Summary of Observations and Issues Identified During the Pre-application Readiness Assessment of the Early Site Permit for the Clinch River Nuclear Site

The purpose of pre-application readiness assessment by NRC staff was to examine selected sections of the Tennessee Valley Authority (TVA) Clinch River early site permit (ESP) draft application, allow staff to become familiar with the level of detail in the draft application, and identify potential impediments to the NRC's ability to conduct its review in a timely and efficient manner. The readiness assessment was also intended to help the NRC staff prepare for the review by becoming familiar with the approaches to the evaluation and methods used to develop the application. The following NRC staff observations from the readiness assessment identify areas where additional information may be warranted in the application in light of applicable NRC requirements and guidance. Once the draft application is closer to completion, TVA may wish to consider additional pre-application interactions with the NRC staff.

Meteorology

For this subject matter area, the staff considered the overall content of the draft ESP application in terms of consistency with NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (SRP). During the readiness assessment, the staff identified some areas where additional information might facilitate a more efficient review. The staff also identified three input/output files that TVA should submit at the time of the ESP application submission to obviate the need for requests for additional information (RAI) and facilitate the staff's review. Specific staff observations shared with TVA during the readiness assessment are as follows:

Site Safety Analysis Report (SSAR) Section 2.3.1

- Inclusion of a more detailed description of the effects of climate change over the expected lifetime of the plant.
- Inclusion of all site characteristics for comparison against site parameters for each design in the plant parameter envelope (PPE).

SSAR Section 2.3.2

- Inclusion of meteorological data consistent with Regulatory Guide (RG) 1.23, "Meteorological Monitoring Programs for Nuclear Power Plants," at the time of ESP application submission.
- Inclusion of a more detailed SSAR description of local topographic effects and the role that it plays in local meteorology.
- Resolution of the differences in the corresponding wind rose plots resulting from the different observation locations.

SSAR Section 2.3.4

- Availability of input and output files for the PAVAN computer code in support of the ESP application.
- Explanation of TVA's short term dispersion modeling and boundary assumptions.

SSAR Section 2.3.5

- Potential use of the CALPUFF model to determine if a complex terrain adjustment was needed when using the XOQDOQ computer code.

- Inclusion of input and output files for the XOQDOQ computer code in support of the ESP application.

Hydrology

The staff identified aspects of SSAR Section 2.4 where further clarification and information would benefit the NRC staff's understanding of TVA's evaluation of the Clinch River Nuclear (CRN) site's hydrology with respect to safety-related issues. These considerations were shared with TVA staff at the exit briefing and are outlined below:

- Presenting technical bases in the SSAR in a manner that can be clearly understood by a technically diverse audience.

- Providing explanations for observations rather than simply stating that an observation was made (e.g., contamination is observed in observation well OW-422L in the SSAR with no explanation as to the source).

- Ensuring consistency with regard to a geodetic datum in the SSAR and definition of this vertical datum in Section 2.4 and in other sections of the SSAR.

- For SSAR Section 2.4.3, describing the methodology used on the national inventory of dams (NID) information for inflow calculations, how the information was included in the probable maximum flood (PMF) analysis, and the effect of the information on the hydraulic analyses. A brief discussion is included in the SSAR but the depth of the discussion is limited.

- For SSAR Section 2.4.4, describing the NID information relevant to seismic dam failure used for inflow calculations and the wind wave analysis methodology used for combined effects calculation. The erosion/deposition technical reference that was used in the analyses should be included and referenced in the SSAR.

- For SSAR Section 2.4.12, describing and referring to the Clinch River Breeder Reactor Project closure report for information related to the closure of the site, boring/wells, and the abandonment of these wells after closure.

- For SSAR Section 2.4.13, providing the rationale for assuming the complete mixing of groundwater flowing into the river from the site with the entire flow volume of the river or providing an alternative conceptual model. Although the scenario assumes an extremely low (400 cubic feet per second) river flow, complete mixing of groundwater flowing from the site into the river, with the entire flow of the river, would seem implausible regardless of the riverine flow rate.

Design Basis Accident (DBA) Dose Assessment and Related PPE

The staff considered the information related to the DBA radiological analysis in terms of consistency with the expectations for the topic given in the SRP and Review Standard RS-002, "Guidance for Processing Applications for Early Site Permits." As outlined below, NRC staff identified potential areas where further clarification and information would benefit the staff's

understanding of TVA's evaluation of the CRN site with respect to design basis accident dose and related PPE issues.

- SSAR Chapter 15 should provide more information on the basis for the PPE accident source term, including:
    - a general description of the plant design considered bounding,
    - the power basis in megawatts thermal (MWt) for the PPE accident source term,
    - a general description of accident source term development, and whether the vendor followed any regulatory guidance on source term methodology or instead used novel methods, and
    - how (or if) uncertainty was considered in the PPE accident source term.

- SSAR Table 2.3.4-14 includes an exclusion area boundary atmospheric dispersion factor (χ/Q) for "Release Zone 2," which is a larger value than used in the SSAR Chapter 15 assessment. During the discussion, TVA stated that this release location was only for evaluation of potential reactor locations and it would be removed from the SSAR for submittal of the ESP.

<u>Emergency Planning (EP)</u>

The staff identified issues warranting clarification on several emergency planning topics, including:

- The interfaces among the CRN site, TVA, and State and local authorities with respect to a smaller plume exposure pathway (PEP) emergency planning zone (EPZ) size, including training, interactions, drills, evaluations, reviews of documents, and so forth among the stakeholders.

- The nature of the off-site or public protective actions for a site boundary PEP EPZ and the implementation of the Tennessee and county plans.

- TVA's established operating philosophy with respect to EP and the continuation of established practices with Tennessee and counties.

The staff noted that there was no clear outline in the SSAR or supporting documents of what EP topics would be presented as major features of emergency preparedness to be addressed in the ESP application and those that would be deferred to the combined license (COL) application. The staff also noted a reference to a document not yet issued or endorsed by the NRC. The application should only reference materials that are available at the time of the application.

Examples of staff observations about other TVA draft EP documents include:

Part 2, SSAR, Chapter 13.3:

- Contains inconsistent references (including between the two anticipated sets of plans) to the specific regulation under which the emergency plans are to be submitted.
- Does not provide a technical basis to support the assertion that the risk of a radiological release and offsite consequences is justified. Furthermore, the application does not contain bases for slower rate of progression of postulated accidents, the elimination of several "normally" considered DBAs, and the significantly less likely beyond-design-

basis accidents.

- Contains references to a Tennessee all-hazards plan. However, the draft application does not clearly identify to what extent the CRN plans would depend on the Tennessee response.
- Contains vague terms and ambiguous ideas. Given the unique review and process, the lack of previous experience with small modular reactor applications and the issues involved to inform the review process, greater clarity and definitiveness will be necessary in the application.

Part 5, Emergency Plan, Plan 5a and 5b (SB PEP EPZ Plan and 2-mile PEP EPZ Plan, respectively) does not provide a detailed location description of the Central Emergency Control Center (CECC), which is functionally the same as an Emergency Off-site Facility (EOF). The distances between the CRN site, the CECC, the Local Recovery Center, the Radiological Monitoring Control Center and a "near-site" EOF or response center are not provided to determine whether Title 10 of the *Code of Federal Regulations* (CFR), Part 50, Appendix E, Section IV.E.8.b would be met.

Appendix A to Plan 5b did not provide a starting cue for the 15-minute period to begin the alert notification system notifications.

Part 6, Exemption Request:

- Identified a need for exemptions from FEMA regulations in 44 CFR 350. However, FEMA does not have an exemption process outlined in applicable regulatory or guidance documents.
- Does not provide a basis for not considering sheltering-in-place as a protective action.
- Does not provide a basis for removing on-site evaluated exercises.

Emergency Planning Zone Size Analysis

The staff notes that the technical analysis to support a site-specific EPZ size for the CRN site would not be part of the ESP application, because the analysis relies upon design information which is not available from potential design vendors at the current stage of their design development.

Although the ESP application does not include detailed methods or results for the technical analysis, SSAR Section 13.3.3.1 discussed the criteria and an overview of the methods that would be used in a future COL application. The criteria and analysis method discussed in the SSAR are based on the Nuclear Energy Institute's (NEI) white paper dated December 28, 2013, titled "Proposed Methodology and Criteria for Establishing the Technical Basis for Small Modular Reactor Emergency Planning Zone." TVA indicated that it does not intend to adopt the NEI white paper methods and criteria as they stand in the paper, but will use the methods as a starting point for its selected methods and criteria for analyses to support the proposed EPZ size.

The staff observed that the ESP application should clearly define terms related to this topic area (e.g., “low risk”).

The staff observed that ESP SSAR Section 13.3 should provide more information on the expectations for the COL application on treatment of source term and uncertainty and identification of analysis margin in the analyses to support EPZ size.

Geology, Seismology, and Geotechnical Engineering

For the geology, seismology, and geotechnical engineering topic areas, the staff looked at the information in SSAR Chapter 2.5. The staff considered the draft information related to the geology, seismology, and geotechnical engineering characteristics and associated analyses in light of the NRC guidance for these topics outlined in the SRP.

Based on a limited examination, the staff identified several potential information gaps. Most notably, the staff identified significant concerns regarding many of the assumptions and approaches used in generating the site response results. Should TVA continue with its planned analytical approach, the staff anticipates a higher level of review effort and more RAIs than would be typically expected, which likely would lead to a protracted review schedule. Further, following the more detailed acceptance review conducted upon receipt of the final application, when taken in aggregate these gaps may have implications for a decision on docketing.

Staff understands that, as TVA indicated during the readiness assessment, further work is continuing on the draft application materials, which were incomplete at the time of the assessment. Once the draft application is closer to completion, TVA may wish to consider a second pre-application readiness assessment in this technical area. The specific technical issues are noted in the list below.

- The CRN site subsurface strata slope is about 33 degrees. The site response calculation made available to staff was performed using a 1-D model. While a 1-D analysis is permissible in existing technical guidance for most cases, the nature of the CRN site may not lend itself to a 1-D model. TVA should reference RG 1.208, “A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion,” which notes that “often vertically propagating shear waves are the dominant contributor to free-field ground motions at a site. In these cases, a one-dimensional equivalent-linear analysis or nonlinear analysis that assumes vertical propagation of shear waves may be appropriate. However, site characteristics (such as a dipping bedrock surface, topographic effects, or other impedance boundaries)…may require that analyses are also able to account for inclined waves.” At a minimum, sufficient justification for the use of a 1-D model, as well as a 2-D sensitivity analysis, would enable the staff to conduct its technical review, and could be included at the time of submittal. Through discussions during the readiness assessment, staff understands that TVA conducted a 2-D site response calculation previously for the site, which may serve this function.

- The draft application materials referenced guidance (Electric Power Research Institute (EPRI) Report 1025287, “Seismic Evaluation Guidance, Screening, Prioritization and Implementation Details [SPID] for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic,” November 27, 2012, Agencywide Documents Access and Management System Accession No. ML12333A170) developed for Near-Term Task

Force 2.1 reviews for operating reactors in its site response calculations. Because the Screening, Prioritization and Implementation Details (SPID) was specifically developed for operating reactors with very limited subsurface data, the use of SPID is not appropriate for new reactor siting applications. Significant subsurface data is available for the CRN site, as expected for a new reactor applicant. As such, the results of TVA's current analytical approach may not properly represent the conditions at the site and may affect the final hazard results such that the ground motion response spectrum (GMRS) may not be representative of the site. TVA may wish to consider utilizing prior site response analyses that the staff understands were conducted following RG 1.208 in an earlier calculation (as referenced above).

- TVA performed updates to the seismic catalog as well as the seismic sources. As specified in NUREG-2117, "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies," the application should provide full details of the updates, and the justification that those updates were performed consistent with Senior Seismic Hazard Analysis Committee (SSHAC) Level 2 guidance.

- Because of the karst features in the subsurface, the application should include further information related to karst in terms of dissolution rates, excavation geologic mapping and expected void sizes and locations (further details provided in the items below).

Other Technical Gaps and Observations that should be considered:

SSAR Section 2.5.1 Geologic Characterization Information

- Include more information on the Chestnut Ridge fault, with consideration of whether it is essentially contemporaneous with the White Oak Mountain fault rather than older.

- Include more information on the possibility of blind faults at or adjacent to the site.

- Include more information on potential tear faults in the site region (i.e., analogy is made for the Bitter Creek and Emory River faults as tear faults with the Jacksboro fault, but the Jacksboro fault is not described to make the case for the analogy).

- Include reference to a report prepared by Robert Hatcher on geology of the Oak Ridge site and other references besides A J. Crone and R L. Wheeler (2000) when characterizing faults postulated to possibly be of Quaternary age (i.e., Kentucky River Fault System and Rough Creek-Shawneetown Fault System).

SSAR Section 2.5.2 Vibratory Ground Motion

- The draft application in its seismicity updates does not go into the details of declustering algorithm(s). Discussion on the algorithm(s) and performance indicators should be provided.

- The draft application does not provide detailed discussion of potential local seismic source and earthquake recurrence rates modifications/updates. NUREG 2115, "Central and Eastern United States Seismic Source Characterization for Nuclear Facilities," models are regional models and NUREG 2115 specifically states site-specific updates should be considered by a potential applicant, including:

- Discussion of the need to change and/or add new seismic sources;
- Adequacy of the regional seismicity rates in NUREG 2115 for the CRN site;
- There is new information available on the Eastern Tennessee Seismic Zone and potential impacts of such new information on the published seismic source models and the subsequent seismic hazard curves calculated need to be discussed in detail; and
- Comparison of probabilistic seismic hazard analysis (PSHA) model with the most recent PSHA studies, such as the U.S. Geological Survey (USGS) National Seismic Hazard Map.

- The draft application discusses the use of EPRI 2013 ground motion prediction equations (GMPEs) in its PSHA calculations. The staff informed TVA that Next Generation Attenuation (NGA) East GMPEs are likely to be published during the review of this application and the staff will be evaluating this as new information, when it is published, consistent with guidance in RG 1.208 regarding the need to consider the latest information in a PSHA. TVA should consider monitoring ongoing activities in this area to more fully address these issues in its application.

- The application should include a discussion of the PSHA software used, as well as the validation process to ensure the software produces accurate results.

SSAR Section 2.5.3 Surface Deformation

- The application should include information on dissolution rates of carbonates and on hypogenic karst dissolution at the site, as well as further details of the approach to be used in the excavation geologic mapping for determining if karst may occur below the foundation grade level.

SSAR Section 2.5.4: Stability of Subsurface Materials and Foundations

- The application should include a description of groundwater chemical test results, including whether the chemical properties of groundwater could adversely affect the properties of the limestone subsurface and future concrete foundations.

- Karst features are found at the proposed site and the existence of voids below foundation level may affect the stability of structures. More detailed information (such as locations and dimensions of the voids inside the zone of influence of the proposed foundation locations, and how these features were characterized) and related evaluations (such as the effect on bearing capacity and foundation stability) should be included, including a discussion of any planned subsurface improvements.

- Kappa value, a parameter used in site seismic response analysis, is discussed in 2.5.4. However, this parameter is not a subsurface material property and 2.5.2 is a more proper section to discuss this parameter.

- A special feature of the proposed site is that the subsurface strata have an inclination angle of about 33 degrees. This feature creates some issues that will not only affect the site stability evaluations but also site seismic response and future SSI analyses. The related issues for which more information should be provided in the application include:

- Some methods/models that are normally used to determine soil and rock strength properties are not likely to be technically justifiable. For example, when determining rock strength properties, the geological strength index (GSI) for jointed rock may not be applicable because the GSI classification system is based on the assumption that the behavior of the rock mass is independent of the direction of the applied loads. Therefore, the GSI system should not be applied to those rock masses in which there is a clearly defined dominant structural orientation or structurally dependent gravitational instability.
- When determining site bearing capacity, the models based on general shear failure assumptions, such as Terzaghi's bearing capacity equation (commonly used in engineering practices) cannot be used without substantial modification and justification, because the existing rock layer incline surface will be a pre-determined failure surface and therefore it will not be a general shear failure. Also, the application presented results of estimated bearing capacity based on several methods, and should include justifications for the design parameter values used in the application.
- Soil shear wave velocity profile is an important input to site seismic response and Soil-Structure Interaction (SSI) analyses. Although SSI is not required for an ESP application (no technology has been selected), properly determined soil profiles in the ESP will reduce, or eliminate the need for re-determination of soil profiles in a future COL application. The inclined rock layers may require 2-D or 3D consideration when conducting site seismic response (as previously described) and SSI analyses, therefore proper soil profiles that can reasonably represent the actual site condition should be provided to meet the needs of site seismic response and SSI analyses.