September 11, 2017

MEMORANDUM TO: Joseph Colaccino, Chief
Licensing Branch 3 Projects Branch
Division of New Reactor Licensing
Office of New Reactors

FROM: Allen Fetter, Senior Project Manager **/RA/**
Licensing Branch 3 Projects Branch
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: SUMMARY REPORT FOR THE MAY 8-9, 2017, GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING INFORMATION AUDIT (SECTION 2.5 OF THE SITE SAFETY ANALYSIS REPORT), TENNESSEE VALLEY AUTHORITY, EARLY SITE PERMIT APPLICATION, CLINCH RIVER NUCLEAR SITE

By letter dated May 12, 2016, Tennessee Valley Authority (TVA) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for an early site permit for the Clinch River Nuclear (CRN) Site located in Oak Ridge, Tennessee. In support of the application, TVA subsequently provided supplemental information, and the NRC staff accepted the application for docketing and detailed review on December 30, 2016. A notice of NRC's docketing decision was published in the Federal Register on January 12, 2017.

As part of the NRC's staff review, the Geoscience and Geotechnical Engineering Branch (RGS), Division of Site Safety and Environmental Analysis conducted an audit of data and information used to support Section 2.5 (Geology, Seismology, and Geotechnical Engineering) of the Site Safety Analysis Report (SSAR), as supplemented, at TVA offices in Knoxville, Tennessee on May 8, 2017. In conjunction with the information audit in May, NRC staff visited the CRN site and surrounding area in an effort to become familiar with the site layout, the surrounding geologic and tectonic features, as well as physiography as portrayed in the SSAR. Additionally, the staff was also able to observe select examples of rock core borings (identified as information needed in the audit plan), which provided the staff first-hand view of the geologic bearing layers at the site. The audit plan used to support these interactions is located in NRC's Agencywide Documents Access and Management System (ADAMS) under Accession No. ML17108A822. The staff developed an initial list of 14 information need items in the audit plan, which were alpha-numerically categorized in TVA's "Seismic-Geotechnical Audit Information Packet and Geologic Features Field Guide (ADAMS Accession No.ML171736A033), and are shown in table form in Enclosure 5 below.

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301-415-8556

Enclosures relevant to this audit are included in this memorandum. The enclosures are as follows: (1) Geology, Seismology, and Geotechnical Engineering Audit Summary, (2) Geology, Seismology, and Geotechnical Engineering Audit Agenda, (3) Geology, Seismology, and Geotechnical Engineering Audit Participants, (4) Trip Report - Geology, Seismology, and Geotechnical Engineering Site Safety Audit, and (5) Table of Geology, Seismology, and Geotechnical Engineering Site Safety Audit Information Need Audit Activities, Observations and Resolution/Status of Information Needs.

Docket No.: 52-047

Enclosures: As stated

SUBJECT: SUMMARY REPORT FOR THE MAY 8-9, 2017, GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING INFORMATION AUDIT (SECTION 2.5 OF THE SITE SAFETY ANALYSIS REPORT), TENNESSEE VALLEY AUTHORITY, EARLY SITE PERMIT APPLICATION, CLINCH RIVER NUCLEAR SITE

Dated: September 11, 2017

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CLINCH RIVER NUCLEAR SITE, EARLY SITE PERMIT APPLICATION
GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING
AUDIT SUMMARY

1. Background

Tennessee Valley Authority (TVA) submitted geologic, seismic and geotechnical engineering characterization information to the U.S. Nuclear Regulatory Commission (NRC) as part of their Clinch River Nuclear (CRN) Site Early Site Permit (ESP) application. In preparation for the audit, the NRC staff reviewed the data and information within Section 2.5 of the Site Safety Analysis Report (SSAR), as supplemented, and identified information needs that would enhance the staff's understanding of the detailed analyses and bases underlying the formal application.

In conjunction with the information audit, which took place at the TVA Knoxville Office on May 8, 2017, NRC staff visited the CRN Site and surrounding area in an effort to become familiar with the site layout, the surrounding geologic and tectonic features, as well as physiography. At the CRN Site, the NRC had the opportunity to examine geologic core samples collected during site investigations. Both venues provided the staff an opportunity to discuss the information needs identified during the staff's initial review of the application and associated SSAR sections with TVA's subject matter experts (SMEs), staff and contractors. During the audit, the staff reviewed and discussed probabilistic seismic hazard analysis evaluations methodology, shear zone characterizations within the subsurface, and karst formation evaluations and characterizations proposed in the SSAR, as well as associated calculation packages and supporting modeling documentation. The audit allowed the staff to better understand the site and modeling results so that it will be able to make appropriate safety conclusions concerning site characteristics. The audit also assisted the staff in identifying subsequent requests for additional information that the staff needed to conduct a complete review of the CRN Site ESP application.

