



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
WASHINGTON, DC 20555 - 0001**

January 9, 2019

The Honorable Kristine L. Svinicki  
Chairman  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

SUBJECT: EARLY SITE PERMIT – CLINCH RIVER NUCLEAR SITE

Dear Chairman Svinicki:

During the 659<sup>th</sup> meeting of the Advisory Committee on Reactor Safeguards (ACRS), December 6-7, 2018, we completed our review of the early site permit application submitted by the Tennessee Valley Authority (TVA) for two or more small modular reactors (SMRs) at its Clinch River Nuclear (CRN) Site, and the NRC staff's safety evaluation report. Our Regulatory Policies and Practices Subcommittee received an informational briefing on this topic on November 15, 2017, and also reviewed this matter at its meetings on May 15, August 22, October 17, and November 14, 2018. During our reviews, we had the benefit of discussions with the staff and representatives of TVA. We also had the benefit of the referenced documents. Our reviews of the application and the safety evaluation report were conducted to fulfill the requirements of 10 CFR 52.23, which states that the ACRS shall report on those portions of an early site permit application that concern safety.

**CONCLUSION AND RECOMMENDATIONS**

1. Small modular reactors with design characteristics within the plant parameter envelope used by TVA in developing its Clinch River Nuclear Site early site permit application can be constructed and operated without undue risk to the health and safety of the public.
2. The staff's safety evaluation report of the TVA early site permit application should be issued. The staff accepted TVA's plume exposure pathway emergency planning zone sizing methodology; two *major features* emergency plans (one plan for a site boundary plume exposure pathway emergency planning zone and a second plan for an approximate 2-mile radius plume exposure pathway emergency planning zone); and associated exemption requests. The safety evaluation report also identified a number of items that are treated either as permit conditions or as action items that must be addressed at the operating license stage.
3. The early site permit for the Clinch River Nuclear Site should be issued.

## **BACKGROUND**

An early site permit is the Commission's approval of the safety and environmental suitability for a proposed site to support future construction and operation of one or more nuclear power plants. TVA's submittal addresses site suitability issues, environmental protection issues, and plans for coping with emergencies, independent of the review of a specific nuclear power plant design. Before a plant can be constructed, either under a combined license or a construction permit, a specific reactor technology for the site must be reviewed and approved by the NRC.

TVA filed an early site permit application for its CRN Site in May 2016 and the NRC accepted and docketed the application in December 2016. The TVA application was based on a plant parameter envelope (PPE) approach as a surrogate for a specific plant design. Using inputs from four prospective vendors (NuScale, Holtec, BWX Technologies, and Westinghouse) of light-water reactor-derivative SMR designs, TVA determined bounding values for construction and operation of two or more SMRs at the CRN Site with a total nuclear generating capacity up to 2420 MWt and 800 MWe (up to 800 MWt for a single unit or module). This approach allows TVA flexibility, while also potentially reducing licensing risk.

## **DISCUSSION**

### **Proposed Site, Population, and Hazards Analyses**

The proposed CRN Site encompasses 935 acres of land, bordered by the Department of Energy's Oak Ridge Reservation to the north and east, and by the Clinch River Arm of the Watts Bar Reservoir to the east, south, and west. Located within the City of Oak Ridge, Roane County, Tennessee, it is 6.8 miles east of Kingston, 9.2 miles east-southeast of Harriman, 8.8 miles northwest of Lenoir City, and 25.6 miles west-southwest of Knoxville, Tennessee. The land is owned by the U.S. Government and is managed by TVA as an agent of the federal government.

The exclusion area boundary is delineated by the boundaries of the CRN Property bordered by the Oak Ridge Reservation and the Clinch River. There are no residences, commercial activities, or traversing public roads and active railways within the exclusion area boundary. The low population zone is a one-mile radius from the center point of the site. Population density predictions for a 50-mile radius around the site are estimated at start of construction (2021), commencement of operations (2027), and through end of plant life (2067) to be well below siting guidelines (i.e., less than 500 people per square mile). The staff found the site information provided to be acceptable and meets the requirements of 10 CFR 100.20.

In general, potential hazards and accidents from nearby industrial, transportation, military, and aircraft operations were analyzed and were demonstrated to be well below frequency cut-offs and/or accidental dose guidelines. The staff in its evaluation of hazards set two permit conditions: one regarding main control room habitability for nearby transport of anhydrous ammonia and chlorine; and a second for the possible construction of a commercial airport in the nearby vicinity (about 6 miles from the site).

### **Site Characteristics**

The CRN Site is well characterized in terms of geology, seismology, meteorology, and hydrology, and benefits from past site characterization (e.g., field meteorology measurements, borings, and excavation work) performed when the site was the location of the proposed, later

cancelled, Clinch River Breeder Reactor Project. The staff conducted site visits and audits, performed independent confirmatory calculations, and conducted thorough evaluations and reviews of each of these areas in the application. The staff concluded that the CRN Site characteristics meet the requirements of 10 CFR Part 100, "Reactor Site Criteria" and 10 CFR Part 20, "Standards for Protection Against Radiation." Subject to the safety evaluation report action items and permit conditions, there is reasonable assurance that approved reactor designs falling within the PPE design parameters for the CRN Site characteristics can be operated without undue risk to public health and safety.

## **Potential Radionuclide Releases**

### *Radioactive Waste Management*

TVA developed conservative PPE parameters for normal liquid and gaseous effluent release source terms for use in calculating offsite doses and used the LADTAP-II and GASPAR-II codes, respectively, to conduct exposure pathway dose analyses using site-specific hydrology and meteorology. The staff found that these analyses meet the design objectives of 10 CFR Part 50, Appendix I, environmental standards of 40 CFR Part 190, and dose limits of 10 CFR 20.1301. They concluded that reactor designs falling within the envelope of the PPE normal effluent release source terms and associated offsite doses are without undue risk to public health and safety. The staff issued an action item to verify that calculated doses to the public from normal effluent releases for the chosen reactor design are bounded by the doses evaluated in the early site permit. We concur with the staff's conclusions.

### *Accident Analyses*

To evaluate offsite post-accident doses TVA selected the vendor-supplied design basis accident analyses with the highest post-accident doses for the site-specific dose analysis, and based the PPE source term on light-water reactor fuel representative of the SMR designs under consideration, assuming a single unit or module up to 800 MWt. Using site-specific short-term atmospheric dispersion factors ( $\chi/Q$  methodology), TVA scaled the vendor-supplied doses and dispersion factors to obtain doses at the exclusion area boundary and low population zone boundaries. TVA was able to demonstrate that the surrogate plant would meet the requirements of 10 CFR 50.34(a)(1) and 52.17(a)(1): an individual at any point on the exclusion area boundary for any 2-hour period following the onset of fission product release would not receive a radiation dose in excess of 25 rem total effective dose equivalent (TEDE); and an individual located at any point on the outer boundary of the low population zone exposed to the radioactive cloud from the postulated fission product release (during the entire period of its passage) would not receive a radiation dose in excess of 25 rem TEDE.

Consequences for bounding large-break loss-of-coolant accidents in SMRs are expected to be less than for large light-water reactors. TVA performed a comparison to similar analyses for the AP1000 plant (Vogtle 3 & 4 early site permit application) by scaling its thermal power by 0.235 (800MWt/3400 MWt). The scaled AP1000 dose result was 25% greater than the PPE surrogate for the worst 2-hour period, and roughly equivalent for a 30-day period, providing confidence in its analyses. The staff review found the analytical results adequate and acceptable in meeting the requirements of 10 CFR 50.34(a)(1) and 52.17(a)(1), and the PPE source term used not unreasonable in comparison to the AP1000 design. We concur with the staff's accident analysis assessment.

## **Emergency Preparedness**

TVA proposed a risk-informed, dose-based, consequence-oriented methodology to determine the plume exposure pathway (PEP) emergency planning zone (EPZ). This would be consistent with the dose-savings approach developed in NUREG-0396 and used to meet the dose criteria of the Environmental Protection Agency (EPA) early-phase protective action guides (PAGs), (i.e., protection from doses above the 1 rem TEDE limit). The dose savings criteria of NUREG-0396 for determining the PEP EPZ are: 1) the EPZ should encompass those areas in which projected dose from design basis accidents could exceed the PAG; 2) the EPZ should encompass those areas in which the consequences of less severe core melt accidents could exceed the PAG; and 3) the EPZ should be of sufficient size to provide for substantial reduction in early severe health effects in event of more severe core melt accidents (i.e., the conditional probability of exceeding 200 rem whole body dose outside the PEP EPZ is less than  $1 \times 10^{-3}$ ).

For the first two criteria, an applicant would analyze design basis accidents and appropriate accident scenarios with a mean core damage frequency greater than  $1 \times 10^{-6}$  per reactor-year, determine source terms, calculate dose consequences, and compare results to the EPA early-phase PAG. For substantial reduction in early health effects, an applicant would use a core damage frequency of greater than  $1 \times 10^{-7}$  per reactor-year to select severe accident scenarios, then repeat the above process to calculate a distance at which the conditional probability to exceed 200 rem exceeds  $1 \times 10^{-3}$ .

Based on the above approach, and taking into consideration design information from the four SMRs, TVA developed two *major features*<sup>1</sup> emergency plans: one with the site boundary as the EPZ and a second with an approximate 2-mile radius EPZ. An evacuation time estimate study was also conducted for the 2-mile radius EPZ. The evacuation time estimate did not identify any physical characteristics unique to the site that would pose a significant impediment to development of future emergency plans.

At least one SMR design is expected to meet the dose criteria for the site boundary EPZ; all four are expected to meet the dose criteria for a 2-mile EPZ. TVA also developed a bounding, non-design-specific, composite, accident release source term for the PPE with a 25% added margin. Analyses demonstrate that the PEP EPZ criteria are met. The isotopic total release activity over 96 hours resulted in a TEDE of about 0.9 rem at the site boundary. Although we concur that the 96-hour time period was correctly implemented with the example calculations, it is important to select the most severe 96-hour period for the specific design.

TVA is seeking exemption requests to deviate from the 10-mile PEP EPZ [10 CFR 50.33(g) and 50.47(c)(2)], and from certain emergency planning requirements. To support their exemptions request, TVA cited anticipated enhanced safety features of the SMR designs considered: smaller radionuclide inventory and source terms, reduced likelihood of accidents, slower accident progression rates, and features to minimize or mitigate accident consequences.

TVA would then present a complete and integrated emergency plan with the combined license or construction permit application, based on the selected SMR technology and estimated dose consequences, resulting in either an EPZ at the site boundary, the approximate 2-mile radius, or an appropriately scaled EPZ. The ingestion pathway EPZ for the CRN Site would also be described in the application.

---

<sup>1</sup> 10 CFR 50.47(a)(1)(iv)

The staff concluded that: TVA's PEP EPZ sizing methodology is acceptable because it is consistent with analyses that form the technical basis of the current 10-mile PEP EPZ and maintains the same level of protection (i.e., dose savings); the two *major features* emergency plans are acceptable; and the exemption requests are acceptable and will not present an undue risk to public health and safety. We concur with these staff conclusions.

## **SUMMARY**

The TVA early site permit application and the staff's review demonstrated suitability of the CRN Site considering topics including surrounding population, external hazards, site physical characteristics, potential radionuclide releases, and emergency preparedness. This application is unique in its approach to emergency planning in that it proposes a risk-informed, dose-based, consequence-oriented methodology to determine the appropriate PEP EPZ. We note that this is in parallel to proposed rulemaking on emergency preparedness for small modular reactors and other new technologies, which we agreed with in our recent October 19, 2018 letter on this subject.

The TVA early site permit application benefits from the proposed use of advanced light-water reactor-derivative SMR designs that are expected to exhibit both lower accident frequencies and consequences than the current fleet of large light-water reactors; the large body of knowledge associated with light-water reactor technology, particularly regarding source terms; and extensive light-water reactor operating and licensing experience. TVA's approach to emergency planning in providing dose savings is consistent with that used in developing NUREG-0396 and the staff's proposed current rulemaking on the matter. The early site permit for the Clinch River Nuclear Site should be issued.

Sincerely,

**/RA/**

Michael L. Corradini  
Chairman

## REFERENCES

1. Tennessee Valley Authority, "Clinch River Nuclear Site Early Site Permit Application," May 12, 2016 (ML16139A752, ML16144A033, ML16144A074, ML16144A145, ML16144A150, ML16144A151).
2. U.S. Nuclear Regulatory Commission, Selected Chapters from the Final Safety Evaluation Report presented to the ACRS from May 2018 to November 2018, "Clinch River Nuclear Early Site Permit Application Safety Evaluations with No Open Items," (ML18102B203, ML17289B148, ML18288A360, ML17289B252, ML17289B253, ML17289B254, ML17289B255, ML18102B150, ML17289A625, ML17291A052, ML18102B149, ML17291A547).
3. U.S. Nuclear Regulatory Commission, "Acceptance Review Results for an Early Site Permit Application for Clinch River Nuclear Site," January 5, 2017 (ML16356A226).
4. U.S. Nuclear Regulatory Commission, NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear power Plants," December 1978 (ML051390356).
5. U.S. Environmental Protection Agency, EPA-400/R-17/001, "PAG Manual: Protective Action Guidelines and Planning Guidance for Radiological Incidents," January 2017 (ML17044A073).
6. Nuclear Energy Institute, NEI 10-01, "Industry Guidelines for Developing a Plant Parameter Envelope in support of an Early Site Permit," Revision 0, March 2010 (ML101050329).

January 9, 2019

SUBJECT: EARLY SITE PERMIT – CLINCH RIVER NUCLEAR SITE

Accession No: **ML19009A286**

Publicly Available **Y**

Sensitive **N**

Viewing Rights:  NRC Users or  ACRS Only or  See Restricted distribution \*via email

<b>OFFICE</b>	<b>ACRS/TSB</b>	<b>SUNSI Review</b>	<b>ACRS/TSB</b>	<b>ACRS</b>	<b>ACRS</b>
<b>NAME</b>	QNguyen	QNguyen	MBanks	AVeil	MCorradini ( <i>AVeil for</i> )
<b>DATE</b>	1/09/2019	1/09/2019	1/09/2019	1/09/2019	1/09/2019

**OFFICIAL RECORD COPY**