMR Project operations.

Subsections 5.5.1.2 and 5.5.2 discuss the potential impacts from land disposal of nonradioactive wastes along with management and disposal of hazardous and mixed wastes. While sanitary wastewaters are to be discharged to the City of Oak Ridge Public Works Department, nonradioactive wastes are to be disposed offsite in state-approved sanitary landfills such as the Chestnut Ridge Sanitary Landfill, a Class I Municipal Solid Waste Facility located on the Anderson Knox county line adjacent to I-75. As discussed in Subsection 4.7.2, the Chestnut Ridge Landfill has a 50 year (yr) capacity to accept 1000 tons per day. Hazardous wastes would be managed by a TVA-approved vendor and disposed in accordance with TVA management procedures. The amount of waste would be minimized through TVA waste management programs and the impact would be SMALL.

Cumulative impacts from land-based disposal of nonradiological wastes are primarily a function of land availability. Because TVA would follow hazardous waste management and minimization practices, the facility is anticipated to be rated a Small Quantity Generator of Hazardous Wastes as defined by 40 CFR Part 262 and the operational volume of hazardous waste generated and disposed would be less than 1000 kilograms, or less than one metric ton (MT), per month. As discussed in Subsection 4.7.2, the volume of hazardous and mixed waste generated and disposed in the immediate vicinity of the CRN Site in 2014 included contributions from the Oak Ridge Reservation and exceeded 81 MT; therefore, the incremental increase of hazardous waste disposal associated with the CRN Site would be SMALL.

Past and present projects listed in Table 4.7-1 have cumulatively impacted land use throughout the region. As discussed in Subsection 4.7.2, spurred by the Manhattan Project, land use in the region of interest changed rapidly in the mid-20th century with the designation of large federal land holdings and the development of various hydroelectric dams, transportation routes, and manufacturing facilities. The cumulative impact of these projects has been MODERATE. In addition, continuing development and anticipated projects within the region, as listed in Table 4.7-1, continue to be influenced by the presence of the large federal land holdings in the area;

thus providing a persistent, MODERATE impact on land use. Foreseeable future impacts to land use include continued development of the Roane Regional Business and Technology Park, continued property transfer on the East Tennessee Technology Park (ETTP), planned construction and operation of the Sludge Build-Out Project, the construction and operation of the new Uranium Processing Facility at Y-12, continued operation of the High Flux Isotope Reactor at the Oak Ridge National Laboratory (ORNL), continued operation of the Spallation Neutron Source at ORNL, and planned Tennessee Department of Transportation (TDOT) roadway improvements in the area. Although the land use cumulative impact of foreseeable future products is MODERATE, impacts of the CR SMR Project operations on land use would be SMALL and their cumulative contribution to the overall impact would also be SMALL.

5.11.3 Cumulative Water Impacts

This subsection addresses the cumulative water use and water quality impacts from the proposed CR SMR Project on the CRN Site along with past, present, and reasonably foreseeable future projects. Section 2.3 describes the surface water and groundwater affected by the proposed CR SMR Project at the CRN Site. Section 5.2 describes impacts to hydrology, water use, and water quality during operational activities at the CRN Site. Cumulative impacts are presented separately for hydrology, water use, and water quality.

5.11.3.1 Surface Water Hydrology Impacts

Subsection 4.7.3.1 summarizes the cumulative impacts associated with the past, present, and reasonably foreseeable future projects, including global climate change, on surface water hydrology; and the incremental contribution of preconstruction and construction activities to those cumulative impacts. The geographic area of interest for cumulative surface water hydrology impacts is the watershed for the Watts Bar Reservoir. This subsection addresses the incremental contribution of SMR operation to those cumulative impacts.

Subsection 5.2.1.2.1 describes impacts to surface water hydrology during operation of the SMRs. As discussed in that subsection, impacts from the operation of the SMRs on water flow and pool levels in Watts Bar Reservoir would be SMALL. Although project construction would permanently impact one perennial stream and six ephemeral streams/wet-weather conveyances (WWCs), there would be no further impacts to these features as a result of operations. The hydrologic function of these features in conveying stormwater from the CRN Site would be incorporated into the stormwater management system used during operations. Given the small size of these features, permanent removal would not result in substantial hydrological impacts.

As discussed in Subsection 4.7.3.1, past and present projects listed in Table 4.7-1 have cumulatively impacted perennial streams and WWCs throughout the region. These impacts have occurred through the disturbance of the land area associated with each project, occupation of the original land area by a new facility or feature, and changes in the intensity and duration of precipitation as a result of global climate change. The largest cumulative impacts to perennial streams and WWCs likely resulted from the development of land area associated with

agriculture, urban development, industrial development of the ORR, and development of the reservoirs operated by TVA. As a result, the total number and area of perennial streams and WWCs in the region has been reduced, and the impact of these cumulative projects has been MODERATE. During construction of the SMRs, the number and area of perennial streams and WWCs would be further reduced, adding incrementally to the cumulative impact.

As discussed in Subsection 5.2.1.2.1, project operation would not result in further impacts to surface water hydrology. Therefore, the incremental contribution from operations activities on surface water hydrology within the geographic area of interest would be SMALL.

5.11.3.2 Water Use Impacts

Cumulative water-use impacts are presented separately for surface water and groundwater.

5.11.3.2.1 Surface Water Use Impacts

Subsection 4.7.3.2.1 summarizes the cumulative impacts associated with the past, present, and reasonably foreseeable future projects, including global climate change, on surface water flows and availability; and the incremental contribution of preconstruction and construction activities to those cumulative impacts. The geographic area of interest for surface water use impacts is the seven-county area (Anderson, Knox, Loudon, Meigs, Morgan, Rhea, and Roane counties) surrounding the CRN Site. Although water use within the drainage basin of the Tennessee River both upstream and downstream of the CRN Site can affect the availability of surface water throughout the entire basin, the potential for the CR SMR Project to contribute to such impacts is expected to be highest in close proximity to the CRN Site, and to decrease substantially with distance from the Site. Generally, when impacts from a project within a local area are SMALL to none, it is expected that there would be no cumulative impacts greater than SMALL in the remainder of the geographic area of interest. This subsection addresses the incremental contribution of SMR operation to those cumulative impacts.

Subsection 5.2.1.2.1 describes impacts to surface water hydrology during operation of the SMRs, and Subsection 5.2.2.1.1 describes impacts to surface water availability during operation of the SMRs. As discussed in those subsections, the SMRs would withdraw surface water for cooling and other purposes, and some of the water withdrawn would be consumed through evaporation and drift. The analysis conducted demonstrated that, in the most conservative scenario, with a maximum water withdrawal rate of 30,708 gallons per minute (gpm) and a minimum daily average release of 400 cubic feet per second (cfs; 179,520 gpm) from Melton Hill Dam, the facility would withdraw approximately 17 percent of the daily average flow in the portion of the reservoir adjacent to the CRN Site, and approximately 7 percent of the daily average flow would be consumed. These estimates are expected to be conservative, as they are based only on the surface water that enters the reservoir through Melton Hill Dam, and does not include the much larger volume of water that enters the reservoir through Fort Loudoun Dam. As a result, the expected maximum consumptive use of water at the CRN site is considered to be inconsequential compared to the combined average conveyances from Melton

Hill Dam and Fort Loudoun Dam, and the hydrologic impacts of SMR operations on the overall flow and surface water availability in Watts Bar Reservoir would be SMALL

As discussed in Subsection 4.7.3.2.1, past, present, and reasonably foreseeable future projects, combined with the additional potential for a decrease in surface water availability due to global climate change, have resulted in SMALL cumulative impacts on surface water availability. Surface water uses for municipal, agricultural, and industrial purposes, including many of the projects listed in Table 4.7-1, remove surface water from the geographic area of interest, resulting in adverse impacts to surface water availability. The baseline data presented for surface water use in Subsection 2.3.2.1 represents the cumulative effect of all past and present projects within the geographic area of interest on surface water use. In addition, because the analysis included projections of water use to the year 2035, it incorporates reasonably foreseeable water uses. The estimates used to develop the reservoir operating policy included a total withdrawal of 13,990 million gallons per day (mgd) with a return of 13,010 mgd resulting in a net water demand of 980 mgd. As discussed in Subsection 2.3.2.1.1, the net water demand in the geographic area of interest in 2010 was 471 mgd, or 3.9 percent of the total withdrawals. The current watershed projection of water demand to 2035 indicates a total withdrawal of 9449 mgd with a return of 8737 mgd resulting in a net water demand of 712 mgd. (Reference 5.11-1) Therefore, both the current and projected future water demands are within the limits established for the reservoir operating policy, and cumulative impacts to surface water uses from past, present, and reasonably foreseeable future projects are SMALL.

TVA's management of the dam and reservoir system stores excess surface water for use during periods of low precipitation. While this action does not increase the amount of surface water in the system, it does provide a beneficial impact on surface water availability by making water available during periods of low precipitation, except for periods of extreme drought.

As discussed in Subsection 5.2.2.1.1, the proposed SMR withdraws an average of 26 mgd (44 mgd maximum), which would increase the current projected total withdrawal within the Tennessee River Watershed to 9475 mgd (9493 mgd maximum). The proposed SMR withdrawal represents approximately 0.27 percent (0.46 percent maximum) of the current projected total withdrawal within the Tennessee River Watershed. The average and maximum net water use is 18 mgd, increasing the estimated projected net water demand to 730 mgd within the watershed and to 44 mgd for the Clinch River arm of the Watts Bar Reservoir upstream of the CRN Site. With the addition of the water use from SMR operation to the cumulative water use from other past, present, and reasonably foreseeable future projects, the cumulative water use is still well within the estimates that were used in the development of TVA's reservoir operation system policy. Although operation of the SMRs would remove surface water from the system, the small amount that would be removed, as compared to the total amount available and the total amount projected to be needed for future use, show that the additional incremental cumulative impact would be SMALL.

5.11.3.2.2 Groundwater Use Impacts

Section 2.3 describes the groundwater affected by the proposed SMR Project at the CRN Site. In general, groundwater at the CRN Site recharges through precipitation and discharges to the Clinch River.

Subsections 5.2.1.2.2 and 5.2.2.1.2 describe impacts to groundwater use during normal operation of the proposed project at the CRN Site. There are no planned uses for groundwater during operational activities. Potable water is to be supplied to the CRN Site by the City of Oak Ridge. No new areas would be disturbed during anticipated operation and maintenance activities of the proposed CR SMR Project. Additional dewatering activities during operations and maintenance are anticipated to be smaller than preconstruction and construction dewatering activities. Therefore, it was concluded that impacts to groundwater use during normal operation of the proposed project at the CRN Site would be SMALL.

This cumulative analysis considers impacts from operation and maintenance activities along with impacts from past, present, and reasonably foreseeable actions that may contribute to cumulative impacts to groundwater use within the geographic area of interest, the area most likely to be affected by the proposed CR SMR Project. For the purposes of this cumulative impact analysis, the geographic area of interest for groundwater use impacts is the Lower Clinch River Watershed from Melton Hill Reservoir down to the confluence of the Clinch, Emory, and Tennessee Rivers.

Groundwater use and availability are linked to water quality. As discussed in Subsection 2.3.3.2.2.2, groundwater contaminants from previous operations in the Lower Clinch River Watershed include radionuclides, volatile organic compounds (VOCs), and metals (arsenic, barium, and cadmium). Also discussed in Subsection 2.3.3.2.2.2, legacy contaminants from operations at the ORR include groundwater contaminant plumes with VOCs, metals, and radionuclides. As a result of these contaminant plumes, groundwater availability is curtailed both now and in the foreseeable future. Although current and future activities within the region would follow federal, state, and local regulations and guidelines, thus minimizing impacts to the groundwater system, the cumulative impact to groundwater use from past activities in the region is MODERATE, and the incremental impact from the CRN SMR Project would be SMALL.

In addition, the increasing probability of intense drought periods followed by intense precipitation events predicted by many of the climate change models may result in less permeable soils and thus less infiltration and recharge of the groundwater system. Further, these resultant changes to the groundwater system may favor different flow patterns; thus possibly changing contaminant transport through the groundwater system and thereby changing water availability for use. Although readily abundant surface water is expected to remain the chosen water source for the foreseeable future, changes in the utility of the groundwater may stress the water cycle system. However, because there are no planned uses for groundwater during CR SMR Project operations, the incremental additional cumulative impact associated with groundwater use would be SMALL.

5.11.3.3 Water Quality Impacts

Cumulative water-quality impacts are presented separately for surface water and groundwater.

5.11.3.3.1 Surface Water Quality Impacts

Subsection 4.7.3.3.1 summarizes the cumulative impacts associated with the past, present, and reasonably foreseeable future projects, including global climate change, on surface water quality; and the incremental contribution of preconstruction and construction activities to those cumulative impacts. The geographic area of interest for cumulative surface water quality impacts is the watershed for the Watts Bar Reservoir. Although projects within the drainage basin of the Tennessee River both upstream and downstream of the CRN Site can affect surface water quality throughout the entire basin, the potential for the CR SMR Project to contribute to such impacts is expected to be highest in close proximity to the CRN Site, and to decrease substantially with distance from the Site. Generally, when impacts from a project within a local area are SMALL to none, it is expected that there would be no cumulative impacts greater than SMALL in the remainder of the geographic area of interest. This subsection addresses the incremental contribution of SMR operation to those cumulative impacts.

Subsection 5.2.2.2 describes impacts to surface water quality during operation of the SMRs. As discussed in that subsection, the facility's wastewater discharges would be regulated by the Tennessee Department of Environment and Conservation (TDEC) through a National Pollution Discharge Elimination System (NPDES) permit, and temperatures and chemical concentrations for discharges would be in compliance with the terms and conditions of the Site's NPDES permit. In the most conservative scenario, the maximum facility discharge represents about 10 percent of the reservoir flow past the facility when the maximum discharge occurs coincidentally with the minimum daily average release from Melton Hill Dam. Because the characteristics and constituents of the facility discharge are proposed to be managed within the water quality criteria specified in the facility NPDES permit, and the volume of the discharge is small relative to the overall flow in the reservoir, the impact of facility operation on surface water quality would be SMALL.

Subsection 2.3.3.1 presents surface water quality results from a variety of sources, including studies of the U.S. Geological Survey in the Upper Tennessee River Basin, the TDEC 303(d) list, TVA's Reservoir Ecological Health Program, TVA's Site Preparation Monitoring Program, and TVA's Biological Monitoring Program. These studies provide a baseline for surface water and sediment quality based on analyses which occurred from 1994 to 2015, and therefore effectively represent the cumulative impact of all past and present projects. Impacts to surface water and sediment quality as a result of industry, mining, agriculture, urbanization, and toxic spills and releases have been identified. Surface water quality impacts include elevated bacteria, nutrients, and herbicides as a result of agriculture; elevated concentrations of polychlorinated biphenyls (PCBs), dioxin, and mercury in water, and semivolatile organic compounds in sediment, due to industrial sources and coal mining; and the presence of mercury, PCBs, and cesium-137 in sediment, as a result of past operations at the ORR. Global

climate change also may adversely affect surface water quality in the future as increasing air and water temperatures, more intense precipitation and runoff, and intensifying droughts can result in increases in sediment, nitrogen, and other pollutant loads (Reference 5.11-2). In addition, TVA's operation of the dam and reservoir system has had a beneficial impact on water quality, by managing water flows to increase aeration and dilute industrial discharges.

Although water quality impacts from past and present projects have been documented, surface water quality in the Upper Tennessee River Basin usually meets existing guidelines for drinking water, recreation, and the protection of aquatic life (Reference 5.11-3). Sample results from the Site Preparation Monitoring Program for the Clinch River arm of the Watts Bar Reservoir upstream and downstream of the CRN Site indicate that TDEC's most stringent numeric criteria are being met and that site runoff (should it occur) would not have a significant impact to water quality (Reference 5.11-4). The discharge limits in the CRN Site's NPDES permit would be developed by TDEC to ensure that surface water quality continues to meet existing guidelines. Given that operational discharges would be managed in accordance with the permit limits established by TDEC, they would be unlikely to combine with the effects of past and present projects in a manner which would result in exceedance of existing guidelines. Therefore, the incremental contribution of SMR operation on surface water quality would be SMALL.

5.11.3.3.2 Groundwater Quality Impacts

Section 2.3 describes the groundwater affected by the proposed SMR project at the CRN Site. In general, groundwater at the CRN Site recharges through precipitation with periodic recharge from the Clinch River arm of the Watts Bar Reservoir during high water stages.

Subsection 5.2.2.1.2 describes impacts to the groundwater during operation of the proposed CR SMR Project. Because groundwater would not be used for safety-related or for non-safety-related water supply purposes during anticipated operation and maintenance activities of the proposed CR SMR Project, impacts to groundwater quality would be SMALL.

This cumulative analysis considers impacts from routine operation and maintenance activities along with impacts from past, present, and reasonably foreseeable actions that may contribute to cumulative impacts to the quality of groundwater within the geographic area of interest, the area most likely to be affected by the proposed CR SMR Project. The geographic area of interest for cumulative impacts to the quality of groundwater is the Lower Clinch River Watershed from Melton Hill Reservoir down to the confluence of the Clinch, Emory, and Tennessee Rivers near Kingston; the same as the groundwater use geographic area of interest.

Subsection 2.3.3.2.2.2, discusses the baseline groundwater sampling for the CRN Site. Legacy radionuclides strontium-90, tritium, and technetium-99 were detected along with legacy metals arsenic, barium, cadmium, and chromium at the CRN Site. No mercury or uranium was detected at the CRN Site.

As discussed in Subsection 2.3.3.2.2.2, legacy contamination from operations at the ORR has resulted in contaminated groundwater plumes in areas of the Reservation. Contaminant plumes on ORR include VOCs along with cesium-137, strontium-90, and tritium at the ORNL along with uranium, nitrate, and mercury at Y-12. Plumes at the ETTP also include chromium-6 and technetium-99. In addition, the regularly maintained and monitored fenced complex of White Oak Dam and its 25 acre lake continue to settle legacy ORNL contaminants into the sediment; thus contributing to cumulative impacts to groundwater.

Further, legacy groundwater contamination from the American Nuclear Corporation includes cobalt-60 and cesium-137. And groundwater contamination at the former Anderson County Landfill includes radionuclides and VOCs along with arsenic, beryllium, and cadmium. These legacy sites may potentially impact the groundwater in the Clinch River watershed.

In addition to these legacy contaminants possibly contributing to cumulative impacts to groundwater quality during normal operations and maintenance activities for the proposed project at the CRN Site, anticipated climate change may also contribute to groundwater quality impacts. As mentioned in Subsection 4.7.3.2.2, the increased incidence of both drought and flooding events predicted by some of the models would reduce the amount of infiltration recharging the groundwater system and thus possibly changing the favored flow patterns. These changes may include changes in contaminant transport through the groundwater system and may include induction of flow beneath the Clinch River; thus changing water quality in the geographic area of interest.

Past and present projects listed in Table 4.7-1 and discussed above have cumulatively impacted the groundwater within the geographic area of interest. The cumulative impact of these projects has been MODERATE. In addition, although modern practices are anticipated to minimize impacts to groundwater quality from future projects; thus making their projected incremental impact SMALL, lingering impacts from legacy contaminants are anticipated to continue providing a MODERATE impact to future groundwater quality in the region. However, given that the impact of project operation on groundwater would be SMALL, the cumulative contribution from SMR operations to the overall impact on groundwater would also be SMALL.

5.11.4 Cumulative Ecological Impacts

This subsection describes the cumulative impacts on terrestrial and aquatic ecological resources that may result from operation of the proposed CR SMR Project at the CRN Site. The analysis considers these impacts in conjunction with other past, present, and reasonably foreseeable future activities within the geographic areas of interest for these resources. Subsection 4.7.4 discusses the geographic and temporal aspects of the cumulative analysis of ecological impacts; the cumulative impacts from relevant projects and activities, including global climate change, on ecological resources; and the incremental contribution of preconstruction and construction activities to those cumulative impacts. This subsection addresses the incremental contribution to those cumulative impacts from operation of the CR SMR Project. Terrestrial and aquatic ecology impacts are discussed separately below.

5.11.4.1 Terrestrial Ecology and Wetlands Impacts

Subsection 2.4.1 describes the terrestrial ecology resources, including wetlands, potentially affected by the proposed SMR Project at the CRN Site and provides the baseline for analysis of cumulative impacts to terrestrial ecology. Subsection 5.3.3.2 describes impacts to terrestrial ecosystems from operation of the system for discharging heat to the atmosphere at the CRN Site, and Subsection 5.6.1 describes impacts to terrestrial ecosystems from operation of the 69-kilovolt (kV) underground transmission line to be installed within an approximately 5-mile (mi) segment of an existing, 500-kV transmission line right-of-way (ROW). For the purposes of this cumulative analysis of SMR operation on terrestrial ecology, the geographic area of interest is defined as the area within approximately a 6-mi radius of the CRN Site. This area encompasses the CRN Site and associated offsite areas (Barge/Traffic Area and underground transmission line), and it is expected to encompass those other projects potentially capable of interacting with the CR SMR Project during its operation to affect terrestrial ecological resources.

Table 4.7-1 identifies the past, present, and reasonably foreseeable projects and facilities considered in the cumulative impacts analysis. Eleven of these are within the geographic area of interest for cumulative impacts on terrestrial ecology. Five of these projects may involve construction activities that potentially could affect terrestrial ecological resources relevant to those affected by the CR SMR Project. These include the following projects: transfer of property on the ETTP to private companies, which could subsequently construct facilities on the ETTP; the Roane Regional Business and Technology Park, where sites could be developed; and three roadway improvement projects by the TDOT on Tennessee State Highway (TN) 95 and TN 73. These five projects could involve localized land clearing and earth moving activities, but these activities would not noticeably contribute to cumulative effects on terrestrial habitats or wetlands also affected by the operation of the proposed CR SMR Project at the CRN Site. The other six projects in the geographic area of interest involve operations at existing facilities and would not measurably contribute to cumulative impacts in conjunction with effects from the operation of the CR SMR Project. The Sludge Buildout Project and the CVMR Corporation relocation would occur in already developed areas; the ORNL and its associated Spallation Neutron Source and High Flux Isotope Reactor have been in operation for many years and would not contribute cumulatively to operational impacts from the CR SMR Project; and the ongoing operation of the Melton Hill Hydroelectric Facility would not have terrestrial impacts. Thus, none of these facilities within the geographic area of interest are likely to have effects on terrestrial ecological resources that would be relevant to the effects from operation of the CR SMR Project.

The terrestrial ecosystems at the CRN Site that could be affected by operation of the SMR system for discharging heat to the atmosphere are described in Subsection 2.4.1. Heat dissipation systems at nuclear power facilities potentially can impact terrestrial ecological communities through effects such as those evaluated and discussed in Subsection 5.3.3.1 (salt deposition; increased precipitation, humidity, fogging, and icing; and plume shading), as well as noise and bird collisions with cooling towers. In Subsection 5.3.3.2, the impacts on terrestrial ecological resources from effects potentially associated with the operation of the CR SMR Project were determined to be very localized and minor. Thus, the incremental contribution of

the CR SMR Project to related, cumulative effects from other facilities or activities in the geographic area of interest would be SMALL.

Other electric generating facilities in the region have associated transmission lines that are part of the regional transmission system to which the CR SMR Project would connect. The operation and maintenance of these lines would have similar effects on terrestrial ecological resources in and adjacent to the transmission line ROWs. As discussed in Subsection 5.6.1, TVA has approved methods in place to protect terrestrial habitats from potential adverse effects associated with ongoing transmission line ROW maintenance activities in conjunction with operation of the CR SMR Project. Potential thermal and Electromagnetic Fields (EMF) effects of the proposed underground transmission line on terrestrial habitats are predicted to be negligible. It is expected that the transmission lines associated with the other facilities in the geographic area of interest would continue to be operated and maintained similarly. As discussed in Subsection 4.7.4.1, extensive areas of relatively unfragmented and undisturbed forest habitat exist in the geographic area of interest and the region. The cumulative impacts on terrestrial ecosystems from the operation and maintenance of transmission lines within the relatively small areas of the ROWs in the geographic area of interest would be minimal, and the incremental contribution from the lines associated with the CR SMR Project would be SMALL.

Subsections 4.7.1.2 and 4.7.4 discusses the potential effects of global climate change on terrestrial ecosystems in the southeastern United States, including Tennessee and the region that surrounds the CRN Site. Operation of the CR SMR Project is expected to provide beneficial effects with regard to global climate change by providing needed electricity without the release of carbon dioxide. The magnitude of incremental contributions to adverse cumulative impacts on climate change in the geographic area of interest during the period in which the facility is in operation would be SMALL.

In summary, as discussed in Subsection 4.7.4.1, cumulative impacts on terrestrial ecological resources from past and present activities in the geographic area of interest have occurred, and have been MODERATE. This assessment considered impacts on terrestrial communities from factors such as the operation of the SMR system for discharging heat to the atmosphere, transmission line operation, and global climate change. Based on this analysis, the cumulative impacts on terrestrial ecological resources in the geographic area of interest from past, present, and reasonably foreseeable future actions, including operation of the proposed CR SMR Project on the CRN Site, would also be MODERATE. However, the incremental contribution from operation of the CR SMR Project to these cumulative impacts on terrestrial ecology within the geographic area of interest would be SMALL.

5.11.4.2 Aquatic Ecology Impacts

Subsection 2.4.2 describes the aquatic ecology resources potentially affected by the proposed SMR Project at the CRN Site and provides the baseline for analysis of cumulative impacts to aquatic ecology. Subsection 4.3.2 describes impacts to aquatic ecosystems during preconstruction and construction activities at the CRN Site, on the offsite Barge/Traffic Area,

and within the off-site, 500-kV transmission line ROW in which an underground 69-kV transmission line is to be installed.

The geographic area of interest for this analysis of cumulative impacts on aquatic ecological resources is defined as the CRN Site, Barge/Traffic Area, and underground 69-kV transmission line area; and the Clinch River arm of the Watts Bar Reservoir in the vicinity of the CRN Site. This geographic area of interest encompasses drainages associated with the CRN Site and associated offsite areas where ecological effects from the operation of the CR SMR Project would occur. It also includes the limited area within the Clinch River arm of the Watts Bar Reservoir that may be affected by operation of the CR SMR Project as well as other facilities or activities capable of having effects that could interact with the facility to cumulatively impact aquatic ecological resources. This portion of the Clinch River arm of the Watts Bar Reservoir in the vicinity of the site generally includes the area of the reservoir downstream to the confluence with the Emory River arm of the Watts Bar Reservoir and upstream to Melton Hill Dam (approximately Clinch River Mile 5 to 23). The potential for the CR SMR Project to contribute to such impacts is expected to be highest in close proximity to the CRN Site and to decrease substantially with distance away from the CRN Site.

Past uses of the CRN Site and the Clinch River arm of the Watts Bar Reservoir in its vicinity have had cumulative effects on the aquatic ecology of the geographic area of interest. As discussed in Subsection 4.7.1.2, past dam and reservoir projects to regulate the Tennessee River system have substantially altered the natural flow regime of the Tennessee River and its tributaries, including the Clinch River. The Tennessee River system is described in Subsection 4.7.3.2.1. Because the dams and their associated water users have been affecting surface water flow rates since before 1979, the baseline surface water flow conditions described in Subsection 2.3.1.1.2.1 and the ecological community described in Subsection 2.4.2.1.1 represent the cumulative effects from the ongoing operation of the dams in the system on surface water flow in the Clinch River arm of the Watts Bar Reservoir. In addition, because the Reservoir Operations Study included long-range planning for operation of the system to the year 2030, the analysis also represents reasonably foreseeable flow conditions that may contribute to cumulative impacts on aquatic ecology during future operation of the CR SMR Project.

As discussed in Subsection 4.7.4.2, the cumulative effects of the system of dams and reservoirs on surface water flow in the Tennessee River system has had a LARGE impact on the aquatic community that historically existed in formerly free-flowing riverine ecosystems. These impacts, including reductions in nongame fish species and reduced mussel diversity and abundance, are reflected in present conditions in the Clinch River arm of the Watts Bar Reservoir and are expected to continue in the foreseeable future. The evaluation of surface water use in Subsection 5.11.3.2.1 indicates that the maximum consumptive use of water due to operation of the CR SMR Project is expected to be inconsequential compared to the combined average releases from Melton Hill Dam and Fort Loudoun Dam, and the hydrologic impacts of SMR operations on the overall flow and availability of surface water in the Clinch River arm of the Watts Bar Reservoir would be minimal. In addition, the volume of water that would be discharged from the facility during operation would be small relative to the overall flow in the

reservoir. Accordingly, the incremental contribution from the operation of the CR SMR Project to cumulative impacts on surface water flow and aquatic habitats in the geographic area of interest would be SMALL.

Surface water and substrate characteristics (such as flow, water depth and temperature, levels of oxygen and contaminants, and sediment composition) are preponderant factors affecting aquatic habitats and the aquatic organisms they support. The impact of facility operation on surface water quality and sediment composition would be SMALL because the characteristics and constituents of the discharge from operation of the CR SMR Project would be maintained within the water quality criteria specified in the NPDES permit. These criteria have been established to prevent constituents in surface water from exceeding concentrations that would adversely affect aquatic life. Limitations on constituent concentrations entering surface water would concomitantly limit the potential for concentrations in sediment to increase from the settling of suspended particles with adsorbed constituents.

As discussed in Subsection 5.3.2.2, the thermal plume from the discharge would be localized within the area of the discharge and would not extend far enough downstream to have cumulative effects in conjunction with discharges from other facilities. As discussed in Subsection 5.3.2.1, the results of hydrothermal modeling of the discharge indicate that, for steady flow in the reservoir at or above 400 cfs, the thermal effluent from the CR SMR Project could be assimilated within regulatory limits at a minimum distance of 50 feet (ft) from the diffuser. There are no other facilities or projects within the geographic area of interest that would impact this limited area of the reservoir in which surface water temperatures would be elevated. Modeling performed at a regional scale to evaluate the discharge in the context of the full extent of Watts Bar Reservoir showed that the discharge would have a negligible (SMALL) impact on temperature (outside of the local area of the mixing zone), algae, and dissolved oxygen in the reservoir. Effects on these parameters from the discharge were predicted not to be detectable. Thus, the incremental contribution from the operation of the CR SMR Project to cumulative impacts on surface water and sediment quality, water temperature, and aquatic habitats in the geographic area of interest would be SMALL.

The results of the analysis in Subsection 5.3.1.2 of effects from the operation of the cooling water intake system on the aquatic community of the Clinch River arm of the Watts Bar Reservoir are consistent with the conclusion by the U.S. Nuclear Regulatory Commission (NRC) that the effects of entrainment on aquatic organisms at nuclear facilities with a closed-cycle, cooling-tower-based heat dissipation system are minor. Based on the use of closed-cycle cooling, the small proportion of water that would be withdrawn, the expected design and location of the intake, and the composition of the aquatic community, the impacts from entrainment, impingement, or other effects on fish and other organisms due to the operation of the cooling water intake system for the CR SMR Project would be minimal. No other water intakes with the potential to cause entrainment or impingement of aquatic organisms are present in or planned for the geographic area of interest. Therefore, the incremental contribution from the operation of the CR SMR Project to cumulative impacts on aquatic organism populations due to mortality from operation of water intakes in the geographic area of interest would be SMALL.

As discussed in Subsection 5.6.2, TVA routinely implements measures to minimize potential adverse effects on aquatic habitats from ongoing transmission line ROW maintenance activities. Potential thermal and EMF effects of the proposed underground transmission line on aquatic habitats are expected to be very localized and minor. Therefore, the incremental contribution to cumulative impacts on aquatic ecosystems from the operation and maintenance of transmission lines would be SMALL.

As discussed for terrestrial ecology in Subsection 4.7.1.2, global climate change may affect temperatures and the timing and magnitude of precipitation; in turn, these changes may have cumulative impacts on aquatic ecological resources. Climate change in the southeastern United States generally is expected to cause relatively small changes in precipitation compared to natural variation. However, predictions of the magnitude and extent of the changes vary. Global climate models have not been used to make predictions at the scale of the State of Tennessee, but regional studies indicate temperatures and rainfall may increase in the southeastern United States. Climate models forecast three trends that may affect aquatic habitats: warmer mean annual temperatures, greater frequency of intense rainfall events, and drier summers with more severe droughts. Such changes may affect water levels and flows in Tennessee reservoirs through increased evaporation. Increases in temperatures and the intensity of storms may affect reservoir water levels and flows. This higher climate variability may result in less predictable management of reservoir hydrology, with resulting effects on fish habitat, abundance, community composition, and population dynamics. (Reference 5.11-5) The effects from operation of the CR SMR Project on surface water flow and aquatic habitats and organisms in the geographic area of interest would be SMALL, and the incremental contribution to adverse aquatic impacts from operation of the CR SMR Project in conjunction with global climate change also would be SMALL. Furthermore, operation of the CR SMR Project is expected to provide beneficial effects with regard to global climate change by providing needed electricity without the release of carbon dioxide.

In summary, as discussed in Subsection 4.7.4.2, cumulative impacts on ecological resources from past and present activities in the geographic area of interest have occurred, and are SMALL to LARGE. This assessment considered impacts on aquatic communities from factors such as the direct effects of operation of the CR SMR Project on aquatic organisms and habitats, consumptive water use, regulation of water levels and flows by dams, operation of other commercial and industrial facilities in the geographic area of interest, and other natural and anthropogenic stressors, including climate change. This assessment indicates that cumulative impacts from past, present, and reasonably foreseeable future actions on aquatic resources in the geographic area of interest would also range from SMALL to LARGE. However, the incremental contribution from operation of the CR SMR Project to impacts on aquatic resources of the water bodies in the geographic area of interest would be SMALL.

5.11.5 Cumulative Socioeconomics and Environmental Justice Impacts

The following subsections describe the evaluation of cumulative impacts on socioeconomics and environmental justice that may result from operation of the proposed CR SMR Project at the CRN Site.

5.11.5.1 Socioeconomic Impacts

Socioeconomic resources addressed in this subsection include physical impacts (air quality, noise, thermal emissions, and visual intrusions) and social and economic impacts.

5.11.5.1.1 Physical Impacts

Sections 2.7 and 2.8 and Subsection 2.5.2.5.1 address air quality, noise, and visual resources, respectively, in the vicinity of the CRN Site and serve as the baseline for analysis of cumulative impacts to these resource areas. Subsection 5.8.1 describes the potential impacts from operation of the CR SMR Project on air quality and noise levels. The following discussions in this subsection address the cumulative impacts of emissions to the atmosphere, noise and visual resources. These discussions consider the incremental impact of the proposed project along with impacts from past, present, and reasonably foreseeable actions that may contribute the project's geographic area of interest.

Air Quality

Subsection 2.7.2 describes current air quality conditions for Roane County in which the CR SMR Project would be located. Air quality emissions and potential impacts during operations of the CR SMR Project are addressed in Subsection 5.8.1.2.

As discussed in Subsection 2.7.2, the CRN Site location in Roane County is in attainment for all criteria pollutants, indicating pollutant levels are below air quality standards. As identified in 40 CFR 81.57, Roane County is located in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region. Based on preliminary design information of the CR SMR Project and attainment status of Roane and surrounding counties, the CR SMR Project's air related geographic area of interest during operations, for criteria pollutants, is expected to fall within Roane County and the surrounding counties of Loudon, Knox, Anderson, and Morgan. Once an SMR design is selected, air quality modeling under the Tennessee air permitting process would detail the project's air quality geographic area of interest in the context of other nearby sources. Because the project's supporting equipment, which emits criteria pollutants, would be operated infrequently and for limited periods of time, it is expected the project's modeling impact area would be within 10 mi. The area out to 10 mi would include Roane County and portions of Loudon, Knox, Anderson and Morgan counties, Tennessee. Also, even though the project area is in attainment of all criteria pollutants, the surrounding nonattainment areas may need to be considered during air permitting. As noted in Subsection 2.7.2, the surrounding counties of Loudon, Knox, Anderson and Blount, along with Census Block Group 47-145-0307-2 in Roane County, are nonattainment for particulate matter with a diameter of 2.5 micrometers or less

($PM_{2.5}$). Once the project design is selected and vendor data are provided to support more detailed air quality analysis, the geographic area of interest would be refined as necessary, at the combined license application (COLA) stage.

Subsection 4.7.5.1.1 addresses air quality related cumulative impacts associated the with the preconstruction and construction phases of the CR SMR Project. Air related impacts from emissions of criteria pollutants and greenhouse gases were considered for construction workforce motor vehicles, deliveries to the site, earth moving, and construction equipment. Emissions from these sources, however, would be temporary and mitigated under a construction related mitigation plan.

Subsection 5.8.1.2 provides preliminary estimates of the project's operational air emissions. Generation of electricity associated with the operation of two or more SMRs would not be a source of criteria pollutants or air toxics emissions. Supporting equipment such as cooling towers, emergency diesel generators, auxiliary boilers, standby power gas turbines, and other combustion sources emit criteria pollutants and air toxics. Emission estimates from fossil fuel fired combustion sources indicate the project's emissions would not exceed the "major source" threshold of 250 tons per year for any pollutant. Further, supporting equipment would be used intermittently, thus limiting emissions from these sources.

Motor vehicle emissions would be emitted during the workforce commute, ongoing site maintenance and improvements work, and also from deliveries to the CRN Site. Air impacts from motor vehicle activity during facility operations, as noted in Subsection 5.8.1.2, are expected to be minimal because: (1) mitigation measures would be implemented to reduce vehicular emissions as necessary (measures could include staggered shift times, requiring delivery vehicles to shut down engines during off-loading, restricting idling times of onsite vehicles, use of electric and hybrid vehicles, and supporting and promoting van/carpooling and other commuter programs), (2) with recommended transportation improvements, level of service at the local intersections would be adequate to mitigate vehicle queuing and improve flow through these intersections, (3) emissions from the workforce are not continuous throughout the day and are primarily limited to the hours during which shift changes occur, and (4) the project is currently located in attainment areas for carbon monoxide (CO), particulate matter (PM), nitrogen oxide (NO_x), and ozone (O_3), which are the primary criteria pollutants of concern for motor vehicles.

Table 4.7-1 includes proposed projects and ongoing construction projects that could potentially impact air quality in the CR SMR Project's geographic area of interest. For a cumulative impact assessment, existing major sources must also be identified. Table 5.11-2 provides a list of major sources under the Title V Operating Permit program (40 CFR 70) for Roane, Anderson, Knox, Loudon, and Morgan counties.

Through the state and federal air permitting process, proposed power projects must obtain a permit to construct. In addition, under this process, proposed projects must demonstrate that air quality impacts would not violate state and federal ambient air quality standards. Once a vendor

for the project is selected and the technology is defined, the TDEC would be contacted to address air quality permitting and cumulative air quality modeling with other sources, as necessary. The air permitting process, under the authority of the U.S. Environmental Protection Agency (EPA) and TDEC, and the state's air monitoring program are designed to protect against a project causing air quality violations. State and federal air permitting also ensures cumulative impacts from existing and proposed new sources would comply with the Clean Air Act and state air pollution regulations. The details of discussions with the TDEC and required cumulative air quality modeling would be provided at COLA.

Since supporting equipment combusting fossil fuels would have limited use and because of the regulatory oversight and control required under state and federal air regulations, the project's air quality impacts are expected to be SMALL for criteria pollutants.

Because climate change is global in nature and currently focuses on the policies established by national governing agencies, the project's geographic area of interest for greenhouse gases (GHG) needs to be considered in the context of United States policy and national GHG emissions. Further, individual states are developing GHG regulations, thus consideration of GHG emissions under state regulations would in all likelihood also be necessary. Therefore, for GHG emissions, the project's operations geographic area of interest is national (United States) in scale.

In 1992, the United States signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC). Under the UNFCCC agreement, the EPA tracks and periodically publishes GHG emissions. In EPA's recent April 15, 2015 report entitled *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013* (EPA-430-R-15-004), the EPA estimates the United States annual GHG emissions for 2013 were 6673 million metric tons (MMT). (Reference 5.11-6) For the State of Tennessee, the EPA provides a 2012 estimate of 99.91 MMT of carbon dioxide (CO_2) for fossil fuel combustion (Reference 5.11-7). As stated in Subsection 4.7.5.1.1, the State of Tennessee GHG emissions are estimated as 122 MMT of GHGs using a GHG to CO_2 scaling factor of 1.22. (This scaling factor is based on EPA's April 15, 2015 report and national data provided for the year 2012 for the various GHGs.)

Similar to criteria pollutants, project specific GHG emission projections would not be available until a vendor is selected for the project. As noted in Subsection 5.8.1.2, the Nuclear Energy Institute (NEI) provides life cycle (from construction to decommissioning) GHG emission factors for different energy technologies. For nuclear power plants, NEI provides a GHG emission factor of 13 tons per gigawatt-hour. (Reference 5.11-8) A second report provided by the World Nuclear Association provides similar values to NEI, along with an upper value of 30 grams CO2 per kilowatt-hour (33 tons per gigawatt-hour) for a life cycle assuming the processing of low grade uranium ores (Reference 5.11-9). Using this upper value as a worst case CO_2 emission factor, a maximum rating for the CR SMR Project at 800 megawatts (MW), and assuming that the majority of CO_2 emissions over the life time of the facility are associated with operations and the processing of fuel, an annual average CO_2 emissions rate of 210,240 MT per year was

determined. Using the same GHG to CO_2 ratio of 1.22, from above, worst case annual GHG emissions during facility operations would be 256,500 MT per year or 0.2565 MMT per year.

Estimated worst case annual GHG emissions from the CR SMR Project (0.2565 MMT per year) are only a small fraction of national (6673 MMT for 2013) and State of Tennessee (122 MMT for 2012) GHG emissions. Because GHG emissions and associated impacts require a global perspective, small incremental changes from individual projects must be evaluated collectively. This is beyond the scope of an individual project and is, therefore, addressed by the United States under the authority of the EPA at the national scale. Mitigation measures, however, provide individual projects with the ability to minimize GHG emissions. Generally, measures to alleviate emissions of criteria pollutants from fossil fuel-fired equipment, would likewise reduce GHG emissions. Although, cumulative GHG impacts are expected to be MODERATE in the geographic area of interest, the incremental addition of the CR SMR Project's emissions are estimated to be SMALL.

Noise

Ambient noise levels at sensitive receptors site within 5 mi of the CRN Site are described in Section 2.8. This discussion provides a baseline for analysis of cumulative impacts on sensitive receptors. As discussed in Subsection 5.8.1.1, the main source of continuous noise at the CRN Site is associated with the mechanical draft cooling towers. The geographic area of interest for noise includes the CRN Site and the areas within 5 mi of the CRN Site. Based on the projected noise levels at the nearest residence, noise impacts from operations at the CRN Site are expected to be SMALL for the surrounding communities and the nearest residents. The transmission lines that serve the CR SMR Project are already operating and it is expected that the noise levels they produce would continue to be acceptable, and the planned underground transmission line would not generate audible noise during operations. Accordingly, the effect of transmission lines on noise would be SMALL. As discussed in Subsection 4.7.5.1.1, 12 of the proposed projects, ongoing construction projects, and operational facilities in the region around Oak Ridge, Tennessee are located within 5 mi of the CRN Site. The closest noise-generating projects or facilities are approximately 3 mi from the CRN Site. Due to the distance, the potential for cumulative impact on noise levels associated with these projects and facilities in conjunction with noise levels generated by operations at the CRN Site would be SMALL.

Thermal Emissions

As discussed in Subsection 5.8.1.3, thermal plumes are released from the CR SMR Project's cooling towers to both the ambient air and back to the Clinch River arm of the Watts Bar Reservoir. The analysis in that subsection determined that there would be no fogging or icing at any distance from the cooling towers and the effects of salt deposition would be limited to the area within 600 meters (m) of the cooling towers. The effects of cooling tower operation on local residents and the public in the surrounding area from precipitation, humidity, fogging or icing, and salt deposition would be SMALL. The geographic area of interest for cumulative impact analysis of thermal discharges to air includes the CRN Site and the areas within 1 mi of the

CRN Site. The past, present, or reasonably foreseeable projects or actions identified within 1 mi of the CRN Site include the industrial facilities within Roane Regional Business and Technology Park. This industrial park is geared toward light to medium industry and could potentially contribute thermal plumes from industrial operations, rather than cooling water use, which would be on a smaller scale than plumes from the CR SMR Project. The incremental contribution of cooling tower thermal emissions, which are localized to within 600 m of the towers, in combination with other nearby sources of thermal plumes to the atmosphere would be SMALL. Therefore, cumulative impacts related to thermal emissions from cooling tower operations to ambient air would be SMALL.

Because the thermal discharge to surface water from the CR SMR Project's cooling towers is managed in accordance with requirements of the TDEC NPDES permit, and the modeling indicates compliance with the thermal water quality criteria, physical effects of the thermal discharge on surface water as discussed in Subsection 5.8.1.3 are considered to be negligible. Accordingly, impacts to the public and recreational users of the Clinch River arm of the Watts Bar Reservoir would be SMALL. As described in Subsection 4.7.3.2.1, for purposes of this cumulative impact analysis, the geographic area of interest for surface water impacts is the Clinch River arm of the Watts Bar Reservoir. Although projects within the drainage basin of the Tennessee River both upstream and downstream of the CRN Site can affect the surface water temperatures throughout the entire basin, the potential for the CR SMR Project to contribute to such impacts on thermal water quality is expected to be highest in close proximity to the CRN Site, and to decrease substantially with distance from the CRN Site. As described in Subsection 5.11.3.2.1, cumulative impacts related to thermal water quality from operation of the CR SMR Project cooling tower discharge would be SMALL. Thus, the incremental contribution of the CR SMR Project to related, cumulative effects from other facilities or activities in the geographic area of interest would be SMALL.

Visual Intrusions

Subsection 2.5.2.5 describes the visual resources potentially affected by the proposed SMR Project at the CRN Site and provides the baseline for analysis of cumulative impacts to visual resources. For the purposes of this cumulative analysis, the geographic area of interest for visual resources includes the 2-mi radius surrounding the CR SMR Project. Subsection 5.8.1.4 evaluates the visual impacts of the CR SMR Project, through use of photographs of existing conditions at locations from which would be visible, and renderings of the tallest facility structures visible as well as the cooling tower plumes at those locations. The visual intrusion due to operation of the CR SMR Project would range from SMALL to MODERATE, due primarily to the visual effect of the plume. Within the 2-mi geographic area of interest, the past, present, and reasonably foreseeable projects and facilities considered in the cumulative impact analysis include industrial parks located approximately 2 mi north of the CRN Site (ETTP) and 0.5 mi south of the CRN Site (Roane Regional Business and Technology Park). These two facilities could potentially be visible from locations that have a view of the CR SMR Project. Accordingly, there would be the potential for SMALL to MODERATE cumulative impacts on visual resources associated with industrial development.

5.11.5.1.2 Social and Economic Impacts

Subsections 2.5.1 and 2.5.2 describe the social and economic characteristics potentially affected by the proposed CR SMR Project, including population, economy, transportation, taxes, land use, recreation, housing, community infrastructure and public services, and education. These discussions provide the baseline for analysis of cumulative impacts to these resource areas. As discussed in Subsection 4.7.5.1.2, cumulative impacts from preconstruction and construction activities at the CRN Site and from other past, present, and reasonably foreseeable future projects within the socioeconomic geographic area of interest could temporarily contribute to MODERATE cumulative effects on transportation. The cumulative economic impact on the geographic area of interest of construction of the CR SMR Project and other ongoing construction projects and reasonable foreseeable projects on employment, income, and taxes would be beneficial and MODERATE.

Subsection 5.8.2 evaluates the social and economic impacts of operations at the CRN Site. This evaluation concluded that impacts associated with operations at the CRN Site would be SMALL, and impacts to three resources would be SMALL and beneficial. Employment of the operations workforce and routine capital expenditures needed to support CR SMR Project operations over the period of operation would have a beneficial impact on the economy of the four-county geographic area of interest. Based on road improvements designed to accommodate the much larger construction workforce, the improved level of service resulting from those improvements would have a SMALL beneficial impact on intersections and local roads. Sales and property taxes as well as TVA tax-equivalent payments would have a SMALL and beneficial economic impact within the geographic area of interest.

This cumulative analysis considers impacts from operations along with impacts from past, present, and reasonably foreseeable future actions that may contribute to cumulative impacts to communities within the geographic area of interest, the area most likely to be affected by the proposed CR SMR Project. The geographic area of interest for socioeconomic impacts includes Roane, Anderson, Knox, and Loudon counties. The socioeconomic impacts associated with the operational facilities (past and present projects) listed in Table 4.7-1 have already been addressed in the baseline conditions presented in Subsections 2.5.1 and 2.5.2 and in the impact analysis presented in Subsection 5.8.2. This cumulative impacts evaluation focuses on reasonably foreseeable projects.

Cumulative impacts from operations at the CRN Site and from other reasonably foreseeable future projects within the socioeconomic geographic area of interest are not expected to contribute to cumulative effects on socioeconomic resources. There are 250 operations workers and 1000 temporary refueling outage workers who are assumed to relocate to the geographic area of interest for the proposed CR SMR Project. As discussed in Subsection 2.5.2, a total of 301,164 people were employed in the geographic area of interest in 2011; the total labor force was 325,167 people. From 2001 to 2011, the number of employed people in the geographic area of interest increased an average of 1.0 percent annually. The additional number of employees associated with the other reasonably foreseeable future projects, including

development within the Roane Regional Business and Technology Park and the ETTP, various projects within ORR, and relocation of CVMR Corporation, would represent a minor portion of the existing labor force in the geographic area of interest. Operations traffic associated with the CR SMR Project and other reasonably foreseeable future projects could slightly increase the commute time along local roadways, including Bear Creek Road, TN 58, and TN 95. However, the roadway improvements recommended to accommodate the peak construction year traffic for the CR SMR Project would also accommodate the operations staff traffic and traffic associated with the other reasonably foreseeable future projects located near the CRN Site. Accordingly, cumulative impacts on population, land use, recreation, housing, transportation, community infrastructure and public services, and education would be SMALL.

Increased employment, as well as new indirect service jobs created by the spending of the additional workers' income, would produce a positive effect on employment and income in the geographic area of interest. The other reasonably foreseeable future projects would similarly generate increased employment and income. Therefore, the cumulative economic impacts on the geographic area of interest from operation of the CR SMR Project and other reasonably foreseeable projects on employment, income, and taxes would be beneficial and MODERATE. Although the amount of income, sales, and property taxes (as well as TVA tax-equivalent payments) generated by the projects would be large in absolute terms, it would be SMALL when compared to the total amount of taxes collected within the geographic area of interest.

The effect of climate change on the economy would be evident in changes to water quality and availability. As discussed in Subsection 3.6.3.2, NPDES-managed nonradiological wastewater and stormwater discharges to the Clinch River Arm of Watts Bar Reservoir would result in SMALL impacts to the water. As discussed in Subsection 4.7.3.2.1, cumulative impacts include releases from industry, agriculture, and urbanization, thus making the impact to water SMALL to MODERATE. Coupled with anticipated climate change phenomena of increased severe storms and less regular precipitation leading to increased water pollution and reduced water availability, impacts upon the water could become more pronounced (Reference 5.11-2). Impacts to the economy become apparent as global changes in climate result in decreasing availability of food and water; thus negatively impacting water quality and availability through increased competition for more limited resources (Reference 5.11-2). Although cumulative impacts to the economy from projected climate change, with increased competition for limited resources, are expected to be MODERATE in the geographic area of interest, the incremental impact to water from nonradiological wastewater generated during operational activities at the CRN Site is estimated to be SMALL.

5.11.5.2 Environmental Justice Impacts

Executive Order 12898 (59 FR 7629) directs federal executive agencies to consider environmental justice under the NEPA. This Executive Order ensures that minority and/or low-income populations do not bear a disproportionate share of adverse health or environmental consequences of a proposed project.

Subsection 2.5.4 provides baseline information on minority and low-income populations within the region (i.e., within a 50-mi radius of the CRN Site) for the cumulative impacts assessment of environmental justice. As shown in Figure 2.5.4-1, the spatial distribution of block groups with minority populations in the region is clustered in the City of Knoxville, in Knox County, Tennessee and the City of Alcoa, in Blount County, Tennessee. No block groups in Roane County (in which the CRN Site is located) or in Anderson County contain minority populations as defined in Subsection 2.5.4.2. The identified aggregate minority population closest to the CRN Site is located approximately 20 mi to the east in Blount County, Tennessee. The closest Hispanic minority population is located in Loudon County, Tennessee, approximately 9 mi southeast of the CRN Site. As shown in Figure 2.5.4-2, the majority of the low-income population in the geographic area of interest is in the City of Knoxville, in Knox County, Tennessee. There is one low-income population block group within Roane County, Tennessee and one within Anderson County, Tennessee. The closest low-income population block group is located in Loudon County, Tennessee, approximately 7 mi southeast of the CRN Site. No other populations or groups (e.g., subsistence populations) were identified that represent environmental justice populations in the region.

Subsections 4.7.5.2 and 5.8.3 evaluate the potential environmental justice impacts from preconstruction and construction activities and from operations at the CRN Site, respectively. Because of the spatial distribution of the minority and low income populations across the region, the potential for disproportional impacts to low-income and minority populations from operations activities is SMALL. No uniquely vulnerable low-income or minority community, such as a subsistence population, was identified in the region. In summary, the overall SMALL impact of the CR SMR Project, combined with the spatial distribution of the low-income and minority population, results in a SMALL potential for adverse socioeconomic impacts that would disproportionately affect low-income and minority communities.

The cumulative analysis considers impacts from operations of the CR SMR Project along with past, present, and reasonably foreseeable actions that could cause disproportionately high and adverse impacts on minority and low-income populations. The geographic area of interest for environmental justice impacts is the area within 50 mi of the CRN Site. The environmental justice analysis presented in Subsection 5.8.3 provides a baseline comparison for consideration of cumulative environmental justice impacts associated with the projects and activities listed in Table 4.7-1. The spatial distribution of block groups with minority and low-income populations in the geographic area of interest is clustered in the City of Knoxville, in Knox County, Tennessee. The reasonably forseeable projects identified in Table 4.7-1 are in locations other than Knoxville, and would be expected to have a SMALL impact on minority or low-income populations. The incremental additional impacts from future projects in combination with operations activities at the CRN Site would be SMALL.

In summary, there would be no disproportionately high or adverse cumulative impacts to minority or low-income populations within the 50-mi geographic area of interest. Therefore, there would be no cumulative environmental justice effects and the impacts would be SMALL.

5.11.6 Cumulative Historic Properties Impacts

Subsection 4.7.5.3 summarizes the geographic and temporal scope of the cumulative analysis. The geographic area of interest for analysis of cumulative impacts to historic properties includes:

- The archaeological resources and historic properties within the CR SMR Project Area of Potential Effect (APE) defined in Subsection 2.5.3 as the approximately 1305-ac area that includes the CRN Site and the Barge/Traffic Area
- The Historic Architectural APE is 0.50-mi radius surrounding the proposed cleared areas (Figure 2.5.3-1)
- The historic properties (those eligible for listing on the NRHP) within a 10-mi radius of the center of the CRN Site (Figure 2.5.3-2)

This section examines the cumulative impacts associated with the past, present, and reasonably foreseeable future projects, including global climate change, on historic and cultural resources; and the incremental contribution of preconstruction and construction activities to those cumulative impacts. This subsection addresses the incremental contribution of SMR operation to those cumulative impacts.

Section 5.1 describes impacts to historic and cultural resources during operation of the SMRs. As discussed in that section, impacts of the operation of the SMRs on historic and cultural resources at the CRN Site and in the vicinity would be SMALL. Although project construction could permanently impact historic and cultural resources on the CRN Site and in the Barge/Traffic Area, there would be no further impacts as a result of CR SMR Project operations.

As discussed in Subsection 4.7.3.1, global climate change is unlikely to have a substantial impact on historic and cultural resources, but past and present projects listed in Table 4.7-1 have cumulatively impacted historic and cultural resources throughout the region. Cultural resources are nonrenewable and therefore impacts are cumulative in nature. Some of these projects have resulted in the destruction, removal, and/or disturbance of historic and cultural resources within the geographic area of interest. Therefore, the cumulative impact of these projects has been MODERATE. However, given that the direct and indirect impacts of project operation on historic properties would be SMALL, their incremental cumulative contribution of SMR operations would also be SMALL.

Cumulative impacts from the CR SMR Project construction and operations must be considered in relation to other reasonably foreseeable future projects, including development within Roane Regional Business and Technology Park and the ETTP, various projects within ORR, and relocation of CVMR Corporation. Most of these projects are located within areas previously developed and therefore have a limited potential to impact historic properties within the geographic area of interest. Several of these projects are also located on federal land and would therefore be subject to Section 106 reviews to examine the potential for impacts to historic

properties. Therefore, cumulative impacts to historic properties in association with the CR SMR Project and these potential future projects would be SMALL.

5.11.7 Cumulative Impacts of Postulated Accidents

As described in Chapter 7, the potential environmental impacts (i.e., risks) of a postulated accident from the operation of CRN Site would be SMALL. Chapter 7 considers both design basis accidents (DBAs) and severe accidents. A detailed accident analysis is to be performed at COLA when the technology is chosen and the facility configuration is known.

Offsite doses are conservatively estimated using the highest post-accident dose from vendor analysis. As shown in Section 7.1, offsite doses due to postulated loss of coolant accidents (LOCA) are expected to have a greater magnitude than more common DBAs. A LOCA is therefore modeled as the bounding DBA for offsite atmospheric release for comparison against the 25 rem total effective dose equivalent limit specified in 10 CFR 52.17. As a result, the site is in compliance and the impact is SMALL.

Environmental impacts from severe accidents with damage to the reactor core and degradation of the containment system are evaluated in Section 7.2 using an SMR design that represents the largest SMR considered for the CRN Site. Reasonable, representative estimates are determined for the CRN Site using MACCS2 code with surrogate SMR specifications along with site-specific meteorology, population, land usage, watershed index, and economic data. Economic costs, including relocation, decontamination, and interdiction, were determined along with human health impacts for a severe accident for the population within a 50-mi radius of the CRN Site. The MACCS2 modeling provided dose from the air pathway and from water ingestion; other pathways were evaluated qualitatively. As discussed in Subsection 7.2.3, dose from the groundwater pathway is considered small or non-existent, dose from surface water recreation is smaller than dose from aquatic food ingestion, which is, in turn, smaller than dose from the air pathway. As discussed in Subsection 7.2.4, because the risk of cancer fatalities as determined using the surrogate’s total calculated dose risk from the air pathway is less than one-tenth of one percent of the overall probability of a cancer-related fatality, the site is in compliance and the health impact of postulated severe accidents is SMALL.

The cumulative analysis considers risk from potential severe accidents at other existing and proposed nuclear power plants that have the potential to increase risks at any location within the geographic area of interest of 50 mi of the proposed CRN Site. The 50-mi radius was selected to cover potential risk overlaps from two or more nuclear plants. Existing operating nuclear power plants that contribute to risk within this geographic area of interest include Watts Bar Unit 1 and Sequoyah Units 1 and 2. In addition, an operating license for Watts Bar Unit 2 has been issued by the NRC.

The ORR has been a participant in nuclear projects since World War II. ORNL, Y-12 National security Complex, The ETTP, and Transuranic (TRU) waste processing center (TWPC) are part of the reservation. High Flux Isotope Reactor (HFIR), an operating 85-megawatt thermal reactor

built for the production of californium and other heavy elements, is located within the boundaries of the adjoining ORNL. The Highly Enriched Uranium Materials Facility at the Y-12 National Security Complex is the nation's central repository for highly enriched uranium. A Uranium Processing Facility is expected to be a part of Y-12 at Oak Ridge. The ETTP used to be Oak Ridge Gaseous Diffusion Plant. Its original mission was to enrich uranium for the commercial nuclear industry from 1945 to 1985, and was permanently shut down in 1987. The U.S. Department of Energy (DOE) established the TWPC as a regional center for the management, treatment, packaging and shipment of DOE TRU waste legacy inventory.

This cumulative analysis considers impacts from postulated accidents for the proposed project at the CRN Site along with impacts from past, present, and reasonably foreseeable actions that may contribute to cumulative impacts within the geographic area of interest. Tables 7.2-5 and 7.2-6 in Section 7.2 provide comparisons of estimated risk for the proposed representative SMR at the CRN Site and the current nuclear power plants undergoing operating license renewal reviews. As provided in Tables 7.2-5 and 7.2-6, the estimated population dose risk for the representative SMR at the CRN Site is well below values for other reactor sites. In addition, estimates of average individual early fatality and latent cancer fatality risks are well below the NRC's safety goals set by the NRC's Safety Goal Policy Statement (51 FR 30028). For existing nuclear generating stations within the geographic area of interest (i.e., Watts Bar Unit 1 and Sequoyah Units 1 and 2) the NRC has determined that the probability-weighted consequences of severe accidents are SMALL (10 CFR Part 51, Appendix B, Table B-1). In NUREG-0498, *Final Environmental Statement: Related to the Operation of Watts Bar Nuclear Plant, Unit 2 - Final Report*, the NRC concluded that the probability-weighted environmental consequences of severe accidents for Watts Bar Unit 2 are SMALL. The HFIR reactor presents a much smaller severe accident risk than a representative SMR at the CRN Site because it has a much smaller reactor core and power level.

The severe-accident risk due to any particular nuclear power plant gets smaller as the distance from that plant increases. However, the combined risk at any location within 50 mi of the CRN Site would be bounded by the sum of risks for all these operating and proposed nuclear power plants and HFIR. Even though several plants could potentially be included in the combination, this combined risk would still be low. On this basis, the cumulative risks from severe accidents at any location within 50 mi of the CRN Site likely would be SMALL.

5.11.7.1 Cumulative Fuel Cycle, Transportation and Decommissioning Impacts

Cumulative impacts from the fuel cycle, transportation activities, and decommissioning activities for the proposed SMR Project at the CRN Site are discussed in this subsection.

5.11.7.1.1 Fuel Cycle

Impacts from the uranium fuel cycle (UFC) for the proposed facility at the CRN Site include impacts from mining and milling uranium ore along with conversion, enrichment, and fabrication of the uranium into fuel and, finally, disposal of the irradiated (spent) fuel. As discussed in

Section 5.7, a 1000 megawatt electric (MWe) light water reactor (LWR) was used as a reference plant to determine UFC impacts from operation of the CRN Site; the proposed facility has effectively the same fuel cycle process and the same type of fuel as the reference plant. As discussed in Subsection 5.7.1.1, the land use required for the SMR Project at the CRN Site produces far more power than a similarly sized coal or natural gas plant, which produces 89 and 68 percent less electricity. Similarly, as discussed in Subsection 5.7.1, water usage, effluents, waste, and transport during CRN operations along with occupational dose are relatively small and within limits. As a result, impacts from the UFC during operation of the proposed facility at the CRN Site are SMALL.

This cumulative analysis considers impacts over the UFC associated with operation of the proposed project at the CRN Site along with impacts from past, present, and reasonably foreseeable actions that may contribute to cumulative impacts within the geographic area of interest, the geographic area most likely to be affected by the proposed SMR Project. The geographic area of interest for impacts of the UFC is nationwide and, with imported uranium, worldwide.

Historically, the majority of uranium has been imported with the majority of domestic uranium mines and mills closing due to market conditions. More than eighty percent of uranium purchased in 2013 for commercial nuclear reactors in the United States was of foreign origin (Reference 5.11-10). Although the DOE plans to continue release of excess uranium from DOE's Portsmouth and Paducah Gaseous Diffusion Plants, demand for uranium is expected to remain steady at almost sixty million pounds per year (Reference 5.11-11).

NUREG-2157, *Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel,* examines the incremental impacts of continued storage on each resource area analyzed in NUREG-2157 in combination with other past, present, and reasonably foreseeable future actions. Section 6.5 of NUREG-2157 indicates ranges of potential cumulative impacts for multiple resource areas. These ranges are primarily driven by impacts from activities other than the continued storage of spent fuel at the reactor site; the impacts from these other activities would occur regardless of whether spent fuel is stored during the continued storage period. In the short-term timeframe, which is the most likely timeframe for the disposal of the fuel, the potential impacts of continued storage for at-reactor storage are SMALL and would, therefore, not be a significant contributor to the cumulative impacts. Because the impacts during the short-term timeframe are SMALL, continued storage would not be a significant contributor to the cumulative impacts. In the longer timeframes for at-reactor storage, or in the less likely case of away-from-reactor storage, some of the impacts from the storage of spent fuel could be greater than SMALL. However, other Federal and non-Federal activities occurring during the longer timeframes, as noted in NUREG-2157, include uncertainties as well, contributing to the cumulative impacts. These uncertainties lead to the ranges in cumulative impacts as discussed throughout Chapter 6 of NUREG-2157. The overall cumulative impact conclusions would not be changed if the impacts of continued storage were removed. Based on the analysis and impact determination in NUREG-2157 the cumulative impacts from radiological wastes from the fuel

cycle (which includes the impacts associated with spent fuel storage during operation and continued storage period) would be SMALL.

5.11.7.1.2 Transportation

Section 7.4 describes the environmental impacts of postulated transportation accidents assuming all shipments are by truck. Shipments include irradiated (spent) fuel, unirradiated fuel, and radioactive waste. Probable transportation routes were bounded by shipping unirradiated fuel 2282 mi from Washington, shipping irradiated fuel 2265 mi to Nevada, and shipping radioactive waste 1162 mi to Texas. Specifically, 15 shipments per year of new fuel, 57 shipments per year of spent fuel, and 75 shipments per year of radioactive waste were modeled to determine impacts from transport (shipment numbers normalized to the NRC's "reference reactor"). Radiological impacts were determined modeling similarly packaged fuel, the average annual fuel reload, and an estimate of 5000 cubic feet per year radioactive waste. Non-radiological impacts were determined using round-trip distances to determine possible injuries and fatalities from transport by truck over commercial routes. Additional traffic would result from shipments of construction materials and movements of construction personnel to and from the site. The additional traffic increases the risk of traffic accidents, injuries, and fatalities. As shown in Section 7.4, impacts from postulated accidents associated with the transport of fuel and waste for the proposed project at the CRN Site are SMALL.

This cumulative analysis considers impacts from postulated accidents associated with the transportation of fuel and waste for the proposed project at the CRN Site along with impacts from past, present, and reasonably foreseeable actions that may contribute to cumulative impacts within the geographic area of interest, the area most likely to be affected by the proposed CR SMR Project. The geographic area of interest for impacts of postulated transportation accidents is nationwide.

Non-radiological cumulative impacts of transportation are related to the increased traffic over commercial routes with the attendant increased risk of traffic, accidents, injuries, and fatalities. Geographically, the CRN Site is near two main transportation corridors, the East-West I-40 and the North-South I-75, which historically channel most of the transport in the region. Although the potential cumulative impact to major traffic routes is SMALL, local roads in the immediate vicinity of the CRN Site would experience an increase in load and frequency. Coupled with the proximity of the ORNL, the ETTP, and the Y-12 campuses, future cumulative impacts to the local roads may be noticeable.

Radiological cumulative impacts associated with transportation of fuel and waste from the CRN Site includes impacts from waste shipments from ORNL shipments, ETTP shipments, and Y-12 shipments along with fuel and waste shipments to and from the Watts Bar and Sequoyah nuclear power plants. Like the shipments associated with the CRN Site described in Section 7.4, the impacts from each individual shipment would be minimal and, when combined with the impacts associated with the CRN Site, the total impact would also be minimal. Therefore the

cumulative impacts of transporting unirradiated fuel to, along with irradiated fuel and radioactive waste from CRN would be SMALL.

5.11.7.1.3 Decommissioning

Section 5.9 discusses the general environmental impacts of decommissioning the proposed facility at the CRN Site. Decommissioning the facility includes the employment of workers and the final disposal of radioactive waste. Worker dose is comparable to occupational dose during normal operational refueling and maintenance activities. A small amount of land is required for offsite radioactive waste burial. Although the various decommissioning methods and alternatives have different impacts, including impacts from size and transport variations, no adverse effects are anticipated from decommissioning activities at the CRN Site.

This cumulative analysis considers impacts from decommissioning activities at the CRN Site along with impacts from past, present, and reasonably foreseeable actions that may contribute to cumulative impacts within the geographic area of interest, the geographic area most likely to be affected by the proposed CR SMR Project. The geographic area of interest for decommissioning impacts is the 50-mi radius for socioeconomic impacts from the workers and nationwide for the final disposal of the radioactive waste.

The other nuclear facilities within 50 mi of CRN are the ORNL, Y-12, and ETTP sites as well as the Watts Bar and Sequoyah nuclear power plants. In NUREG-0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, Supplement 1, the NRC found that the impacts from decommissioning due to radiation dose to workers and the public, waste management, water quality, air quality, ecological resources, and socioeconomics would be SMALL.

Regulations allow reactor decommissioning to take up to 60 yr to complete. However, much of that time can be a relatively inactive period after shutdown that allows high radioactivity materials to decay to safer levels. While several major reactor decommissioning periods in within the geographic area of interest could overlap and have a noticeable impact on some resources, the likelihood of major decommissioning activities from multiple reactor sites in the geographic area of interest occurring at the same time is small. Therefore the cumulative impacts from decommissioning the proposed SMR nuclear plant would also be SMALL.

5.11.8 Nonradiological Health Impacts

Sections 2.2, 2.3, and 2.7 describe the land, water, and air affected by the proposed SMR Project at the CRN Site. Sections 5.1, 5.2, and 5.5 describe impacts to health and the physical environment during operational activities at the CRN Site. Compliance with the site permits coupled with best management practices (BMPs), would result in SMALL impacts from the proposed CR SMR Project to nonradiological health from operational activities.

The geographic area of interest for impacts to nonradiological health is a 50-mi radius around the CRN site, including parts of Roane, Anderson, Knox, and Loudon Counties along with population centers Kingston, Lenoir City, Oak Ridge, Athens, Maryville/Alcoa, and Knoxville.

Nonradioactive health impacts from operation of the CRN SMR Project include localized impacts from noise, vibrations, and dust along with occupational injuries to the workers. Cumulative nonradiological health impacts would include contributions from current developments (ETTP and Bull Run Fossil Plant), future developments (roadway improvements and urbanization), ORR activities (industrialization, decommissioning, and demolition), and other projects listed in Table 4.7-1.

As described in Subsections 3.6.3.2, the CRN SMR Project's cooling towers would discharge nonradioactive wastewater with small amounts of biocides and corrosion inhibitors into the Clinch River Arm of the Watts Bar Reservoir. As discussed in Subsection 5.3.2.1, thermal effects would not extend far from the diffuser; being assimilated within regulatory limits within 50 ft under steady river flow conditions and within 150 ft under unsteady river flow conditions. As discussed in Subsections 5.2.2.2 and 5.11.3.3, discharge would be in compliance with the Site's NPDES permit. Further, because project discharge would be less than 10 percent of the lowest reservoir flow rate at the CRN Site, impact of the discharge on the water is SMALL and thus the health impact is SMALL. Impacts on water from past, present, and reasonably foreseeable projects in the area include the dams listed in Table 4.7-1 along with legacy contributions from the Manhattan Project that contribute to a MODERATE cumulative impact to human health. Anticipated future projects, like the Sludge Build-Out Project and continued industrial development at ETTP and at the Roane Regional Business and Technology Park, would employ modern business practices following waste minimization and NPDES guidelines; thus having a SMALL impact on water and on nonradiological human health. The incremental additional contributions to nonradiological cumulative health impacts from SMR operations would also be SMALL.

Further nonradioactive health impacts include effects from GHG emissions and particulates from transport of crew and supplies along with gaseous effluents from operational activities at the CRN Site. As described in Subsections 3.6.3.1 and 5.5.1.3, operations of the CRN SMR Project includes gaseous and particulate emissions from cooling towers, auxiliary boilers, diesel generators, and gas turbine generators. Emissions would be managed by federal, state, and local air quality control laws and regulations making emissions within the regulatory limits and thus protective of human health. Cumulative health impacts to workers and the public from these GHG and particulate emissions would include state and national contributors. State and federal air permitting coupled with BMPs would help mitigate contributions from the proposed SMR Project along with current and future projects; thus helping minimize the health impacts from these emissions. The incremental contribution of the operational CRN SMR Project to cumulative nonradiological health impacts is SMALL.

In addition, projected climate change for the region contributes to the potential nonradiological health of the populace in the geographic area of interest. Models for the Appalachian region of

East Tennessee often forecast warmer, wetter weather patterns with greater incidence of severe storm events. These severe storms tend to increase water pollution from runoff including increased fertilizers, herbicides, and pesticides along with increased sedimentation impairing the water quality and contributing to adverse health effects. (Reference 5.11-2) Additionally, less regular precipitation events coupled with increased evaporation and transpiration from increased air and water temperatures, may also lead to reduced availability of timely water resources and a need for crop irrigation; thus reducing the local availability of fresh water and food. Further, global changes in climate are expected to result in decreasing availability of food and water and thus negatively impact human health through increased competition for more limited resources. (Reference 5.11-2) Since the human health impact from the projected increase in temperature and storm severity is SMALL and since the nonradiological health impact of operating the proposed CRN SMR Project is also SMALL, the cumulative impact to human health from the projected increase in temperature and storm severity along with impacts from operational activities at the CRN Site would be SMALL.

5.11.9 References

Reference 5.11-1. Tennessee Valley Authority, "Clinch River Small Modular Reactor Site Regional Surface Water Use Study - Revision 2," April 24, 2015.

Reference 5.11-2. U.S. Global Change Research Program, "Climate Change Impacts in the United States," October, 2014.

Reference 5.11-3. U. S. Geological Survey, "Water Quality in the Upper Tennessee River Basin, 1994-1998," Circular 1205, 2000.

Reference 5.11-4. Tennessee Valley Authority, "Clinch River Surface Water Quality Report - Revision 2," July 10, 2015.

Reference 5.11-5. Tennessee Wildlife Resources Agency, "Climate Change and Potential Impacts to Wildlife in Tennessee," September, 2009.

Reference 5.11-6. U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013," EPA 430-R-15-004, April 15, 2015.

Reference 5.11-7. U.S. Environmental Protection Agency, State Energy CO2 Emissions, Website: http://www3.epa.gov/statelocalclimate/resources/state_energyco2inv.html, July 8, 2015.

Reference 5.11-8. Nuclear Energy Institute, Comparison of Lifecycle Emissions of Energy Technologies, Website: http://www.nei.org/Issues-Policy/Protecting-the-Environment/Life-Cycle-Emissions-Analyses/Comparison-of-Lifecycle-Emissions-of-Selected-Ener, 2015.

Reference 5.11-9. World Nuclear Association, Energy Balances and CO2 Implications, Website: http://www.world-nuclear.org/info/Energy-and-Environment/Energy-Balances-and-CO2-Implications/, March, 2014.

Reference 5.11-10. U.S. Department of Energy, 2013 Uranium Marketing Annual Report, Website: http://www.eia.gov/uranium/marketing/pdf/2013umar.pdf, 2013.

Reference 5.11-11. Meade, Thomas B. and Supko, Eileen M., Review of the Potential Impact of DOE Excess Uranium Inventory On the Commercial Markets, Website: http://www.energy.gov/sites/prod/files/2014/05/f15/ERI%20Market%20Analysis.pdf, April 25, 2014.

Reference 5.11-12. Tennessee Department of Environment and Conservation, APC Permits in TN Interactive Report, Website: http://www.tennessee.gov/environment/article/permit-air-title-v-operating-permit, 2015.

Table 5.11-1 (Sheet 1 of 2)
Geographic Areas of Interest Defined for the Analyzed Resource Areas

ER Section	Analyzed Resource	Geographic Area of Interest
4.7.2 / 5.11.2	Land Use	Within a 30-mi radius of the CRN Site
4.7.3.1 / 5.11.3.1	Surface Water Hydrology	Clinch River arm of the Watts Bar Reservoir
4.7.3.2.1 / 5.11.3.2.1	Surface Water Use	Anderson, Knox, Loudon, Meigs, Morgan, Rhea, and Roane counties, Tennessee
4.7.3.2.2 / 5.11.3.2.2	Groundwater Use	Lower Clinch River Watershed from Melton Hill Reservoir downstream to the confluence of the Clinch, Emory, and Tennessee Rivers
4.7.3.3.1 / 5.11.3.3.1	Surface Water Quality	Clinch River arm of the Watts Bar Reservoir
4.7.3.3.2 / 5.11.3.3.2	Groundwater Quality	Lower Clinch River Watershed from Melton Hill Reservoir downstream to the confluence of the Clinch, Emory, and Tennessee Rivers
4.7.4.1 / 5.11.4.1	Terrestrial Ecology and Wetlands	Within a 6-mi radius of the CRN Site
4.7.4.2 / 5.11.4.2	Aquatic Ecology	CRN Site, Barge/Traffic Area, and 69-kV underground transmission line ROW, and Clinch River arm of the Watts Bar Reservoir in the vicinity (within approximately a 6-mi radius) of the CRN Site. This portion of the Clinch River arm of the Watts Bar Reservoir generally includes the area of the reservoir downstream to the confluence with the Emory River arm of the Watts Bar Reservoir and upstream to Melton Hill Dam (approximately Clinch River Mile 5 to 23).
4.7.5.1.1	Socioeconomic/Physical - Air Quality	Within a 6-mi radius of the CRN Site (nationwide, for GHG emissions)
5.11.5.1.1	Socioeconomic/Physical - Air Quality	Roane, Loudon, Knox, Anderson, and Morgan counties, Tennessee (State of Tennessee and nationwide, for GHG emissions)
4.7.5.1.1 / 5.11.5.1.1	Socioeconomic/Physical - Noise	CRN Site and the areas within a 5-mi radius of the CRN Site
5.11.5.1.1	Socioeconomic/Physical – Thermal Emissions (Air)	CRN Site and the areas within a 1-mi radius of the CRN Site

Table 5.11-1 (Sheet 2 of 2)
Geographic Areas of Interest Defined for the Analyzed Resource Areas

ER Section	Analyzed Resource	Geographic Area of Interest
5.11.5.1.1	Socioeconomic/Physical – Thermal Emissions (Water)	Clinch River arm of the Watts Bar Reservoir
5.11.5.1.1	Socioeconomic/Physical – Visual Intrusions	Within a 2-mi radius of the CRN Site
4.7.5.1.2 / 5.11.5.1.2	Social and Economic	Roane, Anderson, Knox, and Loudon counties, Tennessee
4.7.5.2 / 5.11.5.2	Environmental Justice	Within a 50-mi radius of the CRN Site
4.7.5.3 / 5.11.6	Archaeological Resources	The approximate 1305-ac area that includes the CRN Site and the Barge/Traffic Area (Area of Potential Effect)
4.7.5.3 / 5.11.6	Historic Architectural Resources	Within a 0.5-mi radius surrounding the proposed cleared areas
4.7.5.3 / 5.11.6	Historic Properties	Within a 10-mi radius of the center of the CRN Site
4.7.6	Nonradiological Health	Within a 30-mi radius of the CRN Site
5.11.8	Nonradiological Health	Within a 50-mi radius of the CRN Site
5.11.7	Postulated Accidents	Within a 50-mi radius of the CRN Site
5.11.7.1.1	Postulated Accidents/Fuel Cycle	Nationwide (worldwide, for imported uranium)
5.11.7.1.2	Postulated Accidents/Transportation	Nationwide
5.11.7.1.3	Postulated Accidents/ Decommissioning	Within a 50-mi radius, for socioeconomic; nationwide, for radioactive waste disposal

Table 5.11-2
Title V Operating Permit Sources In Roane, Anderson, Knox, Loudon, and Morgan Counties, Tennessee

Facility	DAPC Permit Number[1]	County
Horsehead Corp	562547	Roane
TVA-Kingston Fossil Plant	560775	Roane
Toho Tenax America Inc.	560018	Roane
Oak Ridge National Laboratory	562765	Roane
Oak Ridge National Laboratory	562860	Roane
Diversified Scientific Services, Inc.	566728	Roane
Isotek, LLC	568276	Roane
Oak Ridge National Laboratory (Draft)	569768	Roane
Chestnut Ridge Landfill/Recycling Center	563001	Anderson
TVA-Bull Run Fossil Plant	567519	Anderson
Carlisle Tire	562998	Anderson
National Nuclear Security Administration Y-12 DOE	562767	Anderson
Chestnut Ridge Landfill/Recycling Center (Pending)	569431	Anderson
Omega Cabinetry (Surrendered)	554290	Anderson
CEMEX	Knox Co. No 8[2]	Knox
Leisure Pools and Spas	Knox Co. No 533[2]	Knox
GERDAU AMERISTEEL	Knox Co. No 568[2]	Knox
Schick Manufacturing	Knox Co. No 842[2]	Knox
Republic Plastics K1, LTD	Knox Co. No 970[2]	Knox
Republic Plastics K2, LTD	Knox Co. No 1065[2]	Knox
Tate & Lyle Loudon	561515	Loudon
Hubbell Lenoir City Inc.	563297	Loudon
Kimberly-Clark Corporation	563319	Loudon
Malibu Boats LLC	563414	Loudon
Viskase Corporation	567428	Loudon
Malibu Boats LLC (Pending)	569925	Loudon
Santek Waste Services, Inc./Loudon Co Landfill	569595	Loudon
Heraeus Metal Processing Inc.	561481	Morgan

1 DAPC - Tennessee Department of Environment and Conservation, Division of Air Pollution Control
2 Knox County Health Department administers Title V Operating Permits.

Source: (Reference 5.11-12)