2. Regulatory Basis

This regulatory audit was based on the following:

- NUREG 0800, "Standard Review Plan"
- Regulatory Guide (RG) 1.206, "Combined License Applications for Nuclear Power Plants"
- Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20, "Standards for Protection Against Radiation"
- 10 CFR 100.20, "Factors to be Considered When Evaluating Sites"
- 10 CFR100.21, "Non-seismic Siting Criteria"
- 10 CFR 100.23, "Geologic and Seismic Siting Criteria"
- 10 CFR 52.17 Contents of Applications; Technical Information, subparts (a)(1)(ii) and (a)(1)(vi)

- 10 CFR Part 50, Appendix A, General Design Criterion 2

3. <u>Documents Reviewed</u>

- Early Site Permit (ESP) Application, Revision 0, as supplemented, Section 2.5
- Information Needs (*See* Audit Plan at Agencywide Documents Access and Management System ML17108A822)

4. <u>Audit Results</u>

A table outlining how information needs were addressed, and their resolution status is provided in Enclosure 5

AGENDA

Tennessee Valley Authority Clinch River Nuclear Early Site Permit Site Audit Pertaining to the Review of the Site Safety Analysis Report, Section 2.5
Tennessee Valley Authority, Knoxville Office, Knoxville, Tennessee
Clinch River Nuclear Proposed Site, Oak Ridge, Tennessee

May 8 – 9, 2017

Monday, May 8, 2017, MORNING SESSION: AUDIT – Proprietary

8:30 a.m. - 8:45 a.m.	Audit Entrance / Introduction	[NRC/TVA]
8:45 a.m.-12:00 noon	Documentation Review and Discussion: Methodology for seismic calculations and analysis, void formation evaluation and associated calculations	[NRC/TVA]
12:00 p.m. - 1:00 p.m.	**Lunch**	

Monday, May 8, 2017, AFTERNOON SESSION: AUDIT - Proprietary

1:00 p.m.-4:30 p.m.	Documentation Review and Discussion Continued and Field Trip for Geology Review	[NRC/TVA]
4:30 p.m. - 4:45 p.m.	NRC Internal Caucus Debrief Summary	[NRC] [NRC/TVA]
5:00 p.m.	**Adjourn**	

Tuesday, May 9, 2017, MORNING SESSION: AUDIT - Proprietary

9:00 a.m.-12:15 p.m.	Site Tour (examination of cores/samples, area/vicinity geologic features)	[NRC/TVA]
12:15 p.m. -1:00 p.m.	**Lunch**	

Tuesday, May 9, 2017, AFTERNOON SESSION: AUDIT – Proprietary

1:00 p.m. - 4:30 p.m.	Site Tour (area/vicinity geologic features continued)	[NRC/TVA]
4:30 p.m. - 4:45 p.m.	NRC Internal Caucus	[NRC]
4:45 p.m. - 5:00 p.m.	Audit Exit	[NRC/TVA]
5:00 p.m.	**Adjourn**	

CLINCH RIVER NUCLEAR SITE, EARLY SITE PERMIT APPLICATION
GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING
AUDIT PARTICIPANTS
MAY 8-9, 2017

Name	Affiliation	Name	Affiliation
Bauer, Laurel	NRC	Cahill, Tim	Bechtel
Fetter, Allen	NRC	Carr, Becky	Bechtel
Heeszel, David	NRC	Carson, Alice	Bechtel
Rodriguez, Ricardo	NRC	Clemente, Jose	Bechtel
Stieve, Alice	NRC	Damm, John	Bechtel
Wang, Weijun	NRC	Hummer, Kim	Bechtel
Brellenthin, Jack	TVA	Troup, Alan	Bechtel
Casey, Kevin	TVA	Marrone, James	Bechtel
Doss, Stuart	TVA	Clahan, Kevin	LCI
Holcomb, John	TVA	Huebner, Matt	LCI
Justice, Wally	TVA	Sowers, Janet	LCI
Perry, Jeff	TVA	Toro, Gabriel	LCI
Schiele, Ray	TVA	Wong, Ivan	LCI
Stout, Dan	TVA	Silva, Walt	Pacific Eng.
Criscenzo, Stephen	AMEC	Tastan, Onur	RIZZO
Lear, Michael	AMEC		

TRIP REPORT FOR
GEOLOGY SEISMOLOGY, AND GEOTECHNICAL ENGINEERING AUDIT
MAY 8-9, 2017

On May 8-9, 2017, the U. S. Nuclear Regulatory (NRC) staff conducted the seismology, geology and geotechnical engineering audit at Tennessee Valley Authority's (TVA) Knoxville, Tennessee office complex, and at the proposed Clinch River Nuclear (CRN) Site, and environs, in Oak Ridge, Tennessee. The purpose of the audit on May 8, 2017, was to address information needs in the audit plan (see Enclosure 5) through review and discussion of methodologies, inputs and calculations used by TVA to support seismic and geotechnical engineering models in the Site Safety Analysis Report (SSAR) , as supplemented. For the May 8-9 visit to locations with geologic and tectonic features within the CRN site and vicinity (see Enclosure 5), staff were able to observe and confirm that those features were accurately characterized in the SSAR, as supplemented.

