CHAPTER 3 PLANT DESCRIPTION

Chapter 3 describes the new plant design based on the plant parameter envelope (PPE) and provides general information about the new plant on the Clinch River Nuclear (CRN) Site. This Chapter presents a description of two or more small modular reactors (SMRs) based upon pressurized water reactor technology; however, a specific design has not been selected. Therefore, a plant parameter envelope (PPE) has been developed for use in evaluating potential environmental impacts. The PPE is a composite of SMR- and owner-engineered parameters that bound the environmental impacts of construction and operation of the facility.

The parameters associated with the station appearance, water use, transmission facilities, and its relationship to the surrounding area are described in the following sections:

- External Appearance and Plant Layout (Section 3.1)
- Reactor Power Conversion System (Section 3.2)
- Plant Water Use (Section 3.3)
- Cooling System (Section 3.4)
- Radioactive Waste Management System (Section 3.5)
- Non-radioactive Waste System (Section 3.6)
- Power Transmission System (Section 3.7)
- Transportation of Radioactive Materials (Section 3.8)
- Construction Activities (Section 3.9)
- Workforce Characterization (Section 3.10)

3.1 EXTERNAL APPEARANCE AND PLANT LAYOUT

3.1.1 Site Description

The Clinch River Nuclear (CRN) Site consists of approximately 935 acres (ac) bounded on the east, south, and west by the Clinch River arm of the Watts Bar Reservoir and on the north by the U.S. Department of Energy's Oak Ridge Reservation and the Tennessee Valley Authority's Grassy Creek Habitat Protection Area (HPA). The CRN Site Utilization Plan and facility layout are depicted in Figures 3.1-1 and 3.1-2, respectively. The exclusion area boundary (EAB) is delineated by the boundaries of the Clinch River Property, which includes the CRN Site and the Grassy Creek HPA.

The facility layout was determined by reviewing a representative layout for each of the small modular reactor (SMR) designs under consideration, developing a composite layout, and identifying bounding areas for the power block (nuclear island), turbine building, switchyard, and cooling tower(s). Space is reserved for a future independent spent fuel storage installation. Five retention ponds and one additional small pond have been identified on the CRN Site. All six ponds were determined to be man-made. The five larger ponds were originally created as stormwater retention ponds for the Clinch River Breeder Reactor Project (CRBRP). The sixth pond was created for an unknown purpose. (Reference 3.1-1) The six ponds and onsite wetlands are shown in Figure 2.4.1-2.

The land proposed to be used for construction is indicated Figure 3.1-2. The majority of the construction would occur within the boundaries of the CRN Site. To support site construction and operations, some construction would also occur in offsite areas including the Barge/Traffic Area and the 69-kilovolt (kV) underground transmission line that is located within the 500-kV transmission line right-of-way (ROW) (Figure 3.1-2). Construction in the Barge/Traffic Area would include the addition of a northbound loop ramp at the intersection of Tennessee State Highway 58 and Bear Creek Road as well as improvements to Bear Creek Road as discussed in Subsection 4.4.2.3. The Barge/Traffic Area construction would also include refurbishment of a barge terminal near CRM 14.1. A 69-kV underground transmission line would be constructed from the CRN Site to the Bethel Valley substation along the ROW for an existing 500-kV transmission line as discussed in Section 3.7. Although the total temporarily cleared area indicated on Figure 3.1-2 is expected to bound the land to be used during construction, specific uses of areas for construction support would depend upon the specific design selected.

3.1.2 Power Plant Description

As described in Subsection 2.2.1.1, the CRN Site is located on the site of the previous CRBRP. At the time of the CRBRP's cancellation in 1983, preliminary site work was essentially complete, including the retention ponds, quality control test laboratory, construction shops, concrete batch plants, nuclear island excavation, and concrete foundation for a ringer crane (Reference 3.1-2; Reference 3.1-3). Upon project termination, the main site area was remediated, including partial backfilling the nuclear island excavation. The temporary structures were removed; however the retention ponds and associated drainage infrastructure were left intact. The finished elevation of the remediated nuclear island excavation area is approximately 821 feet (ft) above mean sea level (msl).

The designs under consideration for deployment at the CRN Site are SMRs based upon pressurized water reactor technology; however, a specific design has not been selected. Therefore, a plant parameter envelope (PPE) has been developed for use in evaluating potential environmental impacts. The PPE is a composite of SMR and owner engineered parameters that bound the environmental impacts of construction and operation of the facility. The PPE is used to define a “surrogate plant” that can bound two or more technologies. This surrogate plant is used as an input for the analyses needed to support the development of the early site permit application (ESPA). In order for an applicant to move forward with a combined license application, an SMR technology must be selected. The selection of one of the SMR technologies used in the construction of the PPE or a future SMR technology that is demonstrated to be bounded by the PPE maximizes the benefits of the ESP. This process provides reasonable assurance that siting issues would remain resolved when an SMR technology is selected and the ESP is incorporated into a combined license. Table 1 of the PPE is provided in Table 3.1-1, Site Characteristics, and Table 3.1-2, Site Related Design Parameters. Other PPE tables are provided in Sections 3.5 and 3.6.

The height of structures in the power block area depends upon the SMR technology selected; however, as indicated in Table 3.1-2, Item 1.1.1, the bounding structure height (excluding the cooling tower(s) and facility stack(s)) is 160 ft above grade. In general, buildings are constructed using standard building materials such as concrete, metal with metal siding, or wood with metal, vinyl, or other acceptable siding. The design and construction of building structures would take into consideration the surroundings to minimize aesthetic impacts. A rendering of the facility based on the PPE provided in Tables 3.1-1 and 3.1-2 is provided in Figure 3.1-3.

The circulating water system includes one or more mechanical draft cooling towers with make-up water drawn from the Clinch River arm of the Watts Bar Reservoir. The intake and discharge structures are described in Section 3.4. As described in Section 3.7, a new switchyard and an upgrade to an existing switchyard are required to support the facility, and the existing onsite transmission lines would be modified as required to incorporate the new generation capacity into the electric grid.

After the completion of construction, areas used to support construction activities which are not re-used to support facility operations would be re-graded and landscaped. Areas cleared for temporary construction facilities would be re-vegetated, and topographical features created during construction would be re-contoured to match the surrounding areas.

3.1.3 References

Reference 3.1-1. Howard, Charles S., Henderson, Andrew R., and Phillips, Craig L., "Clinch River Small Modular Reactor and Barge/Traffic Site Evaluation of Aquatic Habitats and Protected Aquatic Animals Technical Report - Revision 5," Tennessee Valley Authority, December 22, 2015.

Reference 3.1-2. U.S. Department of Energy, "Clinch River Breeder Reactor Plant Project Site Redress Plan," March, 1984.

Reference 3.1-3. Breeder Reactor Corporation, "Final Report The Clinch River Breeder Reactor Plant Project," January, 1985.

Table 3.1-1
CRN Site Characteristics

PPE Section[1]	Definition	Parameter Type	PPE Value	ER Section
9. Unit Vent/Airborne Effluent Release Point				
9.1 Atmospheric Dispersion (X/Q) (Accident)				
9.1.1 0-2 hr @ EAB	The atmospheric dispersion coefficients used in the design safety analysis to estimate dose consequences of accident airborne releases in the limiting two hour interval.	Site	5.58E-04 s/m^3	7.1
9.1.2 0-8 hr @ low population zone (LPZ)	The atmospheric dispersion coefficients used in the design safety analysis to estimate dose consequences of accident airborne releases in the first eight hours.	Site	4.27E-05s/m^3	7.1
9.1.3 8-24 hr @ LPZ	The atmospheric dispersion coefficients used in the design safety analysis to estimate dose consequences of accident airborne releases between hours 8 and 24 after the accident.	Site	3.80E-05 s/m^3	7.1
9.1.4 1-4 day @ LPZ	The atmospheric dispersion coefficients used in the design safety analysis to estimate dose consequences of accident airborne releases between the first day and the fourth day after the accident	Site	2.94E-05 s/m^3	7.1
9.1.5 4-30 day @ LPZ	The atmospheric dispersion coefficients used in the design safety analysis to estimate dose consequences of accident airborne releases between day four until the end of the first 30 days after the accident.	Site	2.04E-05 s/m^3	7.1
9.3 Calculated Dose Consequences				
9.3.1 Normal	The design radiological dose consequences due to airborne releases from normal operation of the plant.	Site	10 CFR 20, 10 CFR 50 Appendix I	5.4[2], 7.2[2]
9.3.2 Post-Accident	The design radiological dose consequences due to airborne releases from postulated accidents.	Site	10 CFR 52.17 (a)(1) (ix), 10 CFR 100.20	5.4[2], 7.2[2]

[1] The numbering of the PPE listing is not meant to be sequential, and was compiled from and is consistent with the list developed by industry and refined for this ESPA.
[2] Information utilized in the development of the impacts described in the section, but not referenced specifically in the text.

Table 3.1-2 (Sheet 1 of 5)
CRN Site Related Design Parameters

PPE Section[1]	Definition	Parameter Type	PPE Value	ER Section
1. Structure				
1.1 Building Characteristics				
1.1.1 Height (w/o Stack and Cooling Towers)	The height from finished grade to the top of the tallest power block structure, excluding cooling towers (excludes stairway towers, elevator, etc.).	Rx	160 ft	2.5.2, 3.1, 4.4, 5.8
1.1.2 Foundation Embedment	The depth from finished grade to the bottom of the basemat or the most deeply embedded power block structure (excavation depth is the same elevation as embedment depth).	Rx	138 ft	3.1
3. Normal Plant Heat Sink				
3.1 Condenser				
3.1.2 Condenser / Heat Exchanger Duty	Design value for the waste heat rejected to the circulating water system across the condensers.	Eng	5593 MBTU/hr for site	3.4
3.2 Non-Safety Related Service Water Systems				
3.2.3 Miscellaneous Plant Water Uses Intake	The maximum, and normal, water intake of the plant neglecting cooling tower makeup, potable/sanitary water users, and liquid radwaste treatment.	Eng	Maximum: 5100 gpm Normal: 1345 gpm See Figure 3.3-1	3.4
3.2.4 Miscellaneous Plant Water Uses Discharge	The maximum, and normal, water discharge of the plant neglecting cooling tower makeup, potable/sanitary water users, and liquid radwaste treatment.	Eng	Maximum: 4200 gpm Normal: 445 gpm See Figure 3.3-1	3.4
3.3 Mechanical Draft Cooling Towers				
3.3.1 Acreage	The land required for cooling towers, including support facilities such as equipment sheds, basins, canals, or shoreline buffer areas.	Eng	See Figure 3.1-1	3.4, 5.3
3.3.3 Blowdown Constituents and Concentrations	The maximum expected concentrations for anticipated constituents in the cooling water systems blowdown to the receiving water body.	Eng	Table 3.6-1 (values for site)	3.6
3.3.4 Blowdown Flow Rate	The normal (and maximum) flow rate of the blowdown stream from the cooling water systems to the receiving water body for closed system designs.	Eng	Maximum: (2 COC) 12,800 gpm, Expected: (4 COC) 4270 gpm See Figure 3.3-1	3.4
3.3.5 Blowdown Temperature	The maximum expected blowdown temperature at the point of discharge to the receiving water body.	Eng	90 F	3.4
3.3.6 Cycles of Concentration	The ratio of total dissolved solids in the cooling water blowdown streams to the total dissolved solids in the make- up water streams.	Eng	Maximum: 4, Minimum: 2	3.4, 5.3

Table 3.1-2 (Sheet 2 of 5)
CRN Site Related Design Parameters

PPE Section[1]	Definition	Parameter Type	PPE Value	ER Section
3.3.7 Evaporation Rate	The expected (and maximum) rate at which water is lost by evaporation from the cooling water systems.	Eng	12,800 gpm (Expected and Maximum) - values for site	3.4
3.3.8 Height	The vertical height above finished grade of mechanical draft cooling towers associated with the cooling water systems.	Eng	65 ft	3.4, 5.3, 5.8
3.3.9 Makeup Flow Rate	The expected (and maximum) rate of removal of water from a natural source to replace water losses from closed cooling water system.	Eng	17,078 gpm (expected), 25,608 gpm (maximum)	3.4
3.3.10 Noise	The maximum expected sound level produced by operation of cooling towers, measured at 1000 ft from the noise source.	Eng	<70 dba	5.3, 5.8, 9.3
3.3.11 Cooling Tower Temperature Range	The temperature difference between the cooling water entering and leaving the towers.	Eng	18 F	3.4
3.3.12 Cooling Water Flow Rate	The total cooling water flow rate through the condenser/heat exchangers.	Eng	755,000 gpm	3.4, 5.3
3.3.14 Maximum Consumption of Raw Water	The expected maximum short-term consumptive use of water by the cooling water systems (evaporation and drift losses).	Eng	12,808 gpm	3.4
3.3.16 Stored Water Volume	The quantity of water stored in cooling water system impoundments, basins, tanks and/or ponds.	Eng	5 million gal	3.4
3.3.17 Drift	Rate of water lost from the tower as liquid droplets entrained in the vapor exhaust air stream.	Eng	8 gpm	3.4
5. <u>Potable Water/Sanitary Waste System</u>				
5.1 Discharge to Site Water Bodies				
5.1.1 Flow Rate (Potable/Sanitary Normal)	The expected (normal) effluent flow rate from the potable/sanitary water system to the receiving water body.	Rx	50 gpm	3.4, 3.6, 5.5
5.1.2 Flow Rate (Potable/Sanitary Maximum)	The maximum effluent flow rate from the potable/sanitary water system to the receiving water body.	Rx	100 gpm	3.4, 3.6, 5.5
9.5 Source Term				
9.5.1 Gaseous (Normal)	The expected annual activity, by radionuclide, contained in routine plant airborne effluent streams, excluding tritium.	Rx	Table 3.5-3	3.5
10. <u>Liquid Radwaste System</u>				
10.2 Release Point				
10.2.1 Flow Rate	The discharge (including minimum dilution flow, if any) flow rate of liquid potentially radioactive effluent streams from plant systems to the receiving water body.	Eng	900 gpm - expected normal and maximum -	3.4

Table 3.1-2 (Sheet 3 of 5)
CRN Site Related Design Parameters

PPE Section[1]	Definition	Parameter Type	PPE Value	ER Section
10.3 Source Term				
10.3.1 Liquid	The annual activity, by radionuclide, contained in routine plant liquid effluent streams, excluding tritium.	Rx	Table 3.5-1 (value per site)	3.5
11. Solid Radwaste System				
11.2 Solid Radwaste				
11.2.1 Activity	The annual activity, by radionuclide, contained in solid radioactive wastes generated during routine plant operations.	Rx	Table 3.5-5 (site value)	3.5
11.2.3 Volume	The expected volume of solid radioactive wastes generated during routine plant operations.	Rx	5000 cubic ft/yr (site value)	3.5, 3.8, 5.7, 7.4
13. Auxiliary Boiler System		Eng		
13.1 Exhaust Elevation	The height above finished plant grade at which the flue gas effluents are released to the environment.	Eng	Plant Grade	3.6
13.2 Flue Gas Effluents	The expected combustion products and anticipated quantities released to the environment due to operation of the auxiliary boilers.	Eng	Table 3.6-2	3.6
14. Standby Power System				
14.1 Diesel				
14.1.2 Diesel Exhaust Elevation	The elevation above finished grade of the release point for standby diesel exhaust releases.	Eng	25 ft	3.6
14.1.3 Diesel Flue Gas Effluents	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby diesel generators.	Eng	Table 3.6-3 (value per site)	3.6
14.2 Gas Turbine				
14.2.2 Gas-Turbine Exhaust Elevation	The elevation above finished grade of the release point for standby gas turbine exhaust releases.	Eng	50 ft	3.6
14.2.3 Gas-Turbine Flue Gas Effluents	The expected combustion products and anticipated quantities released to the environment due to operation of the emergency standby gas-turbine generators.	Eng	Table 3.6-4	3.6

Table 3.1-2 (Sheet 4 of 5)
CRN Site Related Design Parameters

PPE Section[1]	Definition	Parameter Type	PPE Value	ER Section
15. Plant Layout Considerations				
15.1 Access Routes				
15.1.1 Heavy Haul Routes	The land usage required for permanent heavy haul routes to support normal operations and refueling.	Eng	5 ac	3.9
15.2 Acreage to Support Plant Operations	The land area required to provide space for plant facilities.	Eng	See Figure 3.1-1	3.7
16. Plant Operations Considerations				
16.1 Megawatts Thermal	The thermal power generated by one unit (may be the total of several modules). Specify both core thermal power and RCP thermal power (if there are RCPs in the design).	Rx	800 MWt (core) 805 MWt (core + RCP), 2420 MWt total for site	5.7, 7.4
16.2 Plant Design Life	The operational life for which the plant is designed.	Rx	60 years	3.2
16.3 Plant Population				
16.3.1 Operation	The estimated number of total permanent staff to support operations of the plant.	Eng	500 (value per site)	3.10, 5.8, 9.3
16.3.2 Refueling / Major Maintenance	The estimated additional number of temporary staff required to conduct refueling and major maintenance activities.	Eng	1000	5.8, 9.3
16.4 Station Capacity Factor	The percentage of time that a plant is capable of providing power to the grid.	Eng	Maximum 98% Minimum: 90%	5.7, 7.4
16.6 Megawatts Electrical (at 100% power with 85F circulating water)	Best estimate of MWe generator output.	Eng	800 MWe (value for site)	3.2, 5.7, 5.9, 7.4, 9.4, 10.1
17. Construction				
17.2 Acreage				
17.2.1 Laydown Areas	The land area required to provide space for construction support facilities. Provide a list of what buildings and/or areas and the associated acreage for each.	Eng	See Figure 3.1-1	3.7

Table 3.1-2 (Sheet 5 of 5)
CRN Site Related Design Parameters

PPE Section[1]	Definition	Parameter Type	PPE Value	ER Section
17.3 Construction				
17.3.1 Noise	The maximum expected sound level due to construction activities, measured at 50 ft from the noise source.	Eng	101 dB at 50 ft	3.9
17.4 Plant Population				
17.4.1 Construction	Maximum number of people onsite during construction.	Eng	2200 (value per site)	3.10
18. Miscellaneous Items				
18.0.1 Fuel Characteristics	What is the form of the reactor fuel and the burnup (GWd/MTU)?	Rx	UO_2, 51 GWD/MTU	5.7, 7.4
18.0.2 Fuel assemblies	Provide the number of fuel assemblies per core and the weight (in MTU) of each assembly.	Rx	Number of Fuel Assemblies: 96 Weight of Each Assembly: 0.304 MTU	3.8, 5.7, 7.4
18.0.4 Refueling	Provide the refueling frequency, average number of assemblies per refueling, and fuel pool capacity (in years).	Rx	Frequency 2 years, Assemblies per Refueling: 96, Capacity: Minimum of 6 years	3.8, 5.7, 5.8
18.0.5 Irradiation fuel transportation	Provide the weight of irradiated fuel per spent fuel shipping cask (MTU).	Rx	21.2 MTU	5.7
18.1 Maximum Fuel Enrichment	Concentration (weight percent fraction) of U-235 in the fuel uranium.	Rx	<5% U-235	3.2, 5.7, 7.4
18.2 Maximum Average Assembly Burnup	Maximum assembly average burn-up at end of assembly life.	Rx	51 GWD/MTU	3.2, 5.7, 7.4
18.3 Peak fuel rod exposure at end of life	Peak fuel rod exposure at end of life.	Rx	62 GWD/MTU	3.2
18.7 Clad Material	Fuel rod clad material.	Rx	Zirc Alloy (Zircaloy)	5.7

[1] The numbering of the PPE listing is not meant to be sequential, and was compiled from and is consistent with the list developed by industry and refined for this ESPA.

Notes:
RX = Reactor Parameter Eng = Owner Engineered Parameter COC = Cycles of Concentration

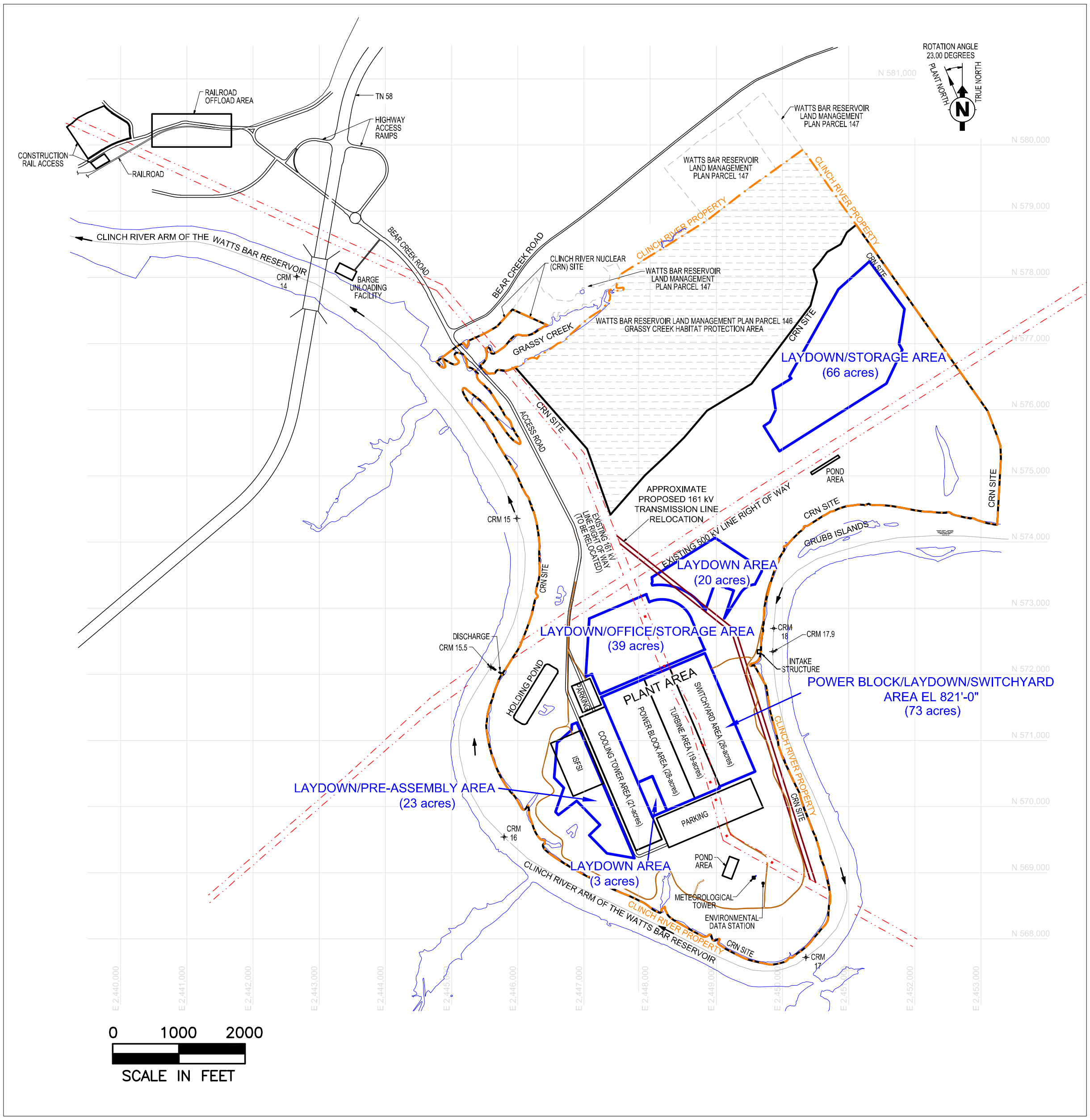


Figure 3.1-1. CRN Site Utilization Plan

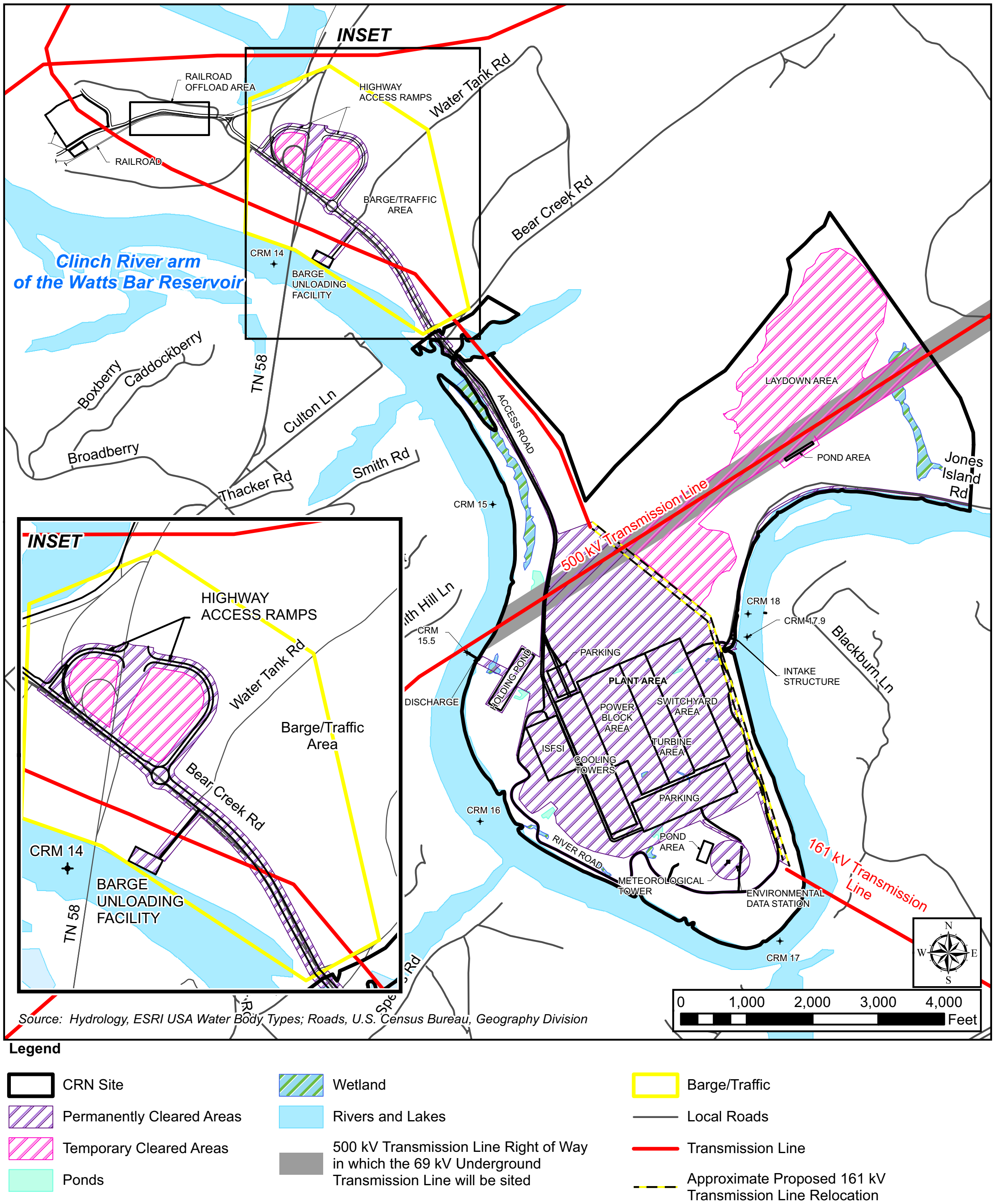


Figure 3.1-2. CRN Site Cleared Areas

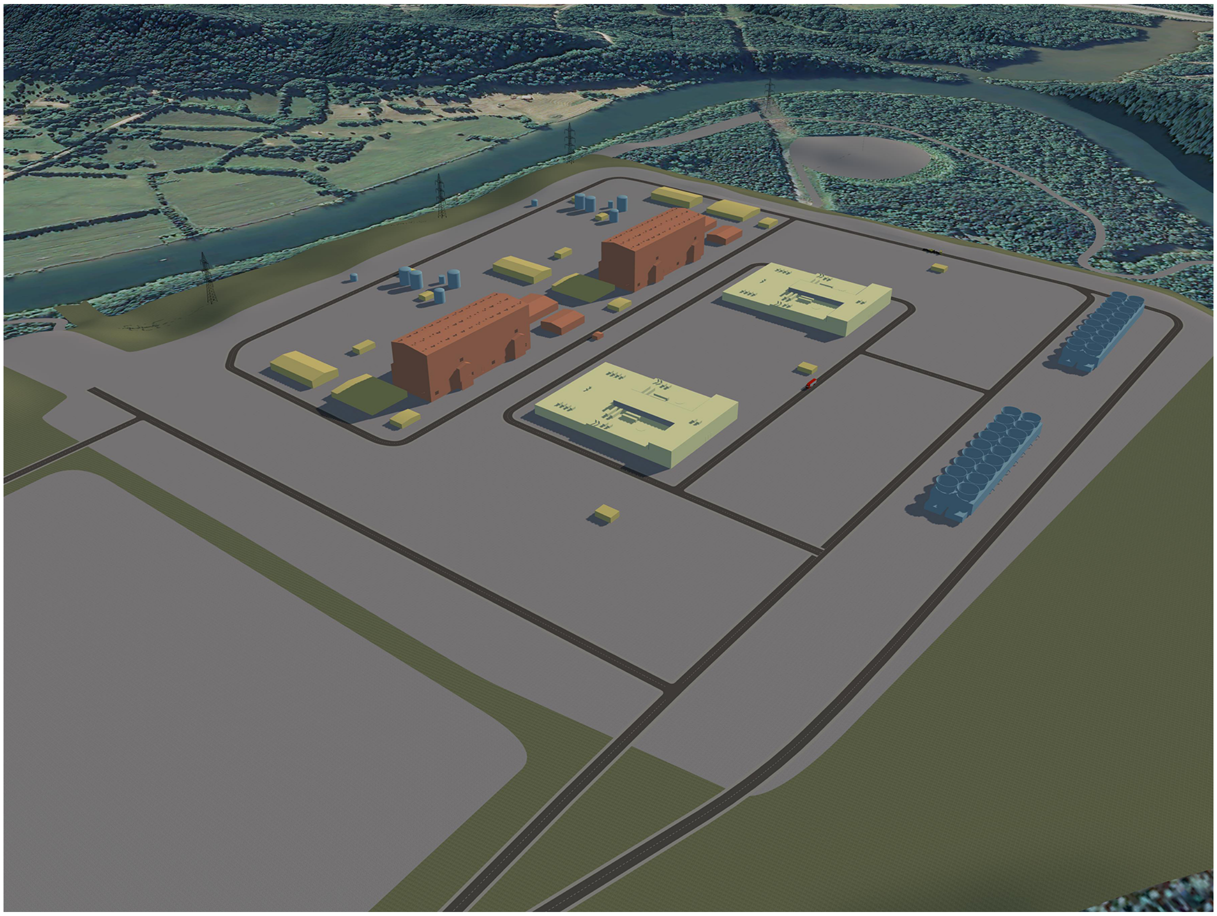


Figure 3.1-3. Architectural Rendering of the Clinch River SMR Surrogate Plant (Two Units) Superimposed on a Site Aerial (View to the Southeast)

3.2 REACTOR POWER CONVERSION SYSTEM

For the Clinch River Nuclear (CRN) Site, the selection of the vendor for a small modular reactor (SMR), and thus the reactor power conversion system, has not been made. Because an SMR technology has not been selected, a plant parameter envelope (PPE) has been developed for use in evaluating potential environmental impacts. The PPE is described in Section 3.1. The SMR technologies being considered for the CRN Site, which are based on a pressurized water reactor (PWR) design, are:

- BWXT mPower (up to 4 units)
- NuScale (up to 12 units)
- Holtec SMR-160 (up to 4 units)
- Westinghouse (up to 3 units)

As provided in Table 3.1-2, Item 16.6, the facility has a maximum total electrical output of 800 megawatt electric (MWe), depending upon the design and number of units deployed.

In general, steam generated by the nuclear steam supply system of each unit flows through the steam turbine, creating rotational mechanical work, which in turn rotates the electric generator to produce electricity.

3.2.1 Reactor Description

Because the number of units vary based upon the SMR technology selected, the arrangement of the units on the CRN Site is to be provided at combined license application (COLA) for the selected technology. The basic layout of the power block, turbine island, switchyard, and cooling tower areas is provided in Figure 3.1-1. The assumed facility design life, as provided in Table 3.1-2, Item 16.2, is 60 years.

The per reactor unit thermal output of the SMR technologies being considered varies from approximately 160 megawatt thermal (MWt) to 800 MWt, with a site total of 1920 MWt to 2420 MWt. The reactor and associated power conversion equipment allows generation of a gross electrical output of approximately 50 MWe to 240 MWe per unit and 600 MWe to 800 MWe total gross output for the facility. Because the auxiliary loads vary between the SMR technologies, the net electrical output is not currently available and is provided for the SMR technology selected at COLA.

Although fuel design is specific to the reactor design selected, all of the SMR technologies being considered for the CRN Site use uranium as their fissile material. As provided in Table 3.1-2, Items 18.1, 18.2, and 18.3, the maximum enrichment would be less than 5 percent uranium-235, the maximum average assembly burnup would be 51,000 megawatt-days per metric ton of uranium (MWD/MTU), and the peak fuel rod exposure would be 62,000 MWD/MTU.

3.2.2 Engineered Safety Features

A range of engineered safety feature (ESF) systems are included in the SMR designs being considered. These include both active and passive types of ESF systems. In general, active safety systems rely on powered components, such as valve openings, to supply safety injection water and provide core and containment cooling. In the event of the loss of preferred normal and preferred alternate alternating current power, the active systems would be powered by redundant power sources, such as a diesel generator or a gas turbine. Alternatively, passive safety systems rely almost exclusively on natural forces, such as differences in density, gravity, or stored energy, to supply safety injection water and to provide core and containment cooling. Specific details about the ESF system for the SMR technology selected are addressed at COLA.

3.2.3 Power Conversion Systems

The various SMR designs each use a steam turbine to convert the heat energy to mechanical energy. Waste heat from the turbine condensers is rejected to one or more cooling towers, which serve as the normal heat sink. Specific details about the power conversion system for the SMR technology selected are addressed at COLA.

3.3 PLANT WATER USE

Water is required to support the facility during construction and operation. Typical water uses for facility operation include the circulating water systems (CWS), potable and sanitary water system, fire protection system, and other auxiliary systems such as demineralized water and a liquid radioactive waste treatment system. The primary water source for plant operations is to be water withdrawn from the Clinch River arm of Watts Bar Reservoir via a new intake structure. During construction activities, water for concrete batch plant operation is to be provided by the City of Oak Ridge. Surface water from the Clinch River Arm of the Watts Bar Reservoir may be used during construction for purposes such as dust control. Water for potable and sanitary uses during both construction and operations are to be obtained from the City of Oak Ridge.

3.3.1 Water Consumption

A water-use diagram for the surrogate facility is provided in Figure 3.3-1. The diagram shows the average and maximum flow rates for the intake and discharge from the reservoir, the rates for consumptive uses, and the relationships between the various water flow systems. The average values are the expected limiting values for normal plant operation with cooling tower operation at four cycles of concentration, and the maximum values are those for cooling tower operation at two cycles of concentration.

The source of water for facility operations is to be the Clinch River arm of the Watts Bar Reservoir. The proposed water intake is located at approximately Clinch River Mile (CRM) 17.9. The intake is to withdraw an average of approximately 18,423 gallons per minute (gpm), and a maximum of approximately 30,708 gpm. Of this total, approximately 17,078 gpm average (approximately 25,608 gpm maximum) is to serve as makeup water for the CWS. The proposed CWS uses mechanical draft cooling towers for heat dissipation from the systems.

Mechanical draft cooling towers consume some water through evaporation and drift. The average and maximum drift rate is estimated to be 8 gpm, and the average and maximum evaporation rate is estimated to be 12,800 gpm. The blowdown from the cooling towers is to be distributed to a holding pond, used for discharge mixing, on the western edge of the site. The blowdown rate is estimated to be an average of 4270 gpm, and a maximum of 12,800 gpm. The holding pond, in turn, discharges water back to the reservoir through the proposed discharge located at CRM 15.5.

The operational modes for the cooling water system are to be defined once a specific reactor design is selected.

Of the total intake withdrawal volume, an average of 1345 gpm (and a maximum of 5100 gpm) is to be directed to the plant and facilities, from which it is to be distributed for use to various auxiliary systems. The consumptive uses of water within these systems are estimated to be negligible. The specific water volumes distributed to each of these individual uses have not been defined, but are to be developed once the reactor design has been selected. The estimated effluent from the miscellaneous raw water users, miscellaneous demineralized water users, and fire protection system are distributed to the holding pond at an average flow rate of 445 gpm and maximum flow rate of 4200 gpm. The effluent from the liquid radioactive waste treatment system is to be discharged directly to the reservoir through the proposed discharge at CRM 15.5, at a maximum flow rate of 900 gpm.

The UHS for the facility is to be a dedicated reservoir of water within the power block area. The source of water for the UHS is addressed at combined license application (COLA). The amount of water required for maintenance of the UHS reservoir is considered to be negligible.

The source of water for the potable and sanitary water systems, as well as concrete batch plant operation, is to be municipal water from the City of Oak Ridge Public Works Department. Consumptive uses of this water are expected to be negligible, and the wastewater is to be discharged to the City of Oak Ridge sanitary treatment system. The water supply rate for the potable and sanitary water systems is estimated to average 50 gpm, with a maximum rate of 100 gpm. The water supply rate for concrete batch plant operation is estimated to average 34 gpm. The City of Oak Ridge obtains the municipal water from Melton Hill Reservoir (Reference 3.3-1).

Surface water may be used during construction for purposes such as dust control.

3.3.2 Water Treatment

Tennessee Valley Authority uses biocides and other chemicals to treat cooling and process water at other facilities, and expects similar treatment at the CRN Site. Specific anti-fouling methods are to be defined at COLA, following selection of a reactor design. The quantities and concentrations of chemicals to be used will be in accordance with a Biocide/Corrosion Treatment Plan, which will be submitted as part of the National Pollution Discharge Elimination System permit application to the Tennessee Department of Environment and Conservation.

3.3.3 References

Reference 3.3-1. City of Oak Ridge, Tennessee, "Annual Water Quality Report 2014," TN0000522, 2014.

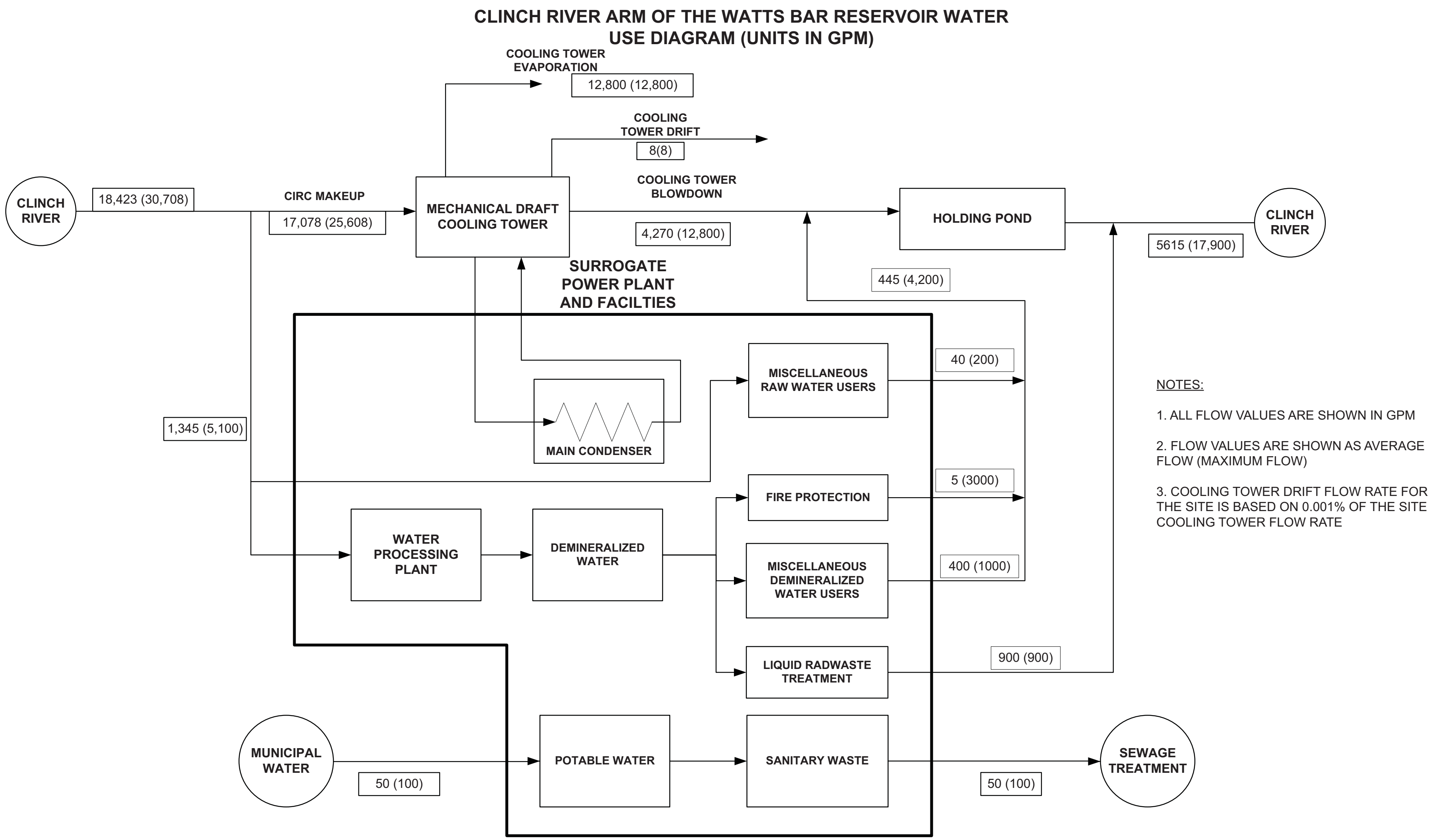


Figure 3.3-1. CRN Site Water Use Diagram

3.4 COOLING SYSTEM

The cooling systems planned for the operation of two or more small modular reactors (SMRs) at the Clinch River Nuclear (CRN) Site are described in Subsection 3.4.1. Design data and performance characteristics for these cooling system components are presented in Subsection 3.4.2. The parameters are used to evaluate the impacts to the environment from cooling system operation. The environmental interfaces of these systems are the plant intake and discharge structures as well as the cooling towers.

3.4.1 Description and Operational Modes

3.4.1.1 System Description

The circulating water systems (CWS) for the facility is planned as a closed-cycle cooling with mechanical draft cooling towers as the mechanism for cooling the main condenser. The design assumes makeup water for the CWS is obtained from an intake on the Clinch River arm of the Watts Bar Reservoir, pumped into the cooling towers, and circulated in and out of the main condenser. A portion of the water is lost as evaporation and drift from the cooling towers. The remainder of the water becomes blowdown from the mechanical draft cooling towers. The blowdown passes through a holding pond on its way to the Clinch River arm of the Watts Bar Reservoir through a discharge planned to be located at approximately Clinch River Mile 15.5.

A description of the service water system planned for the facility is beyond the level of detail required for an early site permit application.

The safety-related ultimate heat sink (UHS) planned for the facility is a dedicated reservoir of water within the power block area. The source of water for the UHS is addressed at combined license application (COLA). The amount of water required for maintenance of the UHS reservoir is considered to be negligible.

3.4.1.2 Operational Modes

The operational modes for the cooling water systems have not been defined. Once the SMR reactor technology has been selected, the operational modes for the cooling water systems are to be determined and addressed at COLA. Tables 3.1-1 and 3.1-2, the plant parameter envelope (PPE), provide enveloping cooling system parameters, including water flow rates and heat transfer characteristics, for full operation. Water flow rates and heat transfer characteristics for other operational modes are to be designed within these parameters.

3.4.1.3 Heat Generated, Dissipated to the Atmosphere, and Released in Liquid Discharges

In full power operation mode, heat is transferred to circulating cooling water in the condensers. The PPE defines a maximum heat rejection rate to the circulating water of 5593 million British Thermal Units per hour (hr) (Table 3.1-2, Item 3.1.2). The CWS releases some of this heat to the atmosphere in the mechanical draft cooling towers, and releases the remainder of the heat to the Clinch River arm of the Watts Bar Reservoir through liquid discharges during blowdown of the cooling towers. The quantities of heat generated, dissipated to the atmosphere, and released in liquid discharges depend on the SMR technology selected and are addressed at COLA.

3.4.1.4 Water Source and Quantities of Water Withdrawn, Consumed, and Discharged

In full power operation mode, the CWS requires withdrawal of makeup water from the Clinch River arm of the Watts Bar Reservoir. A flow chart showing the use of water by the facility, including the CWS, is provided in Figure 3.3-1. The makeup water is withdrawn through the intake at a maximum rate of 25,608 gallons per minute (gpm), and an average rate of 17,078 gpm (Table 3.1-2, Item 3.3.9). Cooling tower water is released to the environment through evaporation, drift, and blowdown. Evaporation and drift are consumptive losses because water is not returned to the Clinch River arm of the Watts Bar Reservoir. The expected and maximum evaporation rate is 12,800 gpm (Table 3.1-2, Item 3.3.7), and the rate of drift is 8 gpm (Table 3.1-2, Item 3.3.17). The short-term and monthly average consumptive water use is 12,808 gpm (Table 3.1-2, Item 3.3.14). The normal blowdown rate, based on four cycles of concentration, is 4270 gpm (Table 3.1-2, Item 3.3.4). The estimated maximum blowdown rate, based on two cycles of concentration, is 12,800 gpm (Table 3.1-2, Item 3.3.4).

Miscellaneous plant water is withdrawn from the Clinch River arm of the Watts Bar Reservoir at a maximum rate of 5100 gpm and an average rate of 1345 gpm (Table 3.1-2, Item 3.2.3). As shown in Figure 3.3-1, discharges from the liquid radioactive waste treatment system (at a maximum of 900 gpm; Table 3.1-2, Item 10.2.1) discharge directly to the Clinch River arm of the Watts Bar Reservoir and miscellaneous raw water users, miscellaneous demineralized water users, and fire protection system (at a maximum of 4200 gpm and an average of 445 gpm) flow to the holding pond. An additional source of water shown in Figure 3.3-1 is municipal water. This water services the potable water and sanitary waste systems at an average of 50 gpm and maximum of 100 gpm (Table 3.1-2, Items 5.1.1 and 5.1.2) and discharges to a sewage treatment plant at the same rate with no appreciable water loss.

3.4.2 Component Descriptions

The layout of various components of the CWS, including the intake, holding pond, and discharge, are shown on Figure 3.1-2. These systems are described in Subsections 3.4.2.1 through 3.4.2.4. Subsection 3.4.2.5 describes the modifications planned for the Melton Hill Dam to ensure a minimum flow rate in the Clinch River arm of the Watts Bar Reservoir at the facility discharge pipe. The following subsections provide a description of each of these components.

3.4.2.1 Intake System

The location of the water intake is shown in Figure 3.1-1. Figure 3.4-2 shows the general configuration of the intake structure with respect to the Clinch River arm of the Watts Bar

Reservoir, and Figure 3.4-3 provides a more detailed depiction of the intake channels, trash racks, flow baffles, and pumps. A cross-sectional view of the intake is shown in Figure 3.4-4.

As shown on Figures 3.4-3 and 3.4-4, the intake system is planned to be approximately 50 feet (ft) in width and 50 ft in length with four intake channels. Each channel includes a stop log slot and bar screen with debris raking system and trash racks, leading to dual flow screens. Once through the screens, the flow from the four channels is re-combined behind a flow baffle, and then separated again into four channels, each serviced by two pumps. Screen wash pumps allow debris to be removed from the dual flow screens. The water is then pumped to the CWS through two pipelines.

The design of the intake structure will comply with the Clean Water Act 316(b) regulations by providing aquatic life protection. The maximum intake inlet velocities, trash rack flow-through velocity, and through-flow velocity at the water screens will be less than 0.5 ft per second. A common intake structure for all reactors is planned for the shoreline with the intake structure front face located at the existing river bank as shown on Figure 3.4-2.

The flow velocities for operational modes other than full power operation have not yet been defined, pending selection of the SMR reactor technology. The anti-fouling methods to be used on the water also have not yet been defined, and is addressed at COLA. The quantities of chemicals used for treatments of intake or process waters will be in accordance with a Biocide/Corrosion Treatment Plan which will be approved by the Tennessee Department of Environment and Conservation (TDEC) and submitted as required with the National Pollutant Discharge Elimination System (NPDES) permit application for the facility.

3.4.2.2 Holding Pond

As shown in Figure 3.3-1, CWS design sends blowdown from the cooling towers through a holding pond on the western side of the CRN Site on its way to the discharge structure located on the Clinch River arm of the Watts Bar Reservoir. The location of the holding pond is shown in Figure 3.1-2.

The planned holding pond is at a grade elevation of 763 ft. The approximate dimensions of the pond are approximately 230 ft wide and approximately 980 ft long, with a water depth of approximately 13 ft. The blowdown flow to the holding pond allows mixing of the blowdown with other plant discharges that enter the holding pond (Section 3.3). This, along with a brief exposure to the atmosphere, can reduce the temperature of the blowdown. However, in the hydrothermal analysis (Section 5.3) a conservative assumption was made not to include any change in temperature of the plant discharge in the holding pond. The purpose of the holding pond is only for mixing of plant discharges.

3.4.2.3 Discharge

A conceptual layout of the discharge is shown in Figure 3.4-5. The bottom geometry of the Clinch River arm of the Watts Bar Reservoir near the discharge location is shown in Figure 3.4-5. The water surface elevation in Watts Bar Reservoir is generally maintained between 735 ft and 741 ft above mean sea level (Reference 3.4-1). The conceptual layout shows the blowdown passing through an instrumentation vault for measurement of flow and temperature, and then continuing through the approach conduits to two diffuser conduits, each approximately 15 ft long (30 ft total length) and 3 ft in diameter. Two separate diffuser conduits allow flow to be isolated to only one conduit, if needed for maintenance. It also allows the exit velocity of the diffuser ports to be maintained, and therefore the rate of mixing to be maintained, in situations where the facility is not operating at full capacity.

The design of the diffuser ports provides an exit velocity of approximately 8 to 10 ft per second (fps). The discharge is estimated to have a maximum temperature of 90 degrees Fahrenheit (°F; Table 3.1-2, Item 3.3.5). The assumed maximum potential concentrations of chemical constituents within the blowdown are provided in Table 3.6-1.

Discharges to the Clinch River arm of the Watts Bar Reservoir are regulated by the TDEC through a NPDES permit. The CRN Site's NPDES permit will include discharge limits established to protect receiving waters, and monitoring requirements to ensure compliance with those limits. Temperatures and chemical concentrations for all discharges will be in compliance with the terms and conditions of the NPDES permit.

3.4.2.4 Heat Dissipation

The heat dissipation mechanism for the planned CWS is through mechanical draft cooling towers. The location of the cooling towers is within the plant area shown in Figure 3.1-2. The cooling tower location occupies an area of approximately 6 acres (Table 3.1-2, Item 3.3.1), and are expected to be a maximum of 65 ft high above plant grade (Table 3.1-2, Item 3.3.8). The quantity of water to be stored in the cooling towers is 5,000,000 gallons (Table 3.1-2, Item 3.3.16), and the water circulates through the cooling towers at a maximum rate of 755,000 gpm (Table 3.1-2, Item 3.3.12). The planned cooling towers are designed for a maximum blowdown temperature of 90°F at the point of discharge to the Clinch River arm of the Watts Bar Reservoir (Table 3.1-2, Item 3.3.5) and an 18°F temperature difference between the cooling water entering and leaving the cooling tower (Table 3.1-2, Item 3.3.11). A minimum of two and a maximum of four cycles of concentration are assumed within the cooling towers (Table 3.1-2, Item 3.3.6).

3.4.2.5 Bypass Flow

To maintain acceptable thermal limits for the cooling system, a bypass capable of providing a continuous flow of approximately 400 cubic ft per second (cfs) will be installed at Melton Hill Dam. The operating policy for Melton Hill Dam requires a minimum daily average release of 400 cfs (Reference 3.4-2). This minimum daily average release can be met, and has in the past been met, by operating the hydropower generating units for a period of only one hour per day. This can result in periods, potentially lasting up to 46 hr, where there are no releases from Melton Hill Dam. However, events during which there is no release from Melton Hill Dam for periods in excess of 36 hr are extremely rare. When this occurs, the flow in the Clinch River arm of the Watts Bar Reservoir becomes quiescent, making it difficult to dilute the plant thermal discharge without exceeding mixing zone guidelines or temperature requirements. Therefore, a bypass, which can produce a continuous flow rate of 400 cfs even when the hydropower generating units are not operating, will be installed at the dam.

3.4.3 References

Reference 3.4-1. Tennessee Valley Authority, "Clinch River Small Modular Reactor Site Regional Surface Water Use Study - Revision 2," April 24, 2015.

Reference 3.4-2. Tennessee Valley Authority, "Programmatic Environmental Impact Statement, Reservoir Operations Study," May, 2004.

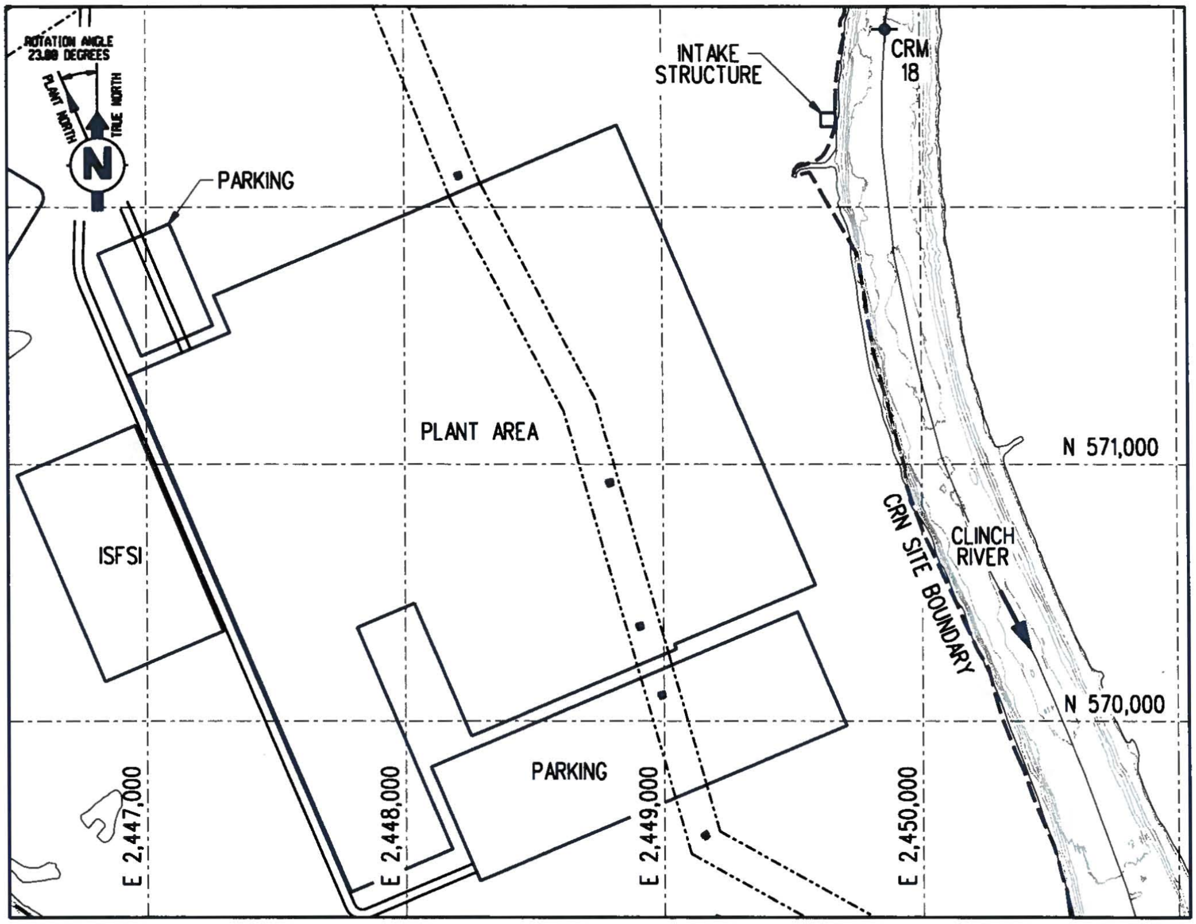


Figure 3.4-1. Location Plan of Intake Structure

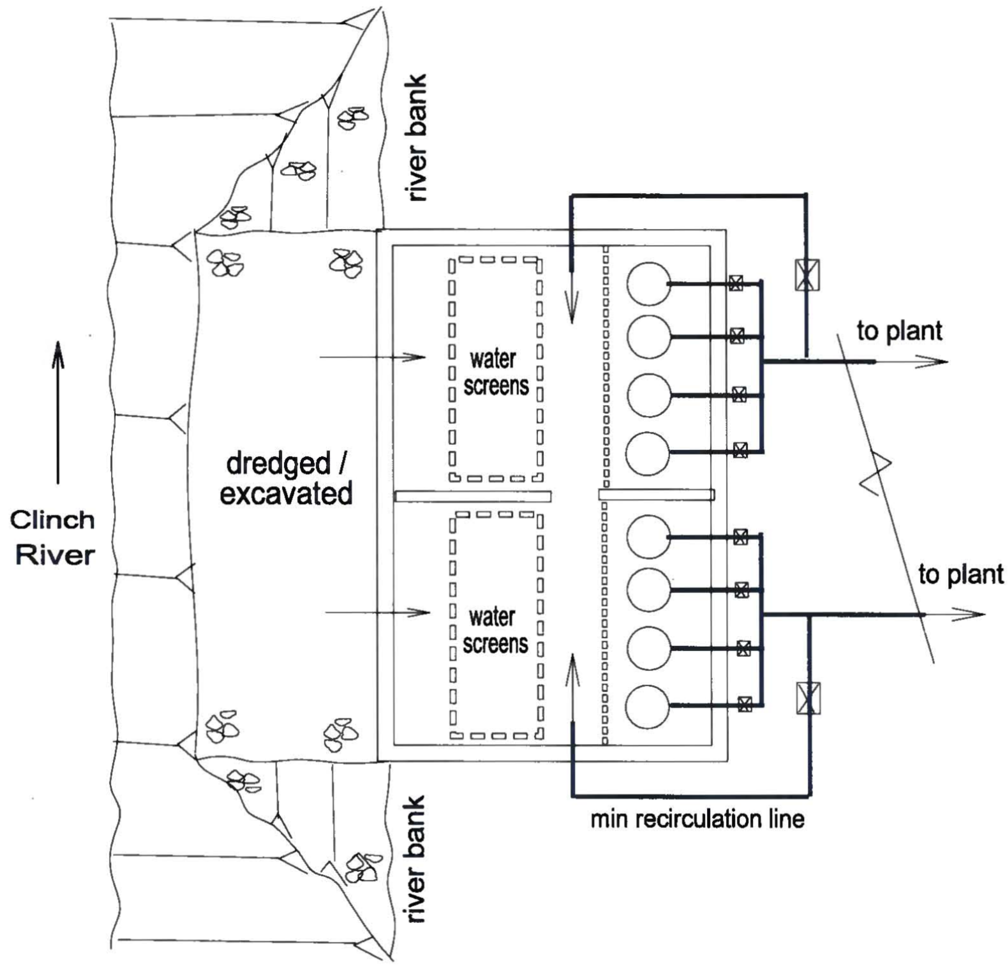


Figure 3.4-2. Conceptual Intake Structure Arrangement

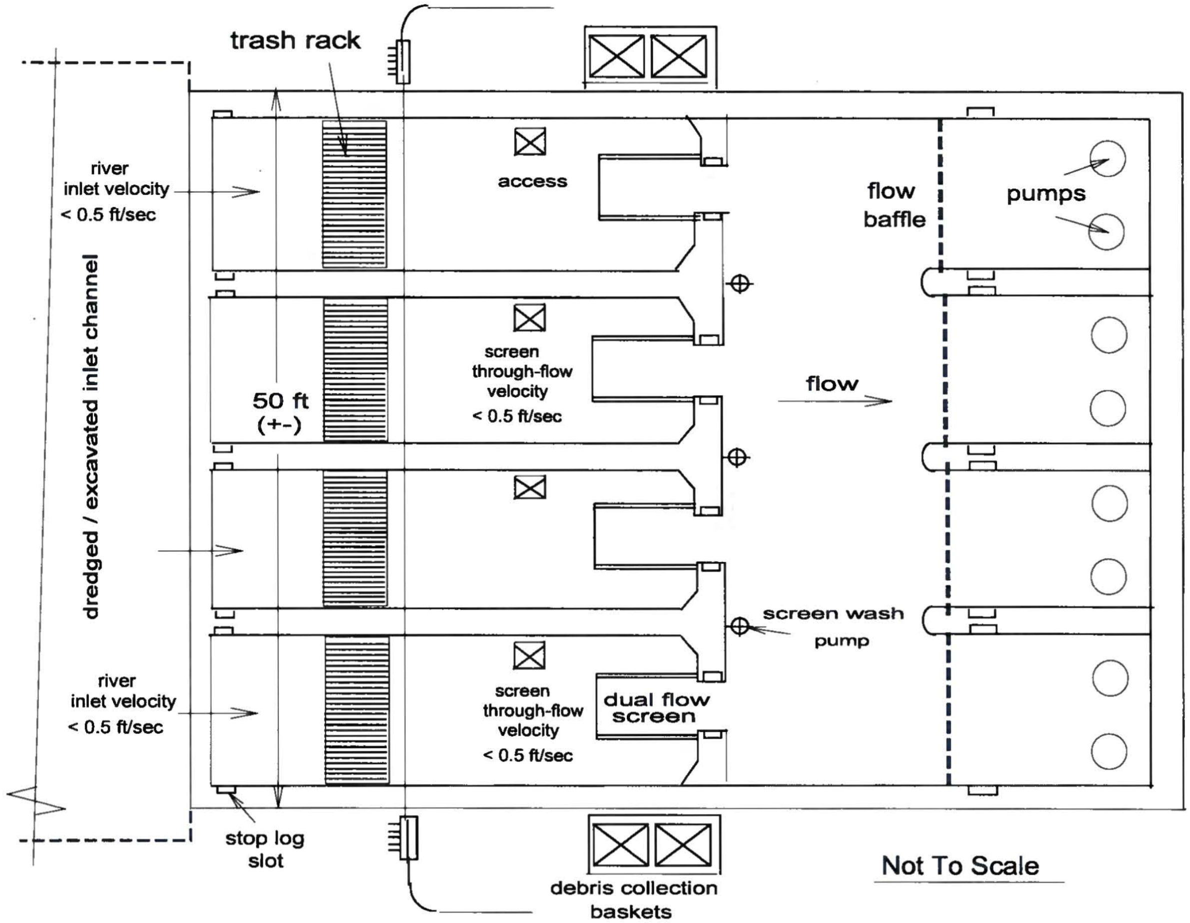


Figure 3.4-3. Conceptual Plan View of Intake Structure

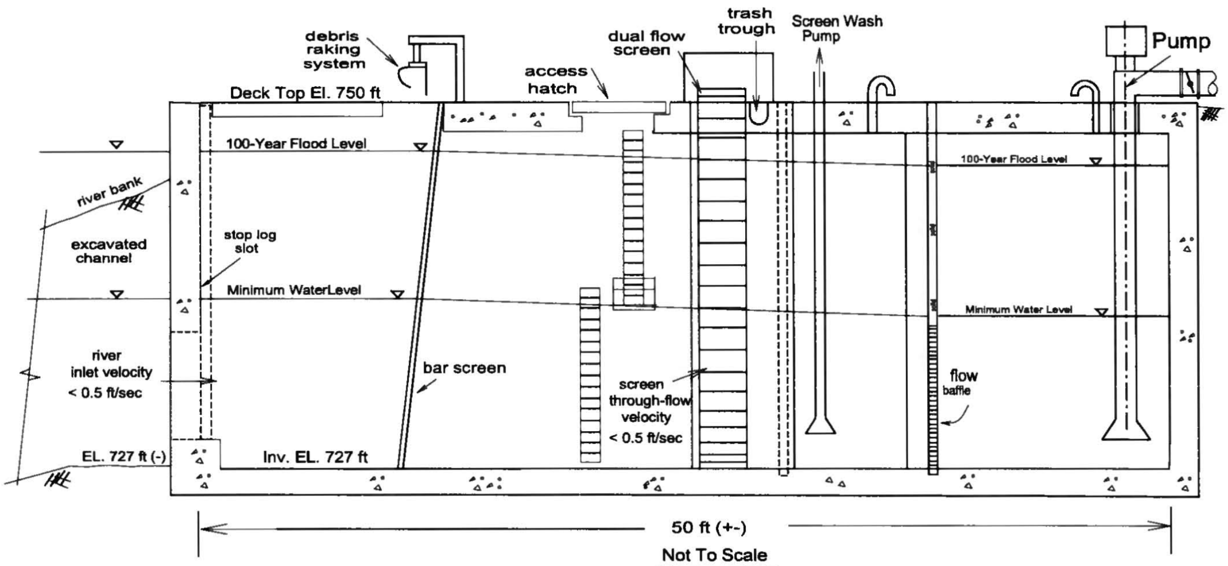


Figure 3.4-4. Conceptual Section View of Intake Structure

Figure 3.4-5. Conceptual Layout of Proposed Discharge Structure

3.5 RADIOACTIVE WASTE MANAGEMENT SYSTEM

Radioisotopes are produced during the normal operation of nuclear reactors through the processes of fission and activation. Fission products may enter the reactor coolant by diffusing from the fuel and then passing through the fuel cladding via leaks or by diffusion. The primary cooling water may contain dissolved or suspended corrosion products and nonradioactive materials leached from plant components. These products and materials can be activated by the neutrons in the reactor core as the water passes through the core. These radioisotopes leave the reactor coolant via plant systems designed to remove impurities, via small leaks that occur in the reactor coolant system and auxiliary systems, or via breaching of systems for maintenance. Therefore, each plant generates radioactive waste that can be liquid, solid, or gaseous.

This section describes the liquid, gaseous, and solid radioactive waste management systems proposed to be used as part of the operation of two or more Small Modular Reactors (SMRs) at the Clinch River Nuclear (CRN) Site. Because a reactor design has not been chosen for the project, bounding values have been developed for the quantities of radioactive wastes that are projected to be generated and processed and then stored or released as liquid or gaseous effluents or as solid waste. The radioactive waste management system is designed to minimize releases from reactor operations to values as low as reasonably achievable (ALARA). These systems are designed and maintained to meet the requirements of Title 10 of the Code of Federal Regulations (10 CFR) Part 20 and 10 CFR Part 50, Appendix I. The dose impacts from normal operation of the facility, including the management of the radioactive waste system, are provided in Section 5.4.

3.5.1 Liquid Waste Management Subsystem

The liquid radioactive waste system will be designed to control, collect, process, handle, store, and dispose of liquid radioactive waste generated as the result of normal operation, including anticipated operational occurrences. Sources of liquid radioactive waste include leakage from systems, wastes generated by processing systems, and maintenance activities. During the design phase of the proposed project, these sources and potential sources will be identified and collection and processing systems will be designed to remove the radioactivity to the extent that the processed liquid can be recycled or discharged in accordance with the requirements of 10 CFR 20 and the ALARA principles of 10 CFR Part 50, Appendix I. Discharges will be to the Clinch River arm of the Watts Bar Reservoir and will be controlled and monitored to measure the activity released. Liquid waste processing systems will be designed to maintain the radiation exposures of plant personnel as low as reasonably achievable. As provided in Table 3.5-1, the total projected bounding annual release activity in liquid effluents from the CRN Site is 887 curies per year (Ci/yr). Table 3.5-2 provides the total projected bounding annual release activity in liquid effluents from a single SMR unit as 221 Ci/yr.

3.5.2 Gaseous Radioactive Waste Management Subsystem

Typical gaseous radioactive wastes include vents from collection tanks and processing equipment and non-condensables in steam systems. The radioactive isotopes contained in these waste streams include fission product iodines and the noble gas fission products xenon and krypton as well as activation products such as argon-41 and cobalt-60. These wastes will be collected and processed to decrease the radioactivity content to the point that they can be released to the environment through a controlled and monitored release point (plant vent or plant stack). The typical processing technique is one of holdup or delay to allow the short-lived activity to decay. Adsorption on activated charcoal or compression and storage are two methods used to create the necessary holdup time. Processing systems will be designed to process gaseous wastes generated by normal plant operation and anticipated operational occurrences.

Minor leakage of radioactive gases from plant systems to building atmosphere will be detected by area radiation monitors. Ventilation systems will process these gases by filtration, if needed, and direct them to a controlled and monitored release point.

Gaseous radioactive waste discharges will be controlled to the requirements of 10 CFR 20 and the ALARA principles of 10 CFR Part 50, Appendix I. Gaseous radioactive waste system equipment will be designed to ensure occupational exposures to plant personnel are as low as reasonable achievable. As provided in Table 3.5-3, the total projected bounding release activity in gaseous waste from the CRN Site is 7130 Ci/yr. Table 3.5-4 provides the total projected bounding annual release activity in gaseous waste from a single SMR unit as 1550 Ci/yr.

3.5.3 Solid Radioactive Waste Management Subsystem

Solid radioactive wastes are produced by multiple activities in a nuclear power station. The solid waste can be either wet or dry, depending on whether the source is a processing activity, maintenance, or other function such as housekeeping. The solid radioactive waste management system is designed to collect, monitor, segregate, process, and prepare solid radioactive wastes prior to and for their shipment or onsite storage. The system design will ensure that the wastes are handled, processed, and stored in a manner that minimizes exposure to plant personnel and the public in accordance with 10 CFR 20 and 10 CFR Part 50, Appendix I. Wastes will be packaged to meet U.S. Department of Transportation (49 CFR 173 and 178) and U.S. Nuclear Regulatory Commission (10 CFR 71) regulations for transportation of radioactive material. Radioactive waste will be transported to either a licensed waste processing facility or a licensed low-level radioactive waste disposal facility. As provided in Table 3.5-5, the projected bounding total annual activity of solid radioactive waste from the CRN Site is 57,200 Ci/yr and, as provided in Table 3.1-2, Item 11.2.3, the projected bounding generated volume of solid radioactive waste from the CRN Site is 5000 cubic feet per year.

Table 3.5-1 (Sheet 1 of 2)
CRN Site Projected Average Normal Liquid Radioactive Release

Radionuclide	Release (Ci/yr)	Radionuclide	Release (Ci/yr)
Ag-110	3.48E-08	La-140	4.27E-03
Ag-110m	2.66E-02	La-141	8.80E-08
Am-241	1.85E-10	La-142	1.19E-08
Ba-137m	2.07E-03	Mn-54	6.53E-02
Ba-139	6.16E-08	Mn-56	1.09E-03
Ba-140	4.80E-02	Mo-99	4.52E-02
Br-82	7.48E-06	Na-24	8.40E-03
Br-83	1.41E-05	Nb-95	1.07E-03
Br-84	1.01E-03	Nd-147	1.07E-06
Br-85	9.68E-09	Ni-63	1.84E-01
C-14	9.83E-03	Np-239	2.99E-02
Ce-141	1.58E-04	P-32	3.03E-04
Ce-143	3.25E-04	Pr-143	6.93E-05
Ce-144	2.99E-03	Pr-144	1.69E-03
Cm-242	3.78E-08	Pu-238	2.64E-09
Cm-244	1.76E-09	Pu-239	3.39E-10
Co-58	5.51E-02	Pu-240	4.27E-10
Co-60	8.21E-03	Pu-241	1.28E-07
Cr-51	1.28E-01	Rb-86	7.48E-05
Cs-134	3.44E-02	Rb-88	1.49E-02
Cs-136	1.17E-02	Rb-89	6.18E-04
Cs-137	4.24E-02	Rh-103m	4.37E-06
Cs-138	1.42E-02	Rh-105	4.27E-07
Cu-64	6.72E-03	Rh-106	3.74E-07
Fe-55	4.87E-02	Ru-103	2.63E-03
Fe-59	1.19E-02	Ru-105	7.04E-08
H-3	8.85E+02	Ru-106	3.92E-02
I-129	5.04E-09	Sb-124	2.29E-04
I-130	1.85E-05	Sb-125	7.92E-09
I-131	1.66E-01	Sb-127	4.40E-08
I-132	1.32E-01	Sb-129	1.76E-08
I-133	2.76E-01	Sr-89	1.67E-04
I-134	3.91E-02	Sr-90	1.43E-05
I-135	1.64E-01	Sr-91	6.67E-04

Table 3.5-1 (Sheet 2 of 2)
CRN Site Projected Average Normal Liquid Radioactive Release

Radionuclide	Release (Ci/yr)	Radionuclide	Release (Ci/yr)
Sr-92	2.36E-04	Te-134	1.06E-06
Tc-99	1.76E-08	W-187	6.30E-04
Tc-99m	2.27E-02	Y-90	1.86E-06
Te-127	1.28E-05	Y-91	1.25E-04
Te-127m	5.72E-06	Y-91m	2.67E-05
Te-129	1.65E-04	Y-92	9.01E-04
Te-129m	6.90E-02	Y-93	7.25E-04
Te-131	4.05E-05	Zn-65	2.11E-02
Te-131m	1.98E-03	Zr-95	2.20E-03
Te-132	1.32E-01	Zr-97	4.40E-07
Total Liquid Radionuclide Release Activity			8.87E+02

Table 3.5-2 (Sheet 1 of 2)
Liquid Effluent Activities Per Reactor

Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)
Ag-110	8.69E-09	I-134	3.26E-03
Ag-110m	2.22E-03	I-135	1.37E-02
Am-241	4.62E-11	La-140	1.07E-03
Ba-137m	5.17E-04	La-141	2.20E-08
Ba-139	1.54E-08	La-142	2.97E-09
Ba-140	1.60E-02	Mn-54	5.44E-03
Br-82	1.87E-06	Mn-56	2.72E-04
Br-83	3.52E-06	Mo-99	3.77E-03
Br-84	8.38E-05	Na-24	2.80E-03
Br-85	2.42E-09	Nb-95	2.67E-04
C-14	8.19E-04	Nd-147	2.67E-07
Ce-141	3.96E-05	Ni-63	1.53E-02
Ce-143	8.13E-05	Np-239	2.49E-03
Ce-144	7.47E-04	P-32	7.57E-05
Cm-242	9.46E-09	Pr-143	1.73E-05
Cm-244	4.40E-10	Pr-144	4.21E-04
Co-58	5.20E-03	Pu-238	6.60E-10
Co-60	2.05E-03	Pu-239	8.47E-11
Cr-51	1.07E-02	Pu-240	1.07E-10
Cs-134	2.87E-03	Pu-241	3.19E-08
Cs-136	2.93E-03	Rb-86	1.87E-05
Cs-137	3.53E-03	Rb-88	3.73E-03
Cs-138	1.18E-03	Rb-89	5.15E-05
Cu-64	1.68E-03	Rh-103m	3.64E-07
Fe-55	4.06E-03	Rh-105	1.07E-07
Fe-59	9.92E-04	Rh-106	9.35E-08
H-3	2.21E+02	Ru-103	6.57E-04
I-129	4.20E-10	Ru-105	1.76E-08
I-130	4.62E-06	Ru-106	9.80E-03
I-131	1.38E-02	Sb-124	5.73E-05
I-132	4.40E-02	Sb-125	1.98E-09
I-133	2.30E-02	Sb-127	1.10E-08

Table 3.5-2 (Sheet 2 of 2)
Liquid Effluent Activities Per Reactor

Isotope	Release (Ci/yr)	Isotope	Release (Ci/yr)
Sb-129	4.40E-09	Te-131m	6.60E-04
Sr-89	4.19E-05	Te-132	4.40E-02
Sr-90	3.57E-06	Te-134	2.64E-07
Sr-91	1.67E-04	W-187	2.10E-04
Sr-92	5.91E-05	Y-90	1.55E-07
Tc-99	4.40E-09	Y-91	3.13E-05
Tc-99m	1.89E-03	Y-91m	6.67E-06
Te-127	3.19E-06	Y-92	2.25E-04
Te-127m	1.43E-06	Y-93	1.81E-04
Te-129	4.13E-05	Zn-65	1.76E-03
Te-129m	2.30E-02	Zr-95	1.83E-04
Te-131	1.01E-05	Zr-97	1.10E-07
		Total Liquid Effluent Activity	2.21E+02

Table 3.5-3 (Sheet 1 of 2)
CRN Site Project Average Normal Gaseous Radioactive Release

Radionuclide	Release (Ci/yr)	Radionuclide	Release (Ci/yr)
Ag-110m	2.14E-03	La-140	1.12E-03
Ar-41	5.44E+02	Mn-54	5.22E-03
Ba-140	1.67E-02	Mn-56	2.17E-03
Br-84	1.28E-05	Mo-99	3.68E-02
C-14	1.00E+01	Na-24	2.50E-03
Ce-141	5.68E-03	Nb-95	7.50E-03
Ce-143	1.16E-07	Ni-63	1.46E-02
Ce-144	1.17E-05	Np-239	7.35E-03
Co-57	1.10E-04	P-32	5.68E-04
Co-58	6.90E-02	Pr-144	1.17E-05
Co-60	2.64E-02	Rb-88	9.80E-06
Cr-51	2.17E-02	Rb-89	2.67E-05
Cs-134	6.90E-03	Rh-103m	1.48E-08
Cs-136	3.68E-04	Rh-106	4.57E-11
Cs-137	3.26E-02	Ru-103	2.17E-03
Cs-138	1.05E-04	Ru-106	2.34E-04
Cu-64	6.18E-03	Sb-124	1.12E-04
Fe-55	4.01E-03	Sb-125	3.77E-05
Fe-59	9.55E-04	Sr-89	9.00E-03
H-3	1.01E+03	Sr-90	3.60E-03
I-129	8.02E-11	Sr-91	6.18E-04
I-131	2.31E-01	Sr-92	4.84E-04
I-132	1.35E+00	Tc-99m	1.83E-04
I-133	1.05E+00	Te-129m	1.35E-04
I-134	2.33E+00	Te-131m	4.68E-05
I-135	1.49E+00	Te-132	7.13E-05
Kr-83m	1.28E-02	W-187	1.17E-04
Kr-85	7.20E+02	Xe-131m	1.67E+03
Kr-85m	3.39E+02	Xe-133	2.24E+03
Kr-87	3.27E+01	Xe-133m	1.05E+02
Kr-88	1.45E+02	Xe-135	2.82E+02
Kr-89	5.00E-07	Xe-135m	1.28E+01

Table 3.5-3 (Sheet 2 of 2)
CRN Site Projected Average Normal Gaseous Radioactive Release

Radionuclide	Release (Ci/yr)	Radionuclide	Release (Ci/yr)
Xe-137	3.00E+00	Y-92	3.84E-04
Xe-138	1.14E+01	Y-93	6.86E-04
Y-90	2.84E-05	Zn-65	6.86E-03
Y-91	1.49E-04	Zr-95	3.00E-03
		Total Gaseous Radionuclide Release Activity	7.13E+03

Table 3.5-4 (Sheet 1 of 2)
Gaseous Effluent Activities Per Reactor

Radionuclide	Release (Ci/yr)	Radionuclide	Release (Ci/yr)
Ag-110m	1.78E-04	La-140	2.79E-04
Ar-41	4.00E+01	Mn-54	8.35E-04
Ba-140	4.17E-03	Mn-56	5.42E-04
Br-84	1.07E-06	Mo-99	9.19E-03
C-14	7.30E+00	Na-24	6.25E-04
Ce-141	1.42E-03	Nb-95	2.50E-03
Ce-143	9.63E-09	Ni-63	1.22E-03
Ce-144	2.92E-06	Np-239	1.84E-03
Co-57	2.75E-05	P-32	1.42E-04
Co-58	2.30E-02	Pr-144	2.92E-06
Co-60	8.80E-03	Rb-88	8.17E-07
Cr-51	5.42E-03	Rb-89	6.67E-06
Cs-134	2.30E-03	Rh-103m	1.23E-09
Cs-136	9.19E-05	Rh-106	3.81E-12
Cs-137	8.14E-03	Ru-103	5.42E-04
Cs-138	2.63E-05	Ru-106	7.80E-05
Cu-64	1.54E-03	Sb-124	2.79E-05
Fe-55	1.00E-03	Sb-125	9.42E-06
Fe-59	1.25E-04	Sr-89	3.00E-03
H-3	3.10E+02	Sr-90	1.20E-03
I-129	6.68E-12	Sr-91	1.54E-04
I-131	7.70E-02	Sr-92	1.21E-04
I-132	3.38E-01	Tc-99m	4.59E-05
I-133	2.63E-01	Te-129m	3.38E-05
I-134	5.84E-01	Te-131m	1.17E-05
I-135	3.72E-01	Te-132	5.94E-06
Kr-83m	1.07E-03	W-187	2.92E-05
Kr-85	1.21E+02	Xe-131m	2.75E+02
Kr-85m	8.47E+01	Xe-133	5.61E+02
Kr-87	8.18E+00	Xe-133m	2.63E+01
Kr-88	3.63E+01	Xe-135	7.04E+01
Kr-89	1.25E-07	Xe-135m	3.19E+00

Table 3.5-4 (Sheet 2 of 2)
Gaseous Effluent Activities Per Reactor

Radionuclide	Release (Ci/yr)	Radionuclide	Release (Ci/yr)
Xe-137	7.50E-01	Y-92	9.60E-05
Xe-138	2.86E+00	Y-93	1.71E-04
Y-90	7.09E-06	Zn-65	1.71E-03
Y-91	3.72E-05	Zr-95	1.00E-03
		Total Gaseous Effluent Activity	1.55E+03

Table 3.5-5
Projected Principal Radionuclides in Solid Radioactive Waste from the CRN Site

Radionuclide	Composite (Site Value) (Ci/yr)	Radionuclide	Composite (Site Value) (Ci/yr)
Ag-110m	2.84E-02	Mn-54	1.57E+03
Ba-137m	1.01E+04	Mn-56	5.52E+02
Ba-140	1.38E+01	Mo-99	1.24E+01
Br-83	8.16E+00	Nb-95	2.00E-01
Br-84	3.96E-01	Ni-63	8.78E+03
Br-85	4.35E-03	Np-239	6.98E+00
C-14	1.76E-01	Pu-241	7.04E-02
Ce-144	6.60E-01	Rb-86	3.45E+01
Co-58	3.77E+02	Rb-88	2.93E+01
Co-60	2.84E+02	Rb-89	1.14E+00
Cr-51	3.44E+02	Sr-89	5.28E+01
Cs-134	1.11E+04	Sr-90	1.27E+01
Cs-136	2.00E+03	Sr-91	1.35E+00
Cs-137	1.06E+04	Sr-92	1.16E-01
Cs-138	1.23E+01	Tc-99m	5.64E-01
Fe-55	1.85E+03	Te-127m	5.78E-01
Fe-59	5.14E+01	Te-131m	1.75E-01
H-3	9.92E-01	Te-132	5.51E+00
I-129	3.99E-03	Y-90	1.24E+01
I-130	1.04E+01	Y-91	6.36E-01
I-131	6.33E+03	Y-91m	4.05E-01
I-132	2.29E+02	Y-92	4.86E-02
I-133	1.93E+03	Y-93	1.05E-04
I-134	8.49E+00	Zn-65	4.33E+02
I-135	4.41E+02	Zr-95	4.42E-02
La-140	1.24E+01	Other	1.852E+01
		Total Activity from Solid Waste	5.72E+04

3.6 NON-RADIOACTIVE WASTE SYSTEM

This section provides a general discussion of typical non-radioactive solid, liquid, and gaseous waste streams generated by the construction and operation of two or more small modular reactors (SMRs) at the Clinch River Nuclear (CRN) Site. Typical non-radioactive waste streams include cooling water that may contain water treatment chemicals or biocides, water-treatment wastes, waste from floor and equipment drains, stormwater runoff, water pumped from excavations during construction, laboratory waste, trash, hazardous waste, effluents from the sanitary sewer system, and miscellaneous gaseous, liquid and solid effluents.

Detailed information regarding the non-radioactive waste management and effluent control systems, process/instrumentation diagrams, and system process flow diagrams are provided as part of the combined license application, submitted following reactor technology selection. The system design in this section is derived from the surrogate plant described by the plant parameter envelope detailed in Section 3.1.

3.6.1 Effluents Containing Chemicals or Biocides

As discussed in Subsection 3.3.2, water used in various SMR operational systems requires treatment using chemicals and/or biocides to avoid scaling or fouling. The rates of inflow into and blowdown out of the water systems are to be managed, and effluents from the systems are to be processed to minimize the concentrations of the chemicals and biocides contained in facility discharges. However, facility discharges may contain low-level concentrations of chemicals and/or biocides. The chemical concentrations in effluent streams are to be controlled through engineering and operational/administrative controls to meet the requirements of a Tennessee Department of Environment and Conservation (TDEC)-approved Biocide/Corrosion Treatment Plan and of a National Pollutant Discharge Elimination System (NPDES) permit, as well as requirements and limitations set by relevant federal, regional, or local regulatory agencies at the time of construction and operation. The specific chemicals and biocides to be used depend upon the characteristics of the water to be treated and the design requirements of the SMR systems. The anticipated constituents and their concentrations in the facility's non-radioactive liquid waste discharges are provided in Table 3.6-1.

3.6.2 Sanitary System Effluents

The proposed facility discharges sanitary wastewaters to the City of Oak Ridge Public Works Department. The City of Oak Ridge operates two wastewater treatment plants. The main plant has a capacity of 30.0 million gallons per day (mgd), and the Rarity Ridge plant, which serves the Clinch River Industrial Park, East Tennessee Technology Park, Horizon Center, and Rarity Ridge, has a capacity of 0.6 mgd. The plants treat a combined flow of 5.6 mgd (Reference 3.6-1). The main plant discharges effluent to East Fork Poplar Creek under TDEC NPDES Permit TN0024155 (Reference 3.6-2). The Rarity Ridge Plant discharges effluent to the Clinch River arm of the Watts Bar Reservoir at Clinch River Mile (CRM) 12.85 under TDEC NPDES Permit TN0078051 (Reference 3.6-3).

The projected effluent flow from the facility's potable/sanitary water system to the City of Oak Ridge sanitary treatment system is included in Table 3.1-2, Item 5.1.1, and is estimated to average 50 gallons per minute (gpm). This equates to an average daily flow of 72,000 gallons per day (gpd). The estimated maximum flow rate, included in Table 3.1-2, Item 5.1.2, is 100 gpm, or a maximum daily flow of 144,000 gpd.

The City of Oak Ridge manages an Industrial Pretreatment Program for Industrial Users (IUs) of their wastewater system. IUs are required to obtain and comply with industrial pretreatment discharge permits (Reference 3.6-4). Prior to construction, Tennessee Valley Authority (TVA) will coordinate with the City of Oak Ridge to determine whether or not the facility qualifies as an IU; if so, TVA will apply for an industrial pretreatment discharge permit.

3.6.3 Other Effluents

This subsection addresses gaseous, liquid, and solid effluents that are non-radioactive.

3.6.3.1 Gaseous Effluents

Operation of two or more SMRs emits gaseous and particulate emissions to the air. The cooling tower is expected to be the primary source of particulate emissions. The primary sources of emissions from auxiliary systems are expected to be auxiliary boilers, standby diesel generators, and emergency standby gas turbine generators. These effluents commonly include particulates, sulfur oxides, carbon monoxide, hydrocarbons, and nitrogen oxides. The auxiliary boilers are to be used for heating the facility buildings, primarily during the winter months, and for process steam during reactor startups. The diesel generators / gas turbines and engine-driven emergency equipment are to be used intermittently and for brief durations.

As stated in Table 3.1-2, Item 13.1, the design auxiliary boiler exhausts at grade, and its estimated emissions are provided in Table 3.6-2. The standby diesel generators' exhaust is at a design elevation of 25 feet (ft) above grade (Table 3.1-2, Item 14.1.2), and their estimated emissions are provided in Table 3.6-3. The design gas turbine exhaust elevation is 50 ft above grade (Table 3.1-2, Item 14.2.2), and its estimated emissions are provided in Table 3.6-4.

TVA will consult with TDEC on air permit requirements following technology selection.

3.6.3.2 Liquid Effluents

Non-radioactive liquid effluents are designed to be discharged to the Clinch River arm of Watts Bar Reservoir. Nonradioactive discharges to surface water from the facility during construction include water pumped from excavations and stormwater. Nonradioactive wastewater discharges to surface water from the facility during operations include cooling tower blowdown; wastewater from the demineralized water system; wastewater from floor drains, sinks, and laboratories; and stormwater runoff. Additional aqueous waste streams may include raw cooling water, air conditioning condensate, steam generator blowdown, and high pressure fire protection water.

Effluent from cooling water system is designed to be discharged via mechanical draft cooling tower.

The preliminary grading plan includes a holding pond on the western side of the CRN Site, which serves as the collection point for most process waste streams except sanitary wastes and some stormwater discharges. The proposed holding pond discharges to Watts Bar Reservoir through one or more diffusers located at CRM 15.5.

The facility’s wastewater discharges will be regulated by TDEC through the NPDES permit. The NPDES permit will include discharge limits established to protect receiving waters, and monitoring to ensure compliance with those limits. Temperatures and chemical concentrations for all discharges will be in compliance with the terms and conditions of the NPDES permit.

The CRN Site currently has a stormwater management system consisting of stormwater runoff/collection ponds and piping. This system is to be modified, as needed, to support the CR SMR Project. Stormwater will be managed in accordance with a site-specific Stormwater Pollution Prevention Plan (SWPPP), which will be developed to prevent or minimize the discharge of pollutants with stormwater, and best management practices (BMPs) initiated through the SWPPP will be employed to control stormwater runoff. BMPs are to be implemented in accordance with existing TVA BMPs and the Construction Stormwater Permit, and may include one or more of the methods described in the State of Tennessee Erosion and Sediment Control Handbook (Reference 3.6-5).

The stormwater management system may include use of existing ponds and/or construction of one or more new ponds, depending on the facility configuration and the technology chosen. Stormwater management may include settling of solids, but would not involve any additional treatment, oil/water separators, or settling tanks. As part of the application for a NPDES permit, TVA will submit a Notice of Intent for Construction Activity Stormwater Discharges and an associated SWPPP to TDEC. The NPDES permit would be obtained before any construction activities take place.

Water pumped from excavations during construction are also to be managed through the stormwater management system. Flow from de-watering would be routed to either an existing stormwater retention pond or to a new pond installed as part of the initial phase of construction. The water would be managed using the same BMPs and under the same SWPPP as stormwater (Reference 3.6-5).

3.6.3.3 Solid Effluents

Operation of the proposed facility results in the generation of hazardous and nonhazardous nonradioactive solid waste. Non-radioactive solid wastes include typical industrial wastes such as metal, wood, and paper, as well as process wastes including hazardous and universal wastes. TVA maintains multiple procedures related to the management of non-radioactive solid waste.

The facility is expected to generate used oil from equipment maintenance. TVA maintains procedures for management of used oil at their facilities, and these TVA procedures are to be followed for used oil wastes generated at the CR SMR Project. Used oil wastes are to be disposed using a TVA-approved vendor.

The facility is also expected to generate paint wastes, solvent wastes, and laboratory wastes, and is expected to be a Small Quantity Generator of Hazardous Wastes. These wastes are to be disposed using a TVA-approved vendor. TVA maintains procedures for management of hazardous waste at their facilities, and these TVA procedures are to be followed for hazardous wastes generated at the CR SMR Project.

Typical nonhazardous solid waste generated include municipal solid waste, debris collected on trash screens at the water intake structure, and construction and demolition waste. Solid waste is to be managed by a TVA-approved solid waste disposal vendor and disposed in a state-approved sanitary landfill. Debris collected on trash screens at the water intake structure would likely be designated as special wastes, and managed and disposed in accordance with TVA procedures.

Universal wastes (i.e., lamps, batteries, and pesticides) would also be generated and are to be managed using TVA-approved vendors. Universal wastes, including batteries, lamps, and pesticides, are to be managed in accordance with TVA procedures.

TVA will comply with applicable federal, state, and local requirements and standards for handling, transporting, and disposing of solid waste. These include the 1976 Resource Conservation and Recovery Act, which amended the 1965 Solid Waste Disposal Act.

3.6.4 References

Reference 3.6-1. City of Oak Ridge, City of Oak Ridge Wastewater Treatment System Webpage, Website: http://www.oakridgetn.gov/department/PublicWorks/Divisions/Wastewater-Treatment, 2015.

Reference 3.6-2. Tennessee Department of Environment and Conservation, Oak Ridge Main Sewage Treatment Plant NPDES Permit TN0024155, Website: http://environment-online.state.tn.us:8080/pls/enf_reports/, 2015.

Reference 3.6-3. Tennessee Department of Environment and Conservation, Rarity Ridge WWTP NPDES Permit TN0078051, Website: http://environment-online.state.tn.us:8080/pls/enf_reports/, 2015.

Reference 3.6-4. City of Oak Ridge, Tennessee, "City of Oak Ridge, Tennessee, Management-Operations-Maintenance Programs (MOM)," January 23, 2012.

Reference 3.6-5. Tennessee Department of Environment and Conservation, "Tennessee Erosion & Sediment Control Handbook - Fourth Edition," August, 2012.

Table 3.6-1
Projected Blowdown Constituents and Concentrations

Constituent	Maximum Potential Concentration (ppm)[1]
Chlorine demand	1000
Free available chlorine	0.5
Chromium	--
Copper	6
Iron	3.5
Zinc	0.6
Phosphate	7.2
Sulfate	3500
Oil and grease	< 10
Total dissolved solids	17000
Total suspended solids	150
Biological Oxygen Demand (BOD), 5-day	< 5
Calcium	260
Magnesium	85
Sodium	990
Manganese	0.1
Alkalinity as $CaCO_3$	150
Nitrate (NO_3)	52
Silicon Dioxide (SiO_2)	150
pH Range	7.5-8.5

1 Assumed 4 cycles of concentration.

Table 3.6-2
Projected Maximum Annual Emissions from Auxiliary Boilers

Pollutant	Bounding Value (lbs/yr)
Particulates	7700
Sulfur oxides	41,575
Carbon monoxide	5930
Hydrocarbons	465
Nitrogen oxides	33,875

Notes:
The emissions are based on inputs as follows:
1. Auxiliary boiler operation during each startup: 36 days/year, 864 hr/yr.
2. Auxiliary boiler size: 75,000 lb/hr at 150 psig, saturation temperature (89.1 MMBtu/hr).
3. Quantity one auxiliary boiler operating at 100% load.
4. Auxiliary boiler without "low NO_x" burners.

Table 3.6-3
Projected Maximum Annual Emissions from Standby Diesel Generators

Pollutant Discharged	Emissions (lbs/yr)
Particulates	281
Sulfur Oxides	Not Available
Carbon Monoxide	3124
Hydrocarbons	740
Nitrogen oxides	38,983

Notes:
The emissions are based on inputs as follows:
1. Fuel used is No. 2 diesel oil with 35° API and LHV of 18,390 Btu/lb.
2. Standby diesel generators operating at 100% load.

Table 3.6-4
Projected Standby Power System Gas Turbines Flue Gas Effluents

Effluent	Consumption Rate/Unit	
	ppmvd	**(lbs)**
NO_x (ppmvd @ 15% 02)	20-220	2280
NO_x as NO_2	2-20	22
CO	5-330	584
Underlying Hazardous Constituents (UHC)	unavailable	unavailable
Volatile Organic Compounds (VOC)	unavailable	15
SO_2	0-100	25
SO_3	0-4	not provided
Sulfur Mist	unavailable	unavailable
Particulates	unavailable	unavailable
Exhaust Analysis	% volume	
Argon	unavailable	
Nitrogen	66-72%	
Oxygen	12-18%	
Carbon Dioxide	1-5%	

Assumption: 4 hr/month operation for testing.

Notes:
Fuel: distillate 20°F ambient
9890 BTU/KWH (LHV)
10,480 BTU/KWH (HHV)
96,960 lb/hr

3.7 POWER TRANSMISSION SYSTEM

3.7.1 Transmission System

The current transmission system within the Clinch River Nuclear (CRN) Site includes the 500-kilovolt (kV) Watts Bar NP – Bull Run FP line and the 161-kV Kingston FP – Fort Loudoun HP #1 line. Both of these lines are owned and operated by Tennessee Valley Authority (TVA).

The following interconnection components and activities would be necessary to complete the connection between the CRN Site and existing power transmission systems and ensure that National Electrical Safety Code (NESC) standards are met. These components are based on a generating output of an 800 megawatt electric (MWe) surrogate plant include:

- Onsite construction of a 500-kV switchyard
- Loop in the Watts Bar NP – Bull Run FP 500 kV line (approximately 0.7 miles (mi) double circuit)
- Onsite construction of a new 161-kV switchyard for auxiliary station service
- Loop in the Kingston FP – Fort Loudoun HP #1 161-kV transmission line (approximately 0.2 mi double circuit)
- Upgrade terminal equipment
- Decrease breaker failure clearing time by changing the settings on breaker failure relays in the Watts Bar 500-kV switchyard
- Re-conductor approximately 122 mi of 161-kV transmission lines
- Uprate approximately 191 mi of 161-kV transmission lines
- Rebuild approximately 13 mi of 161-kV transmission line
- Relocation of a portion of the Kingston FP-Fort Loudoun HP #1 161-kV transmission line within the Site Boundary
- Install a second 500/161-kV transformer at Bull Run

Details on the transmission lines to be rebuilt, reconductored, or uprated are included in Table 3.7-1.

Depending on the final configuration and additional electrical capacity, additional uprating activities may be required. Additional detail on uprating activities is included in Subsection 3.7.3.8.

TVA plans to relocate the 161-kV line within the Site Boundary. The location of the existing transmission lines (500-kV and 161-kV) and the approximate proposed 161-kV transmission line relocation are provided on Figure 3.7-1.

As part of the “power islanding” concept discussed in Section 1.1.1,the Clinch River (CR) Small Modular Reactor (SMR) Project includes installation of a 69-kV underground transmission line along the existing Watts Bar NP – Bull Run FP 500-kV corridor which crosses CRN Site and ties into the Bethel Valley substation (Figure 3.7-2). The transmission work related to the installation of a 69-kV underground transmission line from the CRN Site to the Bethel Valley Substation would include:

- Expansion of Bethel Valley 161-kV Substation to receive 69-kV transmission line
- Construct underground 69-kV transmission line (approximately 5 mi) following an existing TVA 500-kV corridor on U. S. Department of Energy (DOE) property

Figure 3.7-2 shows the proposed route of the underground transmission line from the CRN Site to the Bethel Valley Substation.

Transmission system construction activities are expected to be completed within the CRN Site boundary and/or existing transmission line rights-of-way (ROWs). If needed, additional access roads or clearing would be addressed during the combined license application (COLA).

3.7.2 Transmission Line Corridors

The NESC is the basis for design criteria that are intended to limit the risk of shock and other hazards due to transmission lines. NESC standards provide minimum clearance distances required between conductors and any grounded objects such as buildings, trees, roads, and railroads. These clearances vary with voltage. TVA ROW widths would be selected to ensure the conductors are within the ROW and the minimum clearances, including an additional safety margin, are maintained. ROWs associated with the construction of tie-ins and the relocation of the 161-kV line will be constructed in accordance with NESC standards. The NESC calls for transmission lines to be designed with minimum vertical clearances to the ground so that the short-circuit current to ground produced from the largest anticipated vehicle or object is limited to less than 5 milliamperes (mA). In NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, Rev. 1, the U.S. Nuclear Regulatory Commission indicated that the electrical shock issue is of small significance for transmission lines that are operated in adherence with the NESC.

Periodic inspections of TVA’s transmission lines are performed by aerial surveillance on a regular basis. These inspections are conducted to locate damaged equipment and any conditions that may interfere with normal operation of the line or adversely impact the surrounding area would be reported. During these inspections, the condition of the vegetation within and adjacent to the ROW are noted. These observations are then used to plan corrective maintenance or routine vegetation maintenance. Management of vegetation along the ROWs is necessary to ensure access to structures and to maintain adequate distance between transmission line corridors and vegetation.

3.7.3 Transmission System Design Parameters

3.7.3.1 500-kV Switchyard and 161-kV Switchyard

The CR SMR Project includes the construction of a 500-kV switchyard and a 161-kV switchyard on the CRN Site. The switchyard area location has not been finalized. The switchyard footprint includes both the 500-kV and 161-kV switchyards. As shown in Table 3.1-2, Item 15.2, the acreage required for the two switchyards is shown in the Site Utilization Plan, Figure 3.1-1.

The 500-kV Switchyard may include transformers, breakers, switches, relays, real-time metering, and dual communication paths. Additional equipment would include connecting bus work, a supporting steel superstructure, ground wire towers, switch house, and equipment storage building (Reference 3.7-3). No underground utilities are planned for this switchyard. Figure 3.7-3 provides an aerial view of a typical 500-kV TVA switchyard.

The 161-kV switchyard may include transformers, breakers, switches, and associated relays. Major equipment may include connecting bus work, a supporting steel superstructure, ground wire towers, switch house, and equipment storage building (Reference 3.7-3). Figure 3.7-4 provides and aerial view of a typical 161-kV TVA switchyard.

3.7.3.2 500-kV Structures and Conductors

The proposed 500-kV transmission line connections would use self-supporting, galvanized, laced-steel structures. The electrical conductors (the cables that carry the electrical current) would consist of three sets of three cables bundled in a triangular configuration, suspended under the structure cross arms by insulators. Two single ground wires would be placed on the two highest points of the structures to provide lightning protection. In some cases, these ground wires may carry fiber optic or other communication circuits. Tower height may vary depending on final grade and land use but would normally range between 85 and 125 feet (ft). Tower foundations would normally be laced-steel grillage, one per leg, buried in the earth. Some towers where the line turns at an angle would require foundations of reinforced concrete. Figure 3.7-5 is a sketch of a typical structure with no underbuilt transmission lines.

The 0.7 mi double circuit loop into the 500-kV line would require two separate transmission lines with a 125 foot separation. This would require approximately 10 structures spaced approximately 1000 ft apart. A typical ROW for a 500-kV line is 175 ft wide.

3.7.3.3 161-kV Structures and Conductors

The proposed 161-kV transmission line connections would use a combination of single and H-frame steel-poles similar to those shown in Figure 3.7-6 (Reference 3.7-3). Structure heights would vary depending on final grade and land use but normally range from 80 to 110 ft.

Six conductors would be required to make up a double-circuit in alternating-current transmission lines (Reference 3.7-4). For a 161-kV transmission line, each single-cable conductor would be attached to porcelain insulators suspended from the structure cross arms. A smaller overhead ground wire or wires are attached to the top of the structures. This ground wire may contain fiber optic communication cables.

Poles at angles in the transmission line may require supporting guy wires. Some angle structures may be self-supporting poles or steel towers, which would require concrete foundations. Most poles would be directly imbedded in holes augured into the ground to a depth equal to 10 percent of the pole’s length plus an additional 2 ft. Normally, the holes would be backfilled with the excavated material, but, in some cases, gravel or a concrete-and-gravel mixture would be used.

For the estimated 0.2 mi loop into the 161-kV transmission line, three double circuit structures would be required. Structures are typically spaced 600 ft apart. The typical ROW for this interconnection would be 100 ft wide.

TVA plans to relocate the 161-kV line within the Site Boundary.

3.7.3.4 Underground 69-kV Line

The proposed 5-mi underground transmission line would consist of three conductors that would be placed 36 inches (in.) deep with 12 in. horizontal spacing. The conductors would be direct buried with a protective cover. The transmission line would be buried under the existing 500-kilovolt (kV) Watts Bar NP – Bull Run FP line which crosses CRN Site and ties into the Bethel Valley substation (Figure 3.7-2).

Expansion requirements and other parameters would be defined once the design of the underground transmission line is finalized.

3.7.3.5 General Methods of Construction Switchyard

A construction assembly area (laydown area) would be required for worker assembly, vehicle parking, and material storage during construction. This area would be located within the CRN Site (Figure 3.1-2). Selection criteria used for locating the potential laydown area include:

- Relatively flat
- Well drained
- Previously cleared
- Preferably graveled and fenced
- Preferably wide access points with appropriate culverts
- Sufficiently distant from streams, wetlands, or sensitive environmental features
- Located adjacent to an existing paved road near the transmission line

Trailers used for material storage and office space would be parked in the laydown area. Following completion of construction activities, trailers, unused materials, and construction debris would be removed from the CRN Site.

The footprint of the 500-kV switchyard and the adjacent 161-kV auxiliary station is provided in the Site Utilization Plan, Figure 3.1-1 (Table 3.1-2, Item 17.2.1).

TVA would clear vegetation, remove topsoil, and grade for the required switchyard area. Equipment used during clearing would include chain saws, skidders, bulldozers, tractors, and/or low ground-pressure feller-bunchers. Marketable timber would be salvaged where feasible; otherwise, woody debris and other vegetation would be piled and burned, chipped, or taken off site. In some instances, vegetation may be windrowed along the edge of the CRN Site to serve as sediment barriers. All activities would be conducted in accordance with TVA Site Clearing and Grading Specifications. (Reference 3.7-3)

The site would be leveled using a cut and fill process. The areas of the site that are too high (sloped) would be “cut” down to a level elevation, and other areas that are too low would be “filled” to raise the elevation. Any additional fill required would be obtained from an approved/permitted borrow area. All activities would be conducted in accordance with TVA Site Clearing and Grading Specifications. (Reference 3.7-3)

Once the switchyard site has been graded, spoil would be removed in preparation for foundations. Temporary spoil storage would be located on the CRN Site in several designated areas. Silt fences, site drainage structures, and detention ponds would be installed as required during construction. The substation yard would be covered with crushed stone and enclosed with chain link fencing. (Reference 3.7-3) Construction activities would be conducted in accordance with TVA Transmission Construction Guidelines Near Streams, TVA Quality Protection for Transmission, Substation or Communications Construction, and TVA Substation Lighting Guidelines (Reference 3.7-5).

3.7.3.6 Transmission Line Tie-Ins and Relocation of the 161-kV Transmission Line

As discussed in Subsection 3.7.3.5 for the switchyard, a construction assembly area (laydown area) would be required for assembly, vehicle parking, and material storage during construction. The laydown area for the structures for the transmission line would be approximately 5 ac and would be located within the CRN Site. Selection criteria for this laydown area are the same as for the switchyard and substation laydown area. Trailers used for material storage and office space would be parked in the laydown area. Following completion of construction activities, trailers, unused materials, and construction debris would be removed from the CRN Site.

The transmission structure would be the most visible element of the electric transmission system. Its function would be to keep an adequate distance between the high-voltage conductors and the surrounding area. The transmission line structure type would depend on the line voltage, terrain, and whether the line is single circuit or double circuit. Transmission structure heights would vary depending on final grade and land use but normally range from 80 to 110 ft. The Federal Aviation Administration provides guidance for marking and lighting for structures that may affect navigable airspace. This guidance applies to structures that exceed an overall height of 200 ft above ground level or are located within three nautical miles of an airport. (Reference 3.7-6) Neither of these criteria applies to the 161-kV transmission line to be relocated.

Equipment used during the construction phase would include trucks, truck-mounted augers, and drills, as well as tracked cranes and bulldozers. Low ground-pressure-type equipment would be used in specified locations (such as areas with soft ground) to reduce the potential for environmental impacts.

Reels of conductor and ground wire would be delivered to various staging areas along the ROW, and temporary clearance poles would be installed at road crossings to reduce interference with traffic. A small rope would be pulled from structure to structure. It would be connected to the conductor and ground wire and used to pull them down the line through pulleys suspended from the insulators. A bulldozer and specialized tensioning equipment would be used to pull conductors and ground wires to the proper tension. Crews would then clamp the wires to the insulators and remove the pulleys.

Activities associated with the transmission line tie-ins and relocation would be conducted in according with the following TVA guidance:

- TVA Environmental Quality Protection Specification for Transmission Line Construction
- TVA Transmission Construction Guidelines near Streams (Reference 3.7-5)
- TVA Transmission Construction Standard TC-LCS-06.003.08, Grounding Improvements (Reference 3.7-7)
- TVA Construction Standard TC-LCS-06.003.06, Steel Towers (Reference 3.7-8)

3.7.3.7 69-kV Underground Transmission Line

The underground transmission line would be direct buried (does not require conduit) with a protective cover. Three conductors would be placed 36 in. deep with 12 in. horizontal spacing. The underground transmission line would be buried within the existing 500-kv ROW with a protective cover. Portions of the ROW are 360 ft wide. Equipment, land use, and construction methodology will be defined once the design of the transmission line is finalized.

3.7.3.8 Description of Various Uprating Activities

Uprates are typically performed to increase the electrical capacity of an existing transmission line. Due to the potential system loading of 800 MWe from the CR SMR, uprating ten 161-kV transmission lines, and reconductoring sixteen 161-kV transmission lines (Figure 3.7-7) would be required.

As a matter of context, an 'uprate' can be performed at a single point or at multiple locations along the transmission line. Likewise, reconductoring can occur at a specific line segment or along the length of the transmission line. The total length of the ten 161-kV, and sixteen 161-kV transmission lines that would require some uprates and reconductoring is approximately 191 and 122 mi, respectively. This represents the actual length of the specific transmission line itself, not necessarily the length or extent of the actual uprate or reconductor work. The affected segment of each transmission line requiring uprates or reconductoring are identified in Table 3.7-1, but the particular engineering solution necessary within these segment(s) would depend on the final configuration and additional electrical capacity of the CR SMR. Additionally, one section of the 12.7-mi long Volunteer No 1 – North Knox 161-kV transmission line would require rebuilding. This section of transmission line has already undergone uprating activities in the past and has reached its maximum electrical capacity as currently designed. The final configuration and electrical capacity of the CR SMR would drive the specific engineering solution, but it is expected that some structures may have to be replaced or modified and that the existing conductor may be replaced with a larger size to support the increased electrical load. Descriptions of the types of uprate activities to be performed are described below.

- Moving Structures that Interfere with Clearance: As more electricity is transmitted through a transmission line, the conductor temperature rises and the transmission line may sag. Structures located within the ROW may interfere with the ability to operate the transmission line safety and would be required to be moved.
- Replacement or Modification of Existing Structures or Installation of Intermediate Structure: Typical structure replacement, extensions or installation of intermediate structures would be performed with standard transmission line equipment such as bulldozers, bucket trucks, boom trucks, and forklifts. The end result of this work would be raising the existing conductor to provide the proper ground clearance. Disturbance would usually be limited to an approximately 100 foot circumference around the work structure.
- Conductor Modification: Conductor modifications would include conductor slides, cuts, or floating dead-ends to increase ground clearance. A cut involves removing a small amount of conductor and splicing the ends back together. A slide involves relocating the conductor clamp on the adjacent structure a certain distance toward the area of concern (i.e., "sliding" the clamp). No conductor is removed. A floating dead-end shortens the suspension insulator string of a structure to gain elevation at the attachment point of the conductor, increasing a span's clearance. These improvements require the use of a bucket truck; disturbance would be minimal and confined to the immediate area of the clearance issue.
- Conductor Replacement (Re-conductor): If the existing conductor size cannot support the transmission line's electrical load, the conductor would be replaced. Bucket trucks would be utilized for access and stringing equipment. Reels of conductor would be delivered to various staging areas along the ROW, and temporary clearance poles would be installed at road crossings to reduce interference with traffic. The new conductor would be connected to the old conductor and pulled down the transmission line through pulleys suspended from the insulators. A bulldozer and specialized tensioning equipment would be used to pull

conductors to the proper tension. Crews would then clamp the wires to the insulators and remove the pulleys. Wire pulls vary in length but would be limited to a maximum of 5 mi pulls. Pull point locations depend on the type of structures supporting the conductor as well as the length of conductor being installed and would typically be located along the most accessible path on the ROW (adjacent to road crossings or existing access roads). The area of disturbance at each pull point would typically range from 200 to 300 ft along the ROW.

- Adding Surcharge: Sometimes when height and/or loading modifications are made to a structure, the addition of rock or dirt (surcharge) to structure footing would be required. These changes can create uplift on the existing tower footings or grillage; therefore a stone base settlement may be placed around the existing footings. The additional burden prevents the tower from rising under certain conditions (i.e., weather conditions or conductor loading). Typical installation of surcharge would be performed with tracked equipment with minimal ground disturbance. The stone would be piled around the footings as required and the depth would vary depending on the uplift on the affected structures.
- Modification of Local Power Company Transmission Lines: Local utilities distribution lines are lower in voltage compared to the transmission lines, and are final stage in the delivery of electricity to the end users. These are maintained by the local power company. These may intersect TVA transmission lines. If a local utility crossing does not have adequate clearance, TVA would request that the local utility lower or re-route the crossing.
- Rebuild: The rebuilding of a transmission line typically means installing intermediate structures between existing structures for added structural support and/or clearance or tearing down existing structures and replacing with more robust structures. A combination of intermediate and new structures may be used depending on the condition of the affected structures.

Best management practices (BMPs) would be employed to prevent or minimize impacts from temporarily accessing and working on these line modifications. Impacts on streams, wetlands, and other adjacent habitats from the above activities on portions of existing transmission lines would be prevented or minimized through the use of BMPs such as hand clearing in sensitive areas, silt fencing, and other erosion control methods. BMPs for spill prevention would be employed to prevent chemical contamination of soil or surface water within ROWs during these activities. The TVA procedural documents *Right-Of-Way Vegetation Management Guidelines* and *A Guide for Environmental Protection and Best Management Practices for Tennessee Valley Authority Transmission Construction and Maintenance Activities* provide guidance to TVA personnel performing activities in transmission line ROWs (Reference 4.3-12; Reference 4.3-13). The guidelines address operations such as re-clearing of vegetation, maintenance of access roads, and erosion control. BMPs provided in these documents include methods for re-clearing, such as cutting of trees and herbicide application, and for protection of sensitive resources. Also, structural controls, standards, and specifications are identified for maintaining physical components such as riprap and culverts within ROWs.

Where streams or wetlands are crossed by the lines being modified, BMPs would be employed as needed to prevent or minimize impacts from sedimentation. After the required uprate work is completed, the ROW would be re-vegetated using native, low-growing plant species in appropriate areas. Areas such as pasture, agricultural fields, or lawns would be returned to their former condition.

TVA maintains, and updates on a periodic basis, a database of both desktop and field- verified environmental resources (archeology/cultural resources, aquatics, botany, natural areas, terrestrial zoology, and wetlands) along existing transmission line corridors, including the resources along the transmission line segments identified for possible modification. The potential for impacts to those resources, however, depend entirely on the specific engineering solution presented in the future based upon the final configuration and electrical capacity of the CR SMR. Field reviews would commence when the design is finalized and associated impacts described at COLA.

3.7.4 Predicted Noise Levels from Transmission System Operations

The 500-kV and 161-kV lines are already present on the CRN Site and no additional above-ground transmission lines would be constructed offsite. Therefore, there are no anticipated increases to the current ambient noise levels associated with the operation of the transmission system. Additional information on maintenance of transmission corridors, electric field effects, induced current hazards, corona noise, and radio/television interference is provided in Section 5.6.

3.7.5 References

Reference 3.7-1. Not used.

Reference 3.7-2. Not used.

Reference 3.7-3. Tennessee Valley Authority, "Plateau 500-kV Substation Environmental Assessment, Cumberland County, Tennessee," November, 2013.

Reference 3.7-4. Electrotechnik, Single Circuit and Double Circuit Transmission Lines, Website: http://www.electrotechnik.net/2011/11/single-circuit-and-double-circuit.html, 2015.

Reference 3.7-5. Tennessee Valley Authority, "Selmer-West Adamsville 161-KV Transmission Line and Switching Station Environmental Assessment," January, 2015.

Reference 3.7-6. U.S. Department of Transportation, "Obstructing Marking and Lighting," AC 70/7460-1K, February 1, 2007.

Reference 3.7-7. Tennessee Valley Authority, "Transmission Construction Standard Grounding Improvements," TC-LCS-06.003.08, October 15, 2014.

Reference 3.7-8. Tennessee Valley Authority, "Transmission Construction Standard Steel Towers," TC-LCS-06.003.06, October 15, 2014.

Table 3.7-1 (Sheet 1 of 2)
Detailed Transmission Line Segment Information

Line Name	Total Line Mileage	Total Corridor Acres	Activity	Line Number	Affected Line Segment
Volunteer 1 - North Knox 161-kV	12.7	154	Rebuild	5092	120 – 212
Pineville - Sweet Gum Flats 161-kV	26.5	321	Reconductor	5125	448 – 212
LaFollette-Sweet Gum Flats 161 kV	10.9	132	Reconductor	5125	211 – 118
Coalmont-PTN WIND1 161 kV	5.95	72	Uprate	5167	941B-975
Watts Bar HP-Pikeville 161-kV	30.5	370	Uprate	5173	1-182A & 182A - 40
Pikeville Tap-Spencer Tap 161 kV	8.59	104	Uprate	5173	182A – 40
Great Falls-Spencer Tap 161 kV	14	170	Uprate	5173	442D - 182A
John Sevier 1-Cherokee Hydro 161 kV	37.6	456	Uprate	5186	E1 - E5 & 6 - 234
Fredonia-Peavine 161 kV	3.9	47	Reconductor	5204	198A – 215
Fredonia-Campbell Junction 161 kV	6.1	74	Reconductor	5204	172 - 198A
Rockwood-Peavine 161-kV	19.4	235	Uprate	5205	215-297 & A-G
Elza-Spallation Neutron Source 161 kV	3.53	43	Reconductor	5235	82 – 128
Oak Ridge National Lab-Spallation Neutron Source 161 kV	3.34	40	Reconductor	5280	86 – 119
White Pine-Greenville Tap 1 161 kV	23.65	287	Uprate	5624	E1 - E39 & 40 & E35 & 192 - 84
Bull Run-North Knox 161 kV	11	133	Reconductor	5659	1 to 55
Oglethorpe-J.C. Edwards 161 kV	2.32	28	Reconductor	5697	141 – 154
Concord-J.C. Edwards 161 kV	4.33	52	Reconductor	5697	154 – 178
Winchester-Estill Springs 161 kV	0.07	1	Reconductor	5702	1
Franklin-Estill Springs 161 kV	5.17	63	Reconductor	5702	E47 - 39A & 39 - 1

Table 3.7-1 (Sheet 2 of 2)
Detailed Transmission Line Segment Information

Line Name	Total Line Mileage	Total Corridor Acres	Activity	Line Number	Affected Line Segment
Harriman Tap-Rockwood 161-kV	9.1	110	Reconductor	5743	150-208A
Rockwood Tap – Harriman Tap 161-KV	1	12	Reconductor	5743	208A-44
Braytown-Windrock 161-kV	3	36	Reconductor	5882	298A & 298-310
Elza-Windrock 161-kV	7.62	92	Reconductor	5882	298-361 & 298-310
Braytown-Huntsville (TN) 161-kV	23	279	Uprate	5882	189-213 & 213-298 &298A
Dumplin Valley-White Pine 161-kV	20.43	248	Uprate	5940	E136 - E120 & 120 - 164 & 164 - 185A
Douglas-Newport 161-kV	24.13	292	Reconductor	5957	51 - 181 & 1 - 50
White Pine-Newport 161-kV	7.9	96	Uprate	5957	84 & 1 – 116
	12.7	154	Total Rebuild		
	122.01	1476	Total Reconductor		
	191.02	2317	Total Uprate		

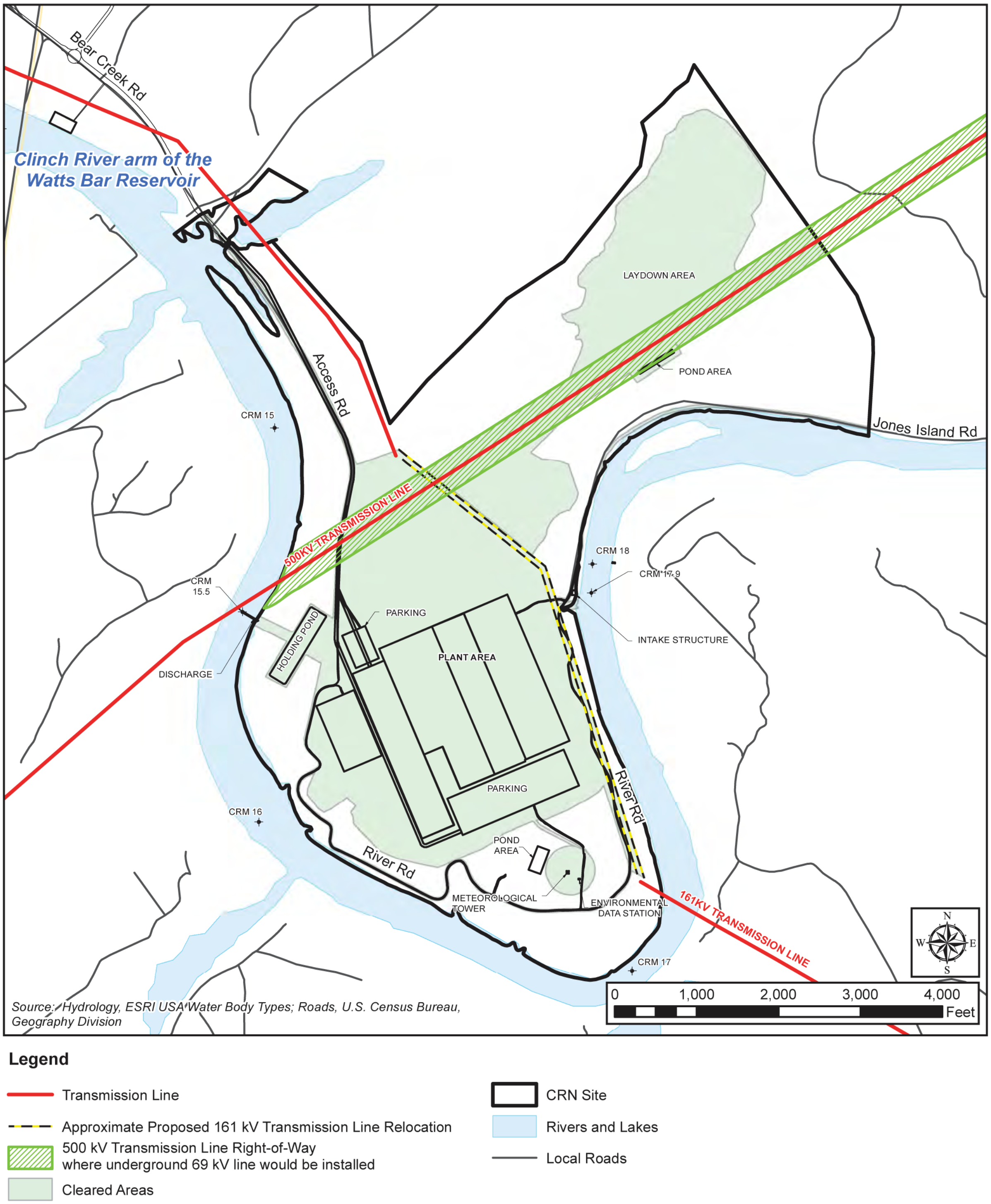


Figure 3.7-1. CRN Site Transmission System

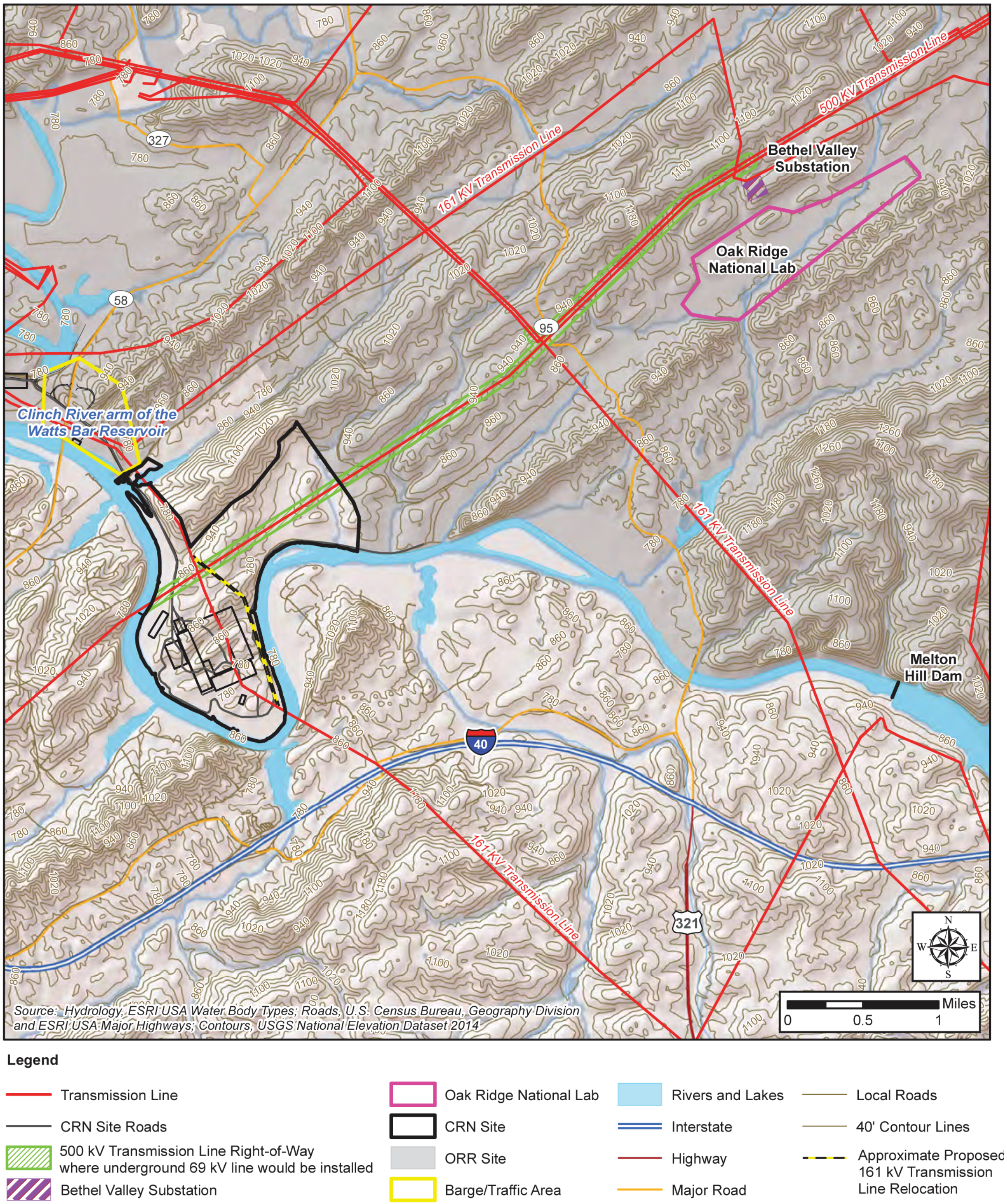


Figure 3.7-2. Transmission Systems in the Vicinity of the CRN Site

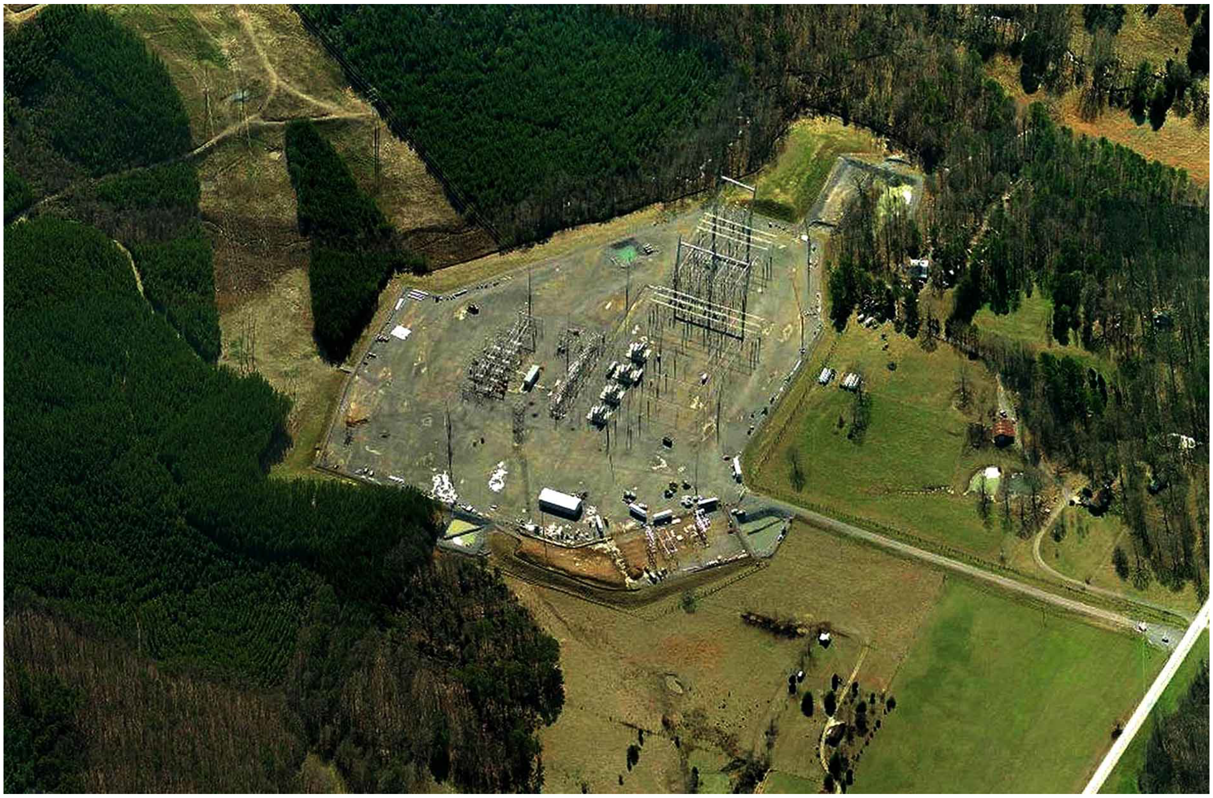
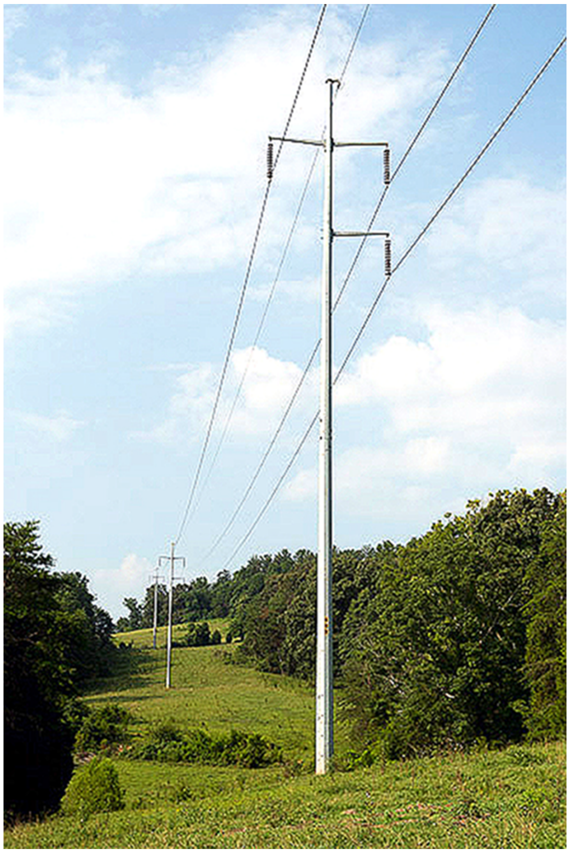


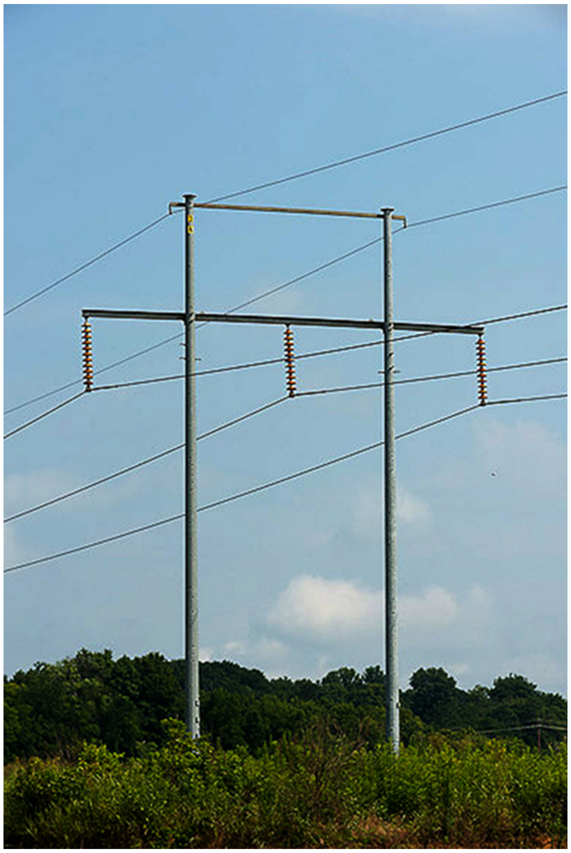
Figure 3.7-3. Typical TVA 500 kV Switchyard

Figure 3.7-4. Typical TVA 161 kV Switchyard

Figure 3.7-5. Typical TVA 500 kV Structure



Single-Pole
161 kV Transmission Structure



Double-Pole Single-Circuit
161 kV Transmission
H-frame Structure

Figure 3.7-6. Typical TVA 161 kV Transmission Structures

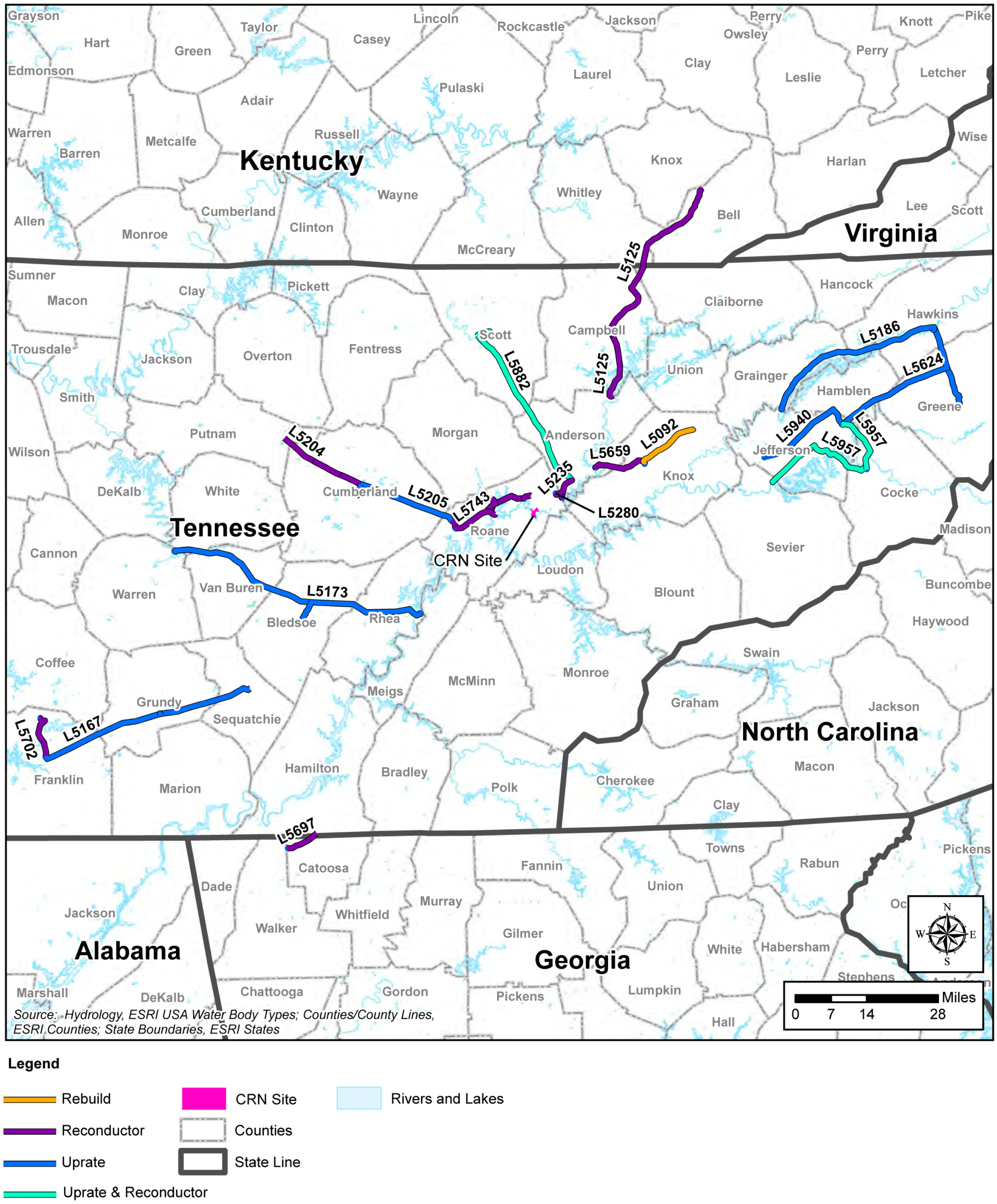


Figure 3.7-7. Transmission Line Segments Requiring Upgrades

3.8 TRANSPORTATION OF RADIOACTIVE MATERIALS

Operation of two or more small modular reactors (SMRs) at the Clinch River Nuclear (CRN) Site, as described by the plant parameter envelope in Table 3.1-2, requires transportation of unirradiated fuel, irradiated fuel (spent nuclear fuel), and radioactive waste. The following subsections describe transportation of these three types of radioactive materials. Subsection 5.7.2 addresses the conditions in subparagraphs under Title 10 of the Code of Federal Regulations (10 CFR) 51.52(a)(1) through (5) and the environmental impact of transportation of fuel and waste to and from the reactor as set forth in 10 CFR 51.52 (c) Table S-4. Section 7.4 addresses radiological transportation accidents.

3.8.1 Transportation of Unirradiated Fuel

Transportation of new fuel assemblies to the CRN Site from a fuel fabrication facility is to be in accordance with U.S. Department of Transportation (DOT) and U.S. Nuclear Regulatory Commission (NRC) regulations. Based on the current bounding case for SMRs at the CRN Site, the initial fuel load may require up to 96 assemblies per unit for the new facility. As provided in Table 3.1-2, Item 18.0.4, refueling is expected to be performed every 2 years (yr) and requires up to 96 fuel assemblies.

The fuel assemblies described in Table 3.1-2, Item 18.0.2 are fabricated at a fuel fabrication plant and shipped by truck to the CRN Site before fuel load. The details of the container designs, shipping procedures, and transportation routes are to be in accordance with DOT (49 CFR 173 and 178) and NRC (10 CFR 71) regulations and depend on the requirements of the suppliers providing the fuel fabrication services. Each truck shipment is to comply with federal and state gross vehicle weight restrictions.

3.8.2 Transportation of Irradiated Fuel

Following fuel burn as described in Table 3.1-2, Item 18.0.4, spent fuel assemblies are to be discharged every 2 yr per unit. Spent fuel assemblies are to remain in the spent fuel pool at each unit for at least 5 yr while short half-life isotopes decay, as required in 10 CFR 961, Appendix E. As provided in Table 3.1-2, Item 18.0.4, each unit is to have a spent fuel pool with capacity for a minimum of 6 yr of fuel discharges. After a minimum 5-year decay period, the fuel is to be removed from the pool and packaged in casks for storage onsite at an independent spent fuel storage installation and may be transported offsite. Uncertainty remains as to the availability of the U.S. Department of Energy (DOE) repository for permanent storage or regional spent fuel storage, including where such facilities would be sited and when the facilities would be in operation. Section 7.4 describes assumptions on transportation distances for irradiated fuel for the use of transportation accident analyses.

Packaging of the fuel for offsite shipment is to comply with applicable DOT (49 CFR 173 and 178) and NRC (10 CFR 71) regulations for transportation of radioactive material. As required by the Nuclear Waste Policy Act of 1982, Section 302, the DOE is responsible for spent fuel transportation from reactor sites to a repository and makes the decision on transport mode. Classification of the irradiated fuel prior to delivery to DOE is to meet the regulation in 10 CFR 961, Standard Contract for Disposal of Spent Nuclear Fuel and/or High-level Radioactive Waste.

3.8.3 Transportation of Radioactive Waste

Solid low-level waste is to be the only type of radioactive waste transported offsite in accordance with 10 CFR 51.52(a)(4). Low-level radioactive waste is to be packaged onsite for transportation to a licensed radioactive waste processor or a licensed low-level radioactive waste disposal facility. Packaging of waste for offsite shipment is to comply with applicable DOT (49 CFR 173 and 178) and NRC (10 CFR 71) regulations for transportation of radioactive material. The packaged waste is to be stored onsite on an interim basis before being shipped offsite to a licensed processing or disposal facility. No long-term storage of solid radiological waste onsite is anticipated. However, the design includes plans for a facility for temporary storage of solid radiological waste to be constructed to house solid radiological waste for up to one year until it is shipped offsite. As provided in Table 3.1-2, Item 11.2.3, the anticipated volume of solid radioactive wastes generated during routine plant operations is 5000 cubic feet per year per unit. Radioactive waste is to be shipped offsite by truck.

3.9 CONSTRUCTION ACTIVITIES

This section provides a conceptual description of preconstruction and construction activities for the deployment of two or more small modular reactors (SMRs) at the Clinch River Nuclear (CRN) Site. Preconstruction activities, which may include site exploration, preparing the CRN Site for construction of the SMRs, excavation, and other activities described in Title 10 of the Code of Federal Regulations (10 CFR) 50.10(a)(2), are not related to nuclear safety and are generally more site-wide in scope. Conversely, construction activities are more likely to be unit-specific and include activities associated with safety-related structures, systems, and components (SSCs), certain fire- and security-related SSCs, and other activities as described in 10 CFR 50.10(a)(1).

SMRs would be manufactured in factories, with large, fabricated components shipped to the facility site. Therefore, less onsite construction is required for installation of SMRs than for installation of a typical commercial reactor. In most SMR designs, the reactor containment vessel is underground and features advanced passive safety systems. Because an SMR design has not yet been selected, a plant parameter envelope (PPE) has been developed for use in evaluating potential environmental impacts. The PPE is described in Section 3.1. The number of units varies based upon the SMR design selected; therefore, the arrangement of the units on the CRN Site is provided as a part of the combined license application (COLA) submittal for the selected design. The basic layout of the CRN Site is provided in Figure 3.1-2.

Development of the facility would be conducted in two stages: (1) preconstruction site preparation activities and (2) construction activities (as described above). Upon receipt of necessary approvals but before receipt of the combined license (COL), preconstruction activities would be initiated at the CRN Site including, for example, initial site excavation and rough grading; installation of temporary facilities; and construction of support facilities, service facilities, utilities, barge unloading area, cooling water pipelines, road improvements, and other nonsafety-related structures, systems, and components. Prior to initiation of preconstruction activities, the necessary permissions, permits, and licenses would be obtained. After receipt of the COL, the construction activities described in 10 CFR 50.10(a)(1) would begin, including placement of safety-related concrete and the in-place erection of the steel containment vessels.

3.9.1 Construction Schedule

The early site permit application (ESPA) for the CRN Site is designed to bound multiple SMR designs with varying numbers of units. The schedule used for the ESPA is based on a sequential construction and operation timeline of the first unit to the last unit. Construction of two twin-pack BWXT mPower plants (four units) was used as the basis for development of the schedule used in this section, because the BWXT mPower design and construction plans were the most developed at the time the schedule was prepared. Table 3.9-1 summarizes the projected major milestones for the preconstruction activities, construction, startup, and operations. The milestones are based on key transition periods from a workforce planning standpoint, when staffing is increased or decreased or the composition of the workforce changes. The projected start date for preconstruction (site preparation) activities is July 2020, which is 12 months prior to the start of initial construction of the selected SMR design in July 2021. Safety-related construction is projected to occur over a five-year period, through fuel load of the last unit in July 2026. Tennessee Valley Authority (TVA) assumes that construction starts on the last unit 21 months after the start of construction of the first unit.

3.9.2 Preconstruction Activities

Preconstruction and site preparation activities would commence upon receipt of the necessary permissions, permits, licenses, and other regulatory approvals. Activities not constituting construction as defined in 10 CFR 50.10(a)(1) are permissible before receipt of a COL.

3.9.2.1 Clearing, Grubbing, and Spoils Management

Initial excavation and grading activities at the CRN Site include clearing, grubbing, and spoils management. Clearing and grubbing would be performed sparingly, with trees being removed to the minimum extent required. Appropriate, approved techniques would be utilized for clearing trees, scrub, and brush. Disposal of organic materials would be through approved local and state waste disposal techniques, and in compliance with TVA procedures.

Temporary spoils areas would be established on the CRN Site to manage materials from clearing, grubbing, and excavation activities at the CRN Site. TVA anticipates that initial grading of the CRN Site would produce cut and fill quantities that are close to being balanced. Therefore, removal of excavated material from the CRN Site is not anticipated. As described in Subsection 2.2.3, TVA anticipates using fill material obtained from currently operating offsite borrow pits. Drainage control measures for the spoils piles may include berms, riprap, sedimentation filters, and detention ponds to control stormwater runoff before its release to the Clinch River arm of the Watts Bar Reservoir or surrounding property.

3.9.2.2 Connection to Existing Power Transmission Corridor

As described in Subsection 3.7.3, preconstruction activities may include construction of a 500-kilovolt (kV) switchyard and a 161-kV switchyard on the CRN Site, relocation of a portion of the Kingston FP-Fort Loudon HP#1 161- kV transmission line within the CRN Site, uprating of existing 161-kV transmission lines, and installation of a 69-kV underground transmission line along the existing Watts Bar NP - Bull Run FP 500-kV corridor which crosses CRN Site and ties into the Bethel Valley substation.

Construction of the replacement 161-kV transmission line/corridor requires clearing and the installation of new towers and lines. Transition to the replacement line can be accomplished without interruption of service. The proposed 69-kV transmission line would be buried within the right-of-way (ROW) of the existing Watts Bar NP - Bull Run FP 500-kV transmission line.

3.9.2.3 Access Road

Site preparation activities include installation of road improvements both onsite and offsite. Road improvements include the proper foundation work, runoff control, and drainage management, including replacement of the Grassy Creek culvert.

Construction traffic is expected to access the CRN Site via Oak Ridge Turnpike (Tennessee State Highway [TN] 58) and Bear Creek Road. Offsite road improvements are anticipated to include work on TN 58, the exit from TN 58 onto Bear Creek Road, Bear Creek Road, and TN 95. Offsite road improvements may include road widening, turn lane additions, and traffic signal additions, as described in Subsection 4.4.2.3. (Reference 3.9-1)

The existing Bear Creek Road and the site access road would be upgraded to serve as a haul route for heavy loads. A shown in Figure 3.1-1, the proposed route starts at the rail delivery area northwest of the CRN Site, passes the barge unloading area, and extends generally southwest onto the CRN Site. Five acres of permanent heavy haul route are anticipated for normal operations and refueling at the CRN Site, as presented in Table 3.1-2, Item 15.1.1.

3.9.2.4 Rail Siding and Barge Facility Improvements

TVA anticipates that the majority of module and component deliveries would be over road and rail. TVA anticipates utilizing the EnergySolutions Heritage Railroad rail siding near the CRN Site for deliveries. The refurbishment of this rail siding is addressed in the U.S. Department of Energy's (DOE) *Environmental Assessment, Transfer of Land and Facilities Within the East Tennessee Technology Park and Surrounding Area, Oak Ridge, Tennessee (DOE/EA-1640)* (Reference 3.9-2).

TVA also anticipates making improvements to the inactive DOE former K-1251 Barge Loading Area, near Bear Creek Road between TN 58 and the CRN Site entrance, for deliveries of equipment and materials by barge to the CR SMR Project. The depth of the reservoir in this area is sufficient to allow barge access. Refurbishment of the barge facility may include improvements such as the repair and/or enlargement of the existing retaining wall if needed to accommodate the barges to be used, and the installation of mooring cells if required. In addition, bollards or other structures may be installed on the shoreline to provide mooring for the barges.

3.9.2.5 Preconstruction Security

Preconstruction security programs and features would be implemented as part of site preparation activities at the CRN Site. Security structures include features such as access control points and security stations. Temporary security measures are also used. (Details of the security plan for safety-related construction activities at the CRN Site is to be provided at COLA.)

3.9.2.6 Temporary Construction Utilities

Temporary utilities to support the construction site and associated activities would be installed during preconstruction at the CRN Site. Temporary utilities include aboveground and belowground infrastructure for power, lighting, communications, waste treatment facilities, fire protection, and construction gases and air systems. Construction areas supported by the utilities include construction offices, warehouses, storage areas, laydown areas, fabrication shops, maintenance shops, the concrete batch plant, test and calibration labs, and the power block area.

3.9.2.7 Temporary Construction Facilities

The parking lot, laydown, storage and fabrication areas, and the road system to accommodate construction traffic would be cleared, grubbed, and graded and appropriately surfaced. Construction facilities, including offices, warehouses, workshops, sanitary facilities, locker rooms, training facilities, storage facilities, and access facilities, would be installed and/or constructed.

The site of the concrete batch plant would be prepared for cement and aggregate unloading and storage and cement storage silos and the concrete batch plant erected. Dry material storage facilities use dust control measures as necessary to meet the requirements of the applicable permits and guidelines.

Preparation for the installation of construction facilities includes activities such as:

- Conducting property surveys to establish local coordinates and the placement of benchmarks for horizontal and vertical control
- Grading, stabilizing, and surfacing laydown areas
- Installing construction fencing
- Installing concrete work slabs for formwork laydown and module assembly
- Installing equipment maintenance and parking areas
- Installing fuel and lubricant storage areas
- Installing concrete foundations and pads for cranes and crane assembly

3.9.2.8 Power Block and Turbine Area Earthwork (Excavation)

Excavation activities for the power block(s) occur in conjunction with site preparation activities. The power block area includes the reactor service building and radwaste building. The radwaste buildings, as well as the turbine buildings, are above-grade structures that require relatively minor excavations in comparison to the reactor service building, which is primarily below grade level.

Excavation requires the removal of soil and rock. Periodic blasting during the dayshift would be used to remove rock. Temporary dewatering and traditional earth retention methods including sheet piling, slurry wall, and earth/rock anchor tie-backs are used to establish the working excavation site. Drainage sumps installed at the bottom of the excavation pump surface drainage and/or accumulated groundwater to an established release point. A fence/fall protection system incorporated into the top of the retention system serves to protect personnel above and below, and an additional system of barriers limits proximity of equipment.

3.9.2.9 Cooling Towers and Makeup Water Supply Pipelines

As described in Section 3.4, mechanical draft cooling towers would be installed to support the SMRs. Site preparation, excavation, and construction of the cooling tower systems, as described in Subsection 3.4.2, includes the following:

- The cooling tower basins, forebays, and pump houses would be constructed on structural fill.
- The circulating water system piping would be routed from the discharge of the circulating water pumps to the condenser in the turbine building and from the condenser to the cooling towers. The section of the circulating water piping beneath the condenser requires deep excavation, and the remaining sections would be installed in open excavations.
- The source water for the circulating water system would be taken from the Clinch River arm of the Watts Bar Reservoir. Make-up piping would be routed from the cooling water intake facility on the east side of the CRN Site to the cooling tower basins.
- The blowdown piping would be routed from the circulating water discharge header to the cooling water outflow on the west side of the CRN Site.

Also, as described in Subsection 3.4.2.2, the blowdown from the cooling water system would pass through a holding pond (for discharge flow mixing) on its way to the discharge on the reservoir. The configuration of the cooling towers, holding pond, and discharge structure on the CRN Site is shown in Figure 3.1-2.

3.9.2.10 Potable Water Pipelines

TVA anticipates obtaining potable water and other process water (i.e., raw water, fire protection water, etc.) for the CRN Site from the City of Oak Ridge Department of Public Works, and plans to route wastewater from the CRN Site to the City of Oak Ridge Wastewater Treatment system. The buried potable water pipeline and fire protection lines, if required as separate lines, are expected to be installed as a preconstruction activity as is the wastewater treatment line. The potable/raw water lines are anticipated to originate at an existing City of Oak Ridge supply line at the Bear Creek Road entrance to the CRN Site and extend onto the CRN Site along the existing main roadway parallel to the abandoned Clinch River Breeder Reactor Project fire protection line. The wastewater line is anticipated to use the same routing on the CRN Site as the potable water lines to exit the site, and tie in to an existing City of Oak Ridge wastewater pumping station located approximately 0.25 miles east of the site entrance behind the commercial buildings located along Bear Creek Road on the north side of the Grassy Creek embayment. The route from the site entrance to the pumping station is planned to follow existing roadways and other cleared areas already present in the vicinity. As shown in ER Figure 4.1-1, the existing roadways have been included in the “Permanently Cleared Area” disturbed areas of the CRN Site.

3.9.2.11 Dredging

No dredging would be required for the project. Shoreline excavation would be required for construction of the intake structure, along a length of shoreline approximately 50 ft wide. The diffuser pipe for the discharge would be partially buried, which would also require underwater excavation. No dredging would be required for construction of the Barge/Traffic Area.

3.9.3 Construction Activities

Construction as defined in 10 CFR 50.10(a)(1) (including safety-related structures, systems, and components) may begin after receipt of the COL. The CR SMR Project is a combined set of buildings and structures with systems installed within the structures. Much of the commodity installation is anticipated to consist of prefabricated civil/structural, electrical, mechanical, and piping modules with field-installed interconnections. Power plants are typically constructed with the major mechanical and electrical equipment and piping systems installed in each respective elevation as the civil construction advances upward. The power block consists of the reactor service building and the radwaste building. Construction of these buildings, the turbine building, and other facilities is described below.

3.9.3.1 Reactor Service Building

The reactor service building would be constructed of steel and concrete and is anticipated to have one or more floor elevations at approximately grade level and several floor elevations below grade. It would be a combination of a reactor containment building housing steel reactor containments and an annex building. Although the details of construction may vary based on the selected SMR design, representative major activities associated with construction of a reactor service building include:

- Placing the combined basemat for the reactor containment vessels
- Erecting the reactor containment vessel modules
- Inside the reactor containment
  - Placing the walls, slabs, platforms, and reactor supports
  - Installing the reactor pressure vessels and coolant pump superstructure
  - Setting the major mechanical and electrical equipment, piping, and valves

  - Setting the reactor containment jib and bridge cranes
  - Setting the upper reactor containment roof structures

- Outside the reactor containment
  - Placing the walls, slabs, and platforms
  - Setting the major mechanical and electrical equipment, piping, and valves
  - Setting the refueling machine
  - Setting the gantry and bridge cranes
  - Setting the diesel generators

The remaining mechanical, piping, fire sprinkler system, heating/ventilation/air conditioning system, and electrical installations begin in the lower elevations and continue above grade. TVA anticipates the containment service building to have the longest construction duration.

3.9.3.2 Radwaste Building

The radwaste building houses equipment for handling, processing, and packaging liquid and solid radioactive wastes. TVA anticipates the radwaste building would have one floor at approximately grade level.

3.9.3.3 Turbine Building

TVA anticipates the turbine building would have three main floor elevations (one at grade and two above) and two additional partial floors above the upper main floor. Construction would begin with installation of the turbine generator pedestal basemat and the buried circulating water pipe, followed by installation of the turbine generator pedestal components. Then the turbine generator building is erected, followed by installation of the turbine building crane and installation and assembly of the turbine generator.

3.9.3.4 Other Facilities

Other facilities anticipated to be constructed or installed include:

- Outage support, laboratory, and medical facilities
- Meteorological tower
- Vehicle service, maintenance, and warehouse buildings
- Tunnels and pipe chases
- Fire protection storage tanks and building
- Water treatment building

- Security stations, sally ports, protected area, and delay fence
- Administration and training building
- Various yard tanks
- Bulk gas storage facilities (compressed gases such as nitrogen and hydrogen)

The common yard area construction is anticipated to occur over the full construction duration beginning at the start of site preparation. The necessary permits and authorizations would be obtained to ensure compliance with all applicable rules and regulations.

3.9.4 Construction Equipment

Approximately 2100 pieces of construction equipment are expected onsite at any one time throughout the six-year construction period, with approximately 4000 pieces of equipment onsite during the peak construction period. The types of construction equipment include such items as:

- Trucks (dump, flatbed, fuel)
- Dozers, loaders, compactors
- Forklifts
- Compressors, welders, pumps
- Generators
- Cranes

3.9.5 Construction Traffic and Scheduling

Over the course of the six-year construction period, approximately 100,000 transport and construction vehicles (tractor-trailers, dump trucks, delivery vans, etc.) are expected to enter and exit the CRN Site. Assuming day shift construction with a normal 10-hour (hr) shift, 4 days per week for 50 weeks per year, approximately 9 vehicles per hr or 90 vehicles per day would enter and leave the CRN Site. TVA anticipates peak construction/transport traffic to be 30 vehicles per hr during the 10-hr day shift (7:00 AM to 5:30 PM).

TVA anticipates the maximum number of vehicles entering and exiting the CRN Site would normally coincide with the arrival and departure of day shift construction workers, between 6:30 and 7:00 AM and 5:30 and 6:00 PM, respectively. Approximately 1777 vehicles are expected to enter and exit the CRN Site, based on the following assumptions:

- A day shift construction staff of approximately 2200 persons
- Approximately 110 operations-related arrivals and departures
- No other construction or commercial vehicle traffic during the subject times

- An average of 1.3 persons per vehicle

Although the majority of workers would be onsite during the dayshift, both night and weekend crews are anticipated. TVA anticipates some night shift construction activities occurring on either a second shift (for example, 6:00 PM to 4:30 AM) or third shift (for example, 11:00 PM to 8:30 AM). Night shift construction activities are expected to involve typical civil, electrical, and mechanical work. TVA anticipates a small number of construction workers would work weekends, tending to critical activities such as dewatering, concrete curing, and maintenance.

3.9.6 Noise

Preconstruction and construction activities at the CRN Site are expected to generate noise and vibrations from various sources, such as:

- Hand tools
- Pneumatic equipment
- Generators
- Cranes
- Pile-drivers
- Earthmoving equipment
- Blasting operations

TVA anticipates that the maximum expected sound level due to construction activities, measured at 50 ft from the noise source, is 101 decibels (dB), as presented in Table 3.1-2, Item 17.3.1. Table 3.9-2 summarizes noise levels from the types of construction equipment that potentially could be used during construction activities at the CRN Site. Subsection 4.4.1.1 addresses the offsite level of construction noise.

3.9.7 References

Reference 3.9-1. AECOM, "Clinch River Site Traffic Assessment, Final Technical Report, Revision 0," Tennessee Valley Authority, March, 2015.

Reference 3.9-2. U.S. Department of Energy, "Environmental Assessment - Transfer of Land and Facilities with the East Tennessee Technology Park and Surrounding Area, Oak Ridge, Tennessee," Oak Ridge, TN, October, 2011.

Reference 3.9-3. Golden, J., R.P Ouelette, S.Saari, and P.N Cheremisinoff, Environmental Impact Data Book, Chapter 8: Noise, Table 8.3 Noise Sources dBA, 1st, Ann Arbor Science, Ann Arbor, Michigan, p.507-509, 1979.

Table 3.9-1
Anticipated Schedule for Construction and Operation of Two or More SMR Units at the CRN Site

Milestone	1st Unit	Last Unit
Site Preparation	7/1/2020	7/1/2020
NRC Issues COL	5/1/2021	5/1/2021
Plant Construction Starts	7/1/2021	4/1/2023
Preoperational Testing Begins	11/1/2023	7/1/2025
Construction Complete	9/1/2024	4/1/2026
Fuel Load	12/1/2024	7/1/2026
Startup Testing Begins	1/1/2025	12/1/2026
Commence Operation	1/1/2026	5/1/2027

**Table 3.9-2
Peak and Attenuated Noise Levels
Expected from Operation of Construction Equipment**

Source	Noise Level				
		Distance from Source			
	(peak)	50 ft	100 ft	200 ft	400 ft
Heavy trucks	95	84–89	78–83	72–77	66–71
Dump trucks	108	88	82	76	70
Concrete mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80–89	74–82	68–77	60–71
Dozer	107	87–102	81–96	75–90	69–84
Generator	96	76	70	64	58
Crane	104	75–88	69–82	63–76	55–70
Loader	104	73–86	67–80	61–74	55–68
Grader	108	88–91	82–85	76–79	70–73
Dragline	105	85	79	73	67
Pile driver	105	95	89	83	77
Forklift	100	95	89	83	77

Note: Noise levels expressed in dBA - decibel (A-weighted sound pressure level)
Source: (Reference 3.9-3)

3.10 WORKFORCE CHARACTERIZATION

This section provides a description of the workforce required to construct and operate the Clinch River (CR) Small Modular Reactor (SMR) Project at the Clinch River Nuclear (CRN) Site. As presented in Section 3.9, the development of two or more SMRs at the CRN Site is conducted in two stages: (1) preconstruction site preparation activities that are not safety related and (2) construction activities that include safety related structures, systems, and components.

The estimated construction and operations workforce, and their anticipated relocation and commuting patterns, are described in the following subsections. As shown in Table 3.9-1, the overall construction schedule duration from the start of preconstruction and site preparation activities until initiation of fuel load of the last unit is projected to be 72 months.

3.10.1 Construction Workforce Characterization

A construction workforce consists of two components: field craft labor and field non-manual labor. Field craft labor, including civil, mechanical/piping, electrical, and support personnel, is the largest component of the construction workforce. It represents approximately 77 percent of the field workforce in conventional pressurized water reactor nuclear facility construction. Field craft labor is used during the construction and startup of the SMRs. Field non-manual labor makes up the balance of the construction workforce, or approximately 23 percent, with the assumption that design engineering is performed offsite. The field non-manual labor includes field management, field supervision, field engineers, quality assurance/quality control, environmental/safety and health, and administrative/clerical staff.

Table 3.10-1 illustrates the representative percentage for each labor category within the field craft and field non-manual labor workforce components for construction activities. The skill set makeup is representative of typical nuclear power facility construction.

3.10.1.1 Preconstruction Activities Workforce

As described in Section 3.9, preconstruction activities include site preparation activities, which are assumed to start 12 months before the start of safety-related construction for the initial unit(s). The onsite peak workforce for the site preparation and excavation activity is estimated to be approximately 400 personnel. Table 3.10-2 and Figure 3.10-1 summarize the workforce personnel requirements by month for preconstruction activities, months 1 through 12.

3.10.1.2 Construction Activities Workforce

The SMR design facilitates a modular construction approach, and erection of multiple units at a time. The amount of modularization depends on the characteristics of the site, transportation route restrictions, and transport methods. Modularization shifts some of the typically onsite work (and workforce) to another offsite location for the prefabrication, thereby decreasing the required onsite construction staff. The construction duration and estimated onsite workforce presented assumes offsite fabrication with onsite module assembly and erection.

Per the construction schedule presented in Section 3.9, the total onsite construction workforce assumes an estimated 22 million construction hours and approximately 4.5 million operations hours during the construction schedule based on a sequential construction and operation timeline from the first unit to the last unit. Construction of the safety-related portion of the facility is estimated to require approximately 65 percent of the total estimated construction labor hours. Operations hours associated with safety-related structures, systems and components during the same period are estimated to be in the same range (that is, approximately 65 percent of the total estimated hours through commencement of commercial operation of the last unit).

It is assumed that a 10 hour (hr) per day, Monday through Thursday, four day work week is used throughout the construction period. It is assumed that approximately two-thirds of the construction workforce works the day shift, from 7:00 AM to 5:30 PM; and that the remaining one-third of the construction workforce works either a second shift (6:00 PM to 4:30 AM) or third shift (11:00 PM to 8:30 AM). A small number of construction workers are assumed to work weekends, tending to critical activities such as dewatering, concrete curing, maintenance, etc. It is assumed that construction personnel commute to and from the CRN Site, and that staggered shift periods are not implemented. However, it is also assumed that no other construction or commercial vehicle traffic is scheduled during the peak arrival and departure times of dayshift construction personnel; that is, between 6:30 and 7:00 AM and 5:30 and 6:00 PM, respectively.

The peak phase of construction is estimated to occur during the fourth year of a projected six-year construction schedule (that is, from beginning of site preparation until fuel load of the last unit). During that period, the maximum construction workforce onsite at any one time is estimated to be 2200, as presented in Table 3.1-2, Item 17.4.1. However, the maximum number of construction personnel onsite during a 24-hr period is estimated to be 3300, due to the potential use of multiple shifts. Table 3.10-2 provides the estimated temporal distribution of the construction workforce monthly, quarterly, and annually, and Figure 3.10-1 summarizes the approximate construction workforce requirements by month.

In addition to the onsite construction activities, there are associated offsite construction activities, such as access road improvements (to the Tennessee State Highway 58 ramp and Bear Creek Road), construction of a 69-kilovolt (kV) underground transmission line following an existing 500 kV Watts Bar NP – Bull Run FP line which crosses CRN Site and ties into the Bethel Valley substation, improvements to a barge loading area, and offsite borrow locations. The estimated workforce for these construction activities is not known, and is not included in this workforce evaluation.

3.10.2 Construction Worker Relocation and Commuting

Several assumptions are used to bound the construction workforce composition with respect to workforce commuting and relocation. It is assumed that construction workers typically commute up to a maximum of 50 miles (mi) to the jobsite, therefore, individuals living within a 50-mi radius of the project site are considered “local”. The largest cities within 50 mi of the CRN Site are Knoxville, Oak Ridge, and Maryville, Tennessee, with 2010 populations of 178,874; 29,330; and

27,465, respectively (Reference 3.10-1). It is assumed that 80 percent of the field craft labor workforce is available to the project from within a 50-mi radius, or approximately 2033 local craft personnel (based on a peak construction personnel workforce number of 3300 and 77 percent field craft labor). The balance of the construction craft workforce (508 personnel) comes from outside the 50-mi radius. These personnel are assumed to relocate within the 50-mi area to minimize their commute distance and seek temporary housing.

It is further assumed that 80 percent of the field non-manual labor workforce (based on 23 percent field non-manual labor) or 607 personnel relocate from outside the 50-mi radius, and seek permanent housing. The balance of the field non manual labor staff or 152 personnel are assumed to come from the local labor market within the 50-mi area, and commute.

Therefore, the total construction workforce assumed to come from within the 50-mi radius is 2185 (2033 local craft workers plus 152 non-manual workers). The total construction workforce assumed to relocate from outside the 50-mi radius is 1115 (508 in-migrating craft workers plus 607 in-migrating non-manual workers).

3.10.3 Operations Workforce

The total facility operations workforce is estimated to be 500, as presented in Table 3.1-2, Item 16.3.1. It is estimated that 50 percent of the operations workforce is recruited and trained from the Oak Ridge/Knoxville area, and 50 percent relocate to the Oak Ridge/Knoxville area from outside the 50-mi radius. The projected monthly operational workforce is provided in Table 3.10-3 and Figure 3.10-2.

It is assumed that operations staffing begins as site preparation begins to allow time for simulator training and startup testing support and increases to the full complement of personnel at the time of the initial unit(s) operation, and continue staffing to ensure a full complement of operations personnel at the time of the additional unit(s) operation.

An additional 1000 workers would temporarily work at the CRN Site during periodic refueling and major maintenance activities, as presented in Table 3.1-2, Item 16.3.2. Refueling activities would begin two years after initial fuel load for each unit and would continue every two years thereafter.

3.10.4 Peak Overlap Workforce

The CR SMR Project includes construction of multiple SMRs that would be brought into operation sequentially. Therefore, there would be a period of time when one or more SMRs is operating while other SMR(s) are being constructed. As described in Subsection 3.10.1.2, the peak phase of construction is estimated to occur between months 42 and 47 during the fourth year of a projected 6-yr construction duration (i.e., from beginning of site preparation until fuel load of the last unit). The maximum number of construction personnel onsite during a 24-hr period is estimated to be 3300, due to the potential use of multiple shifts.

The overlap of projected monthly construction workforce and operational workforce is provided in Figure 3.10-3. A peak overlap workforce of 3666 occurs in month 47 where construction workforce reaches a peak of 3300 and 366 operational workers are anticipated to be onsite. Refueling activities are not projected to occur until after construction activities are complete and would therefore, not impact the peak overlap workforce.

3.10.5 References

Reference 3.10-1. U.S. Department of Commerce, Tennessee: 2010 Population and Housing Unit Counts - Table 10. Rank by 2010 Population and Housing Units: 2000 and 2010, Website: http://www.census.gov/prod/cen2010/cph-2-44.pdf, September, 2012.

Table 3.10-1
Estimated Percent of Onsite Construction Labor Force by Category

Labor Category	Installation Items/Responsibility	Estimated Percent of Total Workforce
Civil/Architectural Workforce	Earthwork, Yard Pipe, Piling, Concrete and Reinforcing Steel, Rigging, Structural/Miscellaneous Steel, Fire Proofing, Insulation, Coatings/Painting	25
Mechanical/Piping Workforce	NSSS, Turbine Generator, Condenser, Cooling Towers, Process Equipment, HVAC, Piping, Tubing, Valves, Hangers/Supports	24
Electrical Workforce	Electrical Equipment, Cable Tray, Conduit, Supports, Cable & Wire, Connections and Terminations	14
Site Support Workforce	Scaffolding, Equipment Operation, Transport, Cleaning, Maintenance, etc.	14
Non-manual Workforce	Management, Supervision, Field Engineering, Quality Assurance/Quality Control, Environmental/Safety and Health, Administration, and Startup	23

Notes:
NSSS – nuclear steam supply system
HVAC – heating, ventilation, air conditioning

Table 3.10-2 (Sheet 1 of 2)
Estimated Construction Workforce for a Projected Six-Year Construction Schedule
(From Beginning of Site Preparation until Fuel Load of the Last Unit)

Month	Estimated Workforce	Approximate Quarterly Average	Approximate Annual Average
1	100	125	250
2	125		
3	150		
4	175	200	
5	200		
6	225		
7	250	275	
8	275		
9	300		
10	325	350	
11	350		
12	400		
13	500	600	1100
14	600		
15	700		
16	800	900	
17	900		
18	1000		
19	1100	1250	
20	1200		
21	1400		
22	1525	1650	
23	1650		
24	1775		
25	1900	2025	2450
26	2025		
27	2150		
28	2275	2375	
29	2400		
30	2475		
31	2500	2575	
32	2550		
33	2650		
34	2750	2850	
35	2850		
36	2950		

Table 3.10-2 (Sheet 2 of 2)
Estimated Construction Workforce for a Projected Six-Year Construction Schedule
(From Beginning of Site Preparation until Fuel Load of the Last Unit)

Month	Estimated Workforce	Approximate Quarterly Average	Approximate Annual Average
37	3050	3125	3250
38	3150		
39	3200		
40	3200	3250	
41	3250		
42	3300		
43	3300	3300	
44	3300		
45	3300		
46	3300	3275	
47	3300		
48	3200		
49	2900	2725	2300
50	2750		
51	2550		
52	2350	2225	
53	2200		
54	2150		
55	2150	2150	
56	2150		
57	2150		
58	2150	2100	
59	2100		
60	2000		
61	1950	1875	1250
62	1900		
63	1800		
64	1700	1600	
65	1600		
66	1500		
67	1400	1125	
68	1200		
69	800		
70	600	400	
71	400		
72	200		

Note: It is also estimated that there will be a small residual onsite construction workforce, in the range of 100 or less, for some period of time following the end of a projected six-year construction schedule (that is, following fuel load of the last unit).

Table 3.10-3 (Sheet 1 of 3)
Estimated Operations Workforce by Month for a Projected Six-Year Construction Schedule (From Beginning of Site Preparation until Fuel Load of the Last Unit)

Month	CRN Units 1 & 2	CRN Units 3 & 4	Total Operational Workforce
1	17	–	17
2	21	–	21
3	25	–	25
4	30	–	30
5	35	–	35
6	40	–	40
7	45	–	45
8	50	–	50
9	55	–	55
10	60	–	60
11	62	–	62
12	64	–	64
13	68	–	68
14	72	–	72
15	74	–	74
16	76	–	76
17	80	–	80
18	85	–	85
19	90	–	90
20	95	–	95
21	100	–	100
22	105	17	122
23	110	21	131
24	115	25	140
25	120	30	150
26	126	35	161
27	131	40	171
28	137	45	182
29	142	50	192
30	148	55	203
31	153	60	213
32	159	62	221
33	164	64	228
34	169	68	237

Table 3.10-3 (Sheet 2 of 3)
Estimated Operations Workforce by Month for a Projected Six-Year Construction Schedule (From Beginning of Site Preparation until Fuel Load of the Last Unit)

Month	CRN Units 1 & 2	CRN Units 3 & 4	Total Operational Workforce
35	172	72	244
36	175	74	249
37	181	76	257
38	187	80	267
39	193	85	278
40	199	90	289
41	205	95	300
42	211	100	311
43	217	105	322
44	223	110	333
45	228	115	343
46	234	120	354
47	240	126	366
48	246	131	377
49	252	137	389
50	258	142	400
51	261	148	409
52	266	153	419
53	270	159	429
54	275	164	439
55	280	169	449
56	285	172	457
57	290	175	465
58	295	181	476
59	300	187	487
60	305	193	498
61	310	199	509
62	315	205	520
63	320	211	531
64	325	217	542
65	330	223	553
66	334	228	562
67	334	234	568

Table 3.10-3 (Sheet 3 of 3)
Estimated Operations Workforce by Month for a Projected Six-Year Construction Schedule (From Beginning of Site Preparation until Fuel Load of the Last Unit)

Month	CRN Units 1 & 2	CRN Units 3 & 4	Total Operational Workforce
68	334	240	574
69	334	246	580
70	334	252	586
71	334	258	592
72	334	261	595
73	334	266	600
74	334	270	604
75	334	275	609
76	334	280	614
77	334	285	619
78	334	290	624
79	334	295	629
80	334	300	634
81	334	305	639
82	334	310	644
83	334	315	649
84	334	320	654
85	334	325	659
86	334	330	664
87	334	334	668

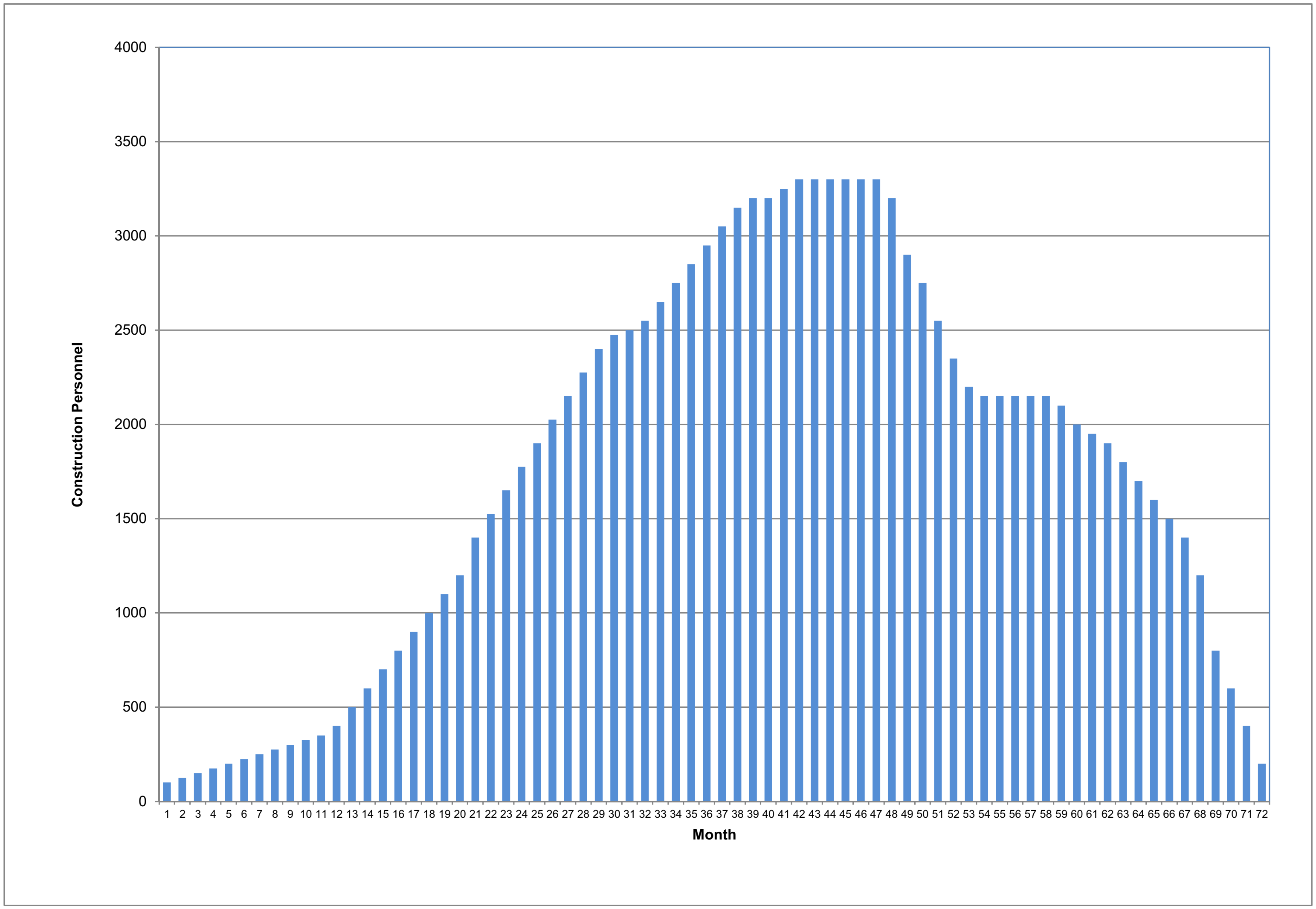


Figure 3.10-1. Estimated Construction Workforce by Month

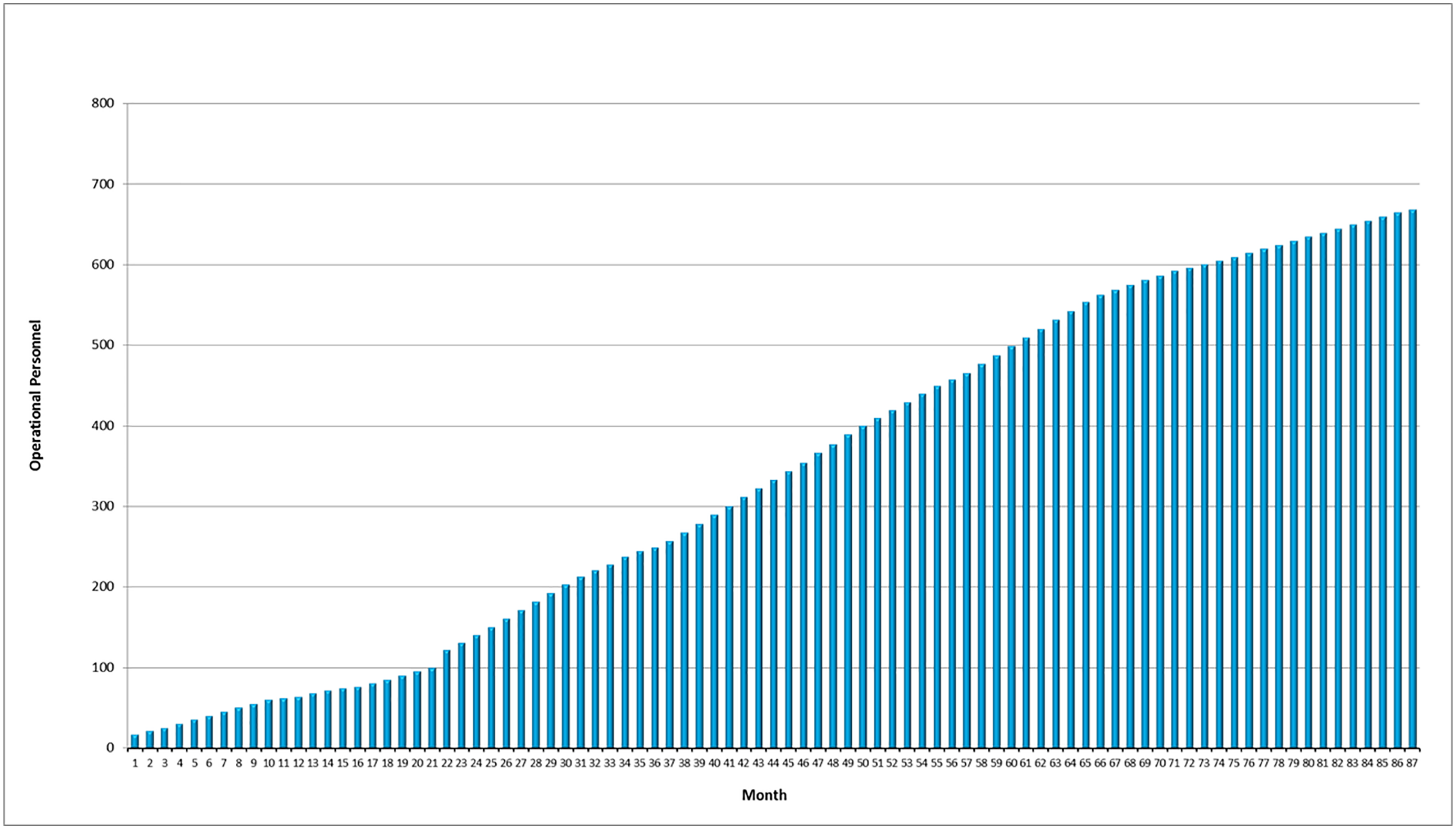


Figure 3.10-2. Estimated Operational Workforce by Month

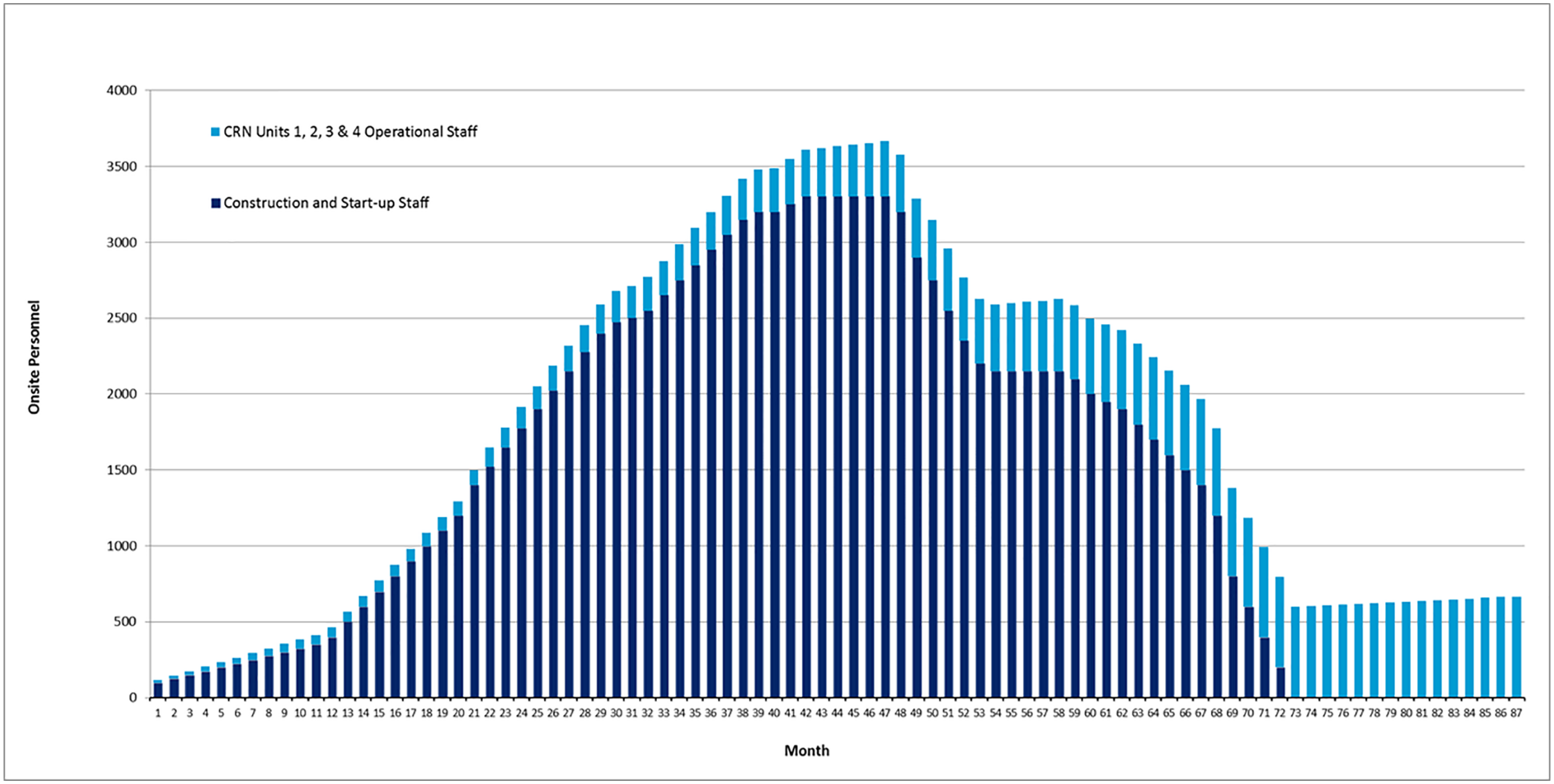


Figure 3.10-3. Estimated Overlap Workforce by Month