During the aforementioned audit activities, NRC staff caucused internally on several occasions to discuss adequacy of audit interactions for resolving the various information needs. Resolution was reached on most of the information needs, though it was determined that requests for additional information (RAI) would likely be necessary (as noted in Enclosure 5).

Late in the afternoon of May 9, 2017, a final audit closeout meeting was held between NRC and TVA to help ensure that there was a common understanding of what information needs had been closed during the audit, and which information needs remained open pending the formal submission of supplemental information on the docket. NRC staff emphasized that even if information needs were considered closed for the purposes of the audit, additional RAIs on the various technical areas were not precluded. Descriptions on the resolution and status of all the information needs are provided in Enclosure 5.

TABLE OF GEOLOGY, SEISMOLOGY AND GEOTECHNICAL ENGINEERING AUDIT INFORMATION NEEDS AUDIT ACTIVITIES, OBSERVATIONS, AND RESOLUTION/STATUS OF INFORMATION NEEDS

Information Need ID Number (Description)	Question/Request	Audit Item/Activity	Observations/Status
CR-01: (Examination of Specific Rock Core Sections)	Examples of shear fracture zone and other fracture zones (to distinguish the difference between shear fracture zones from fracture zones) in boreholes: 21 ft. in MP 423 (718-697 ft. elev, runs 13,14,15,16,17,18); 18 and 6 ft in MP 201 (644-626 ft elev, runs 27,28,29,30) and (497-491 ft elev, runs 56 & 57)); and 6 ft in MP 101 (553-547 ft elev, runs 47, 48), based on information from Tables 2.5.1-16 and -17.	Requested core samples were made available to NRC during May 9, 2017 visit to the Clinch River Nuclear Site	NRC staff examined the requested rock cores to observe the distinction between the shear fracture zones and fracture zones, as described in the SSAR. Based on their observations of the rock core, staff considered that TVA's characterization of these features was consistent and reasonable. **Closed.**
CR-02: (Examination of Specific Rock Core Sections)	Examples of open voids in boreholes (information from ESP Table 2.5.1-11) MP 418 (void at ~ 756 and ~735 ft elev)	Requested core samples were made available to NRC during May 9, 2017 visit to the Clinch River Nuclear Site	NRC staff examined the requested rock cores to observe the size and distribution of open voids in boreholes, as described in the SSAR. Based on their observations, staff considered that TVA's characterization of these voids was consistent and reasonable. **Closed.**
CR-03: (Examination of Specific Rock Core Sections)	Examples of clay or soil filled voids as described in CNL-16-162 (TVA letter). CNL-16-162, pE2-17: A number of the cavities encountered in the boreholes were partially to completely filled with clay or soil.	Requested core samples were made available to NRC during May 9, 2017 visit to the Clinch River Nuclear Site	NRC staff examined the requested rock cores to observe the examples of clay or soil filled voids in boreholes, as described in the CNL-16-162. Based on their observations, staff considered that TVA's characterization of the clay or soil filled voids was consistent and reasonable. **Closed.**

Information Need ID Number (Description)	Question/Request	Audit Item/Activity	Observations/Status
CR-04: (Examination of Specific Rock Core Sections)	Examples of Knox unconformity (Blackford/Knox contact) from borehole **MP 201,** suggest 305-315 ft depth, and **MP 423** suggest 275-280 ft depth, based on information in ESP SSAR Table 2.5.1-2	Requested core samples were made available to NRC during May 9, 2017 visit to the Clinch River Nuclear Site	NRC staff examined the requested rock cores to observe the nature of the Knox unconformity (Blackford/Knox contact), as described in the SSAR. Based on their observations, staff considered that TVA's characterization of the unconformity was consistent and reasonable. **Closed.**
CR-05: (Examination of Specific Rock Core Sections – Under Geotechnical Engineering in Audit Plan)	Borings MP101, MP201, and MP202 with emphasis on shear fracture features	Requested core samples were made available to NRC during May 9, 2017 visit to the Clinch River Nuclear Site	NRC staff examined the requested rock cores to observe the size, distribution and character of the shear fracture features, as described in the SSAR. Based on their observations of the rock core, staff considered that TVA's characterization of these features was consistent and reasonable. **Closed.**
FT-01: (Field trip to visit features described in SSAR text or illustrated in SSAR figures (if possible))	1. Visit the surface <u>projection</u> location of Shear Fracture Zone on site (Figure 2.5.1-65) and across the river if that location is accessible and currently exposed as indicated in TVA letter CNL-16-162, p E1-36. 2. Visit location of Chestnut Ridge and Copper Creek faults in site location. 3. Visit Quaternary deposits and landforms (terraces) in site area. 4. Visit 2 Sinkhole clusters on site (northern boundary) and to the SE (as indicated on fig 2.5.1-46) 5. Visit pinnacle and cutter exposure near Copper Ridge Cave (fig 2.5.1-40), an abandoned phreatic cave within site area. Visit both the hillside exposure and the cave.	TVA and contractors, Bechtel and LCI, led a field trip on May 8th for offsite features (#5, Knox unconformity along Hwy 170, and an additional karst stop) and May 9th for onsite features (#1, #2, #3, and #4, plus various outcrops on site to view various Chickamauga, Knox, and Rome Units)	NRC staff visited the locations of the different geologic and tectonic features with TVA and its contractors. Based on observations of these features, staff considered that TVA's depiction and description of them in the SSAR and in CNL-16-162 were consistent and reasonable. **Closed.**

Information Need ID Number (Description)	Question/Request	Audit Item/Activity	Observations/Status
GE-01: (Geotechnical Engineering)	Discuss Plaxis model calculation package (as part of Rizzo Report).	TVA SMEs were available to discuss during the audit	Based on technical discussions, NRC staff determined that TVA needed to submit a non-proprietary version of the Rizzo Report on the docket. TVA made a commitment to provide the report and make changes to the SSAR to include details of the PLAXIS model and results. TVA letter CNL-17-082 and enclosures submitted to NRC on July 3, 2017 included a non-proprietary version of the Rizzo Report and an addendum as well as related SSAR markups. NRC staff considers the information need **closed**.
GE-02: (Geotechnical Engineering)	Discuss bearing capacity and settlement calculation packages.	TVA SMEs were available to discuss during the audit. TVA provided the Bearing Capacity and Settlement for Power Block calculation for the NRC Reading Room	Based on technical discussions, NRC staff determined that TVA needed to submit a non-proprietary version of the Rizzo Report on the docket. TVA made a commitment to provide the report and make changes to the SSAR to include details of the PLAXIS model and results, and a discussion of RQD (Rock Quality Designation) value distribution with respect to geologic formation contacts. TVA letter CNL-17-082 and enclosures submitted to NRC on July 3, 2017 included a non-proprietary version of the Rizzo Report and an addendum as well as related SSAR markups. Although NRC staff obtained the requested information and this audit item is **closed**, staff issued

Information Need ID Number (Description)	Question/Request	Audit Item/Activity	Observations/Status
			an RAI (eRAI-9035) to seek additional information to support staff on safety evaluations of bearing capacity and settlement at the site.
GE-03: (Geotechnical Engineering)	Discuss the material in Section 2.5.1.2.3.4 Estimation of hypothetical large void in consideration of the material in the Rizzo Report.	TVA SMEs were available to discuss during the audit	Based on technical discussions, NRC staff determined that TVA needed to submit a non-proprietary version of the Rizzo Report on the docket. TVA made a commitment to provide the report and make changes to the SSAR to include details of the PLAXIS model and results, and removal of the hypothetical void discussion from Section 2.5.1. TVA letter CNL-17-082 and enclosures submitted to NRC on July 3, 2017 included a non-proprietary version of the Rizzo Report and an addendum as well as the promised SSAR markups. NRC staff considers the information need **closed**.
GI-01 (Geologic Information)	Discuss TVA evaluation of landslide hazard at the site location in consideration of SSAR section 2.5.3.8.2.2 and regional scale Figures 2.5.1-22 & 2.4.9-5.	TVA SME was available to discuss during the audit and site visit. TVA provided the Geologic Field Reconnaissance Report to the NRC Reading Room	During the site visit, the landslide hazard at the site location was discussed at Field Trip locations 2 (location of Chestnut Ridge and Copper Creek faults in site location) and 3 (Quaternary deposits and landforms (terraces) in site area). NRC staff considers the information need **closed**.

Information Need ID Number (Description)	Question/Request	Audit Item/Activity	Observations/Status
GI-02 (Geologic Information)	Discuss information in Tables 2.5.1-16 and 2.5.1-17 (to understand the differences between them).	TVA SMEs were be available to discuss during the audit. TVA provided the Rock Mass Properties calculation to the NRC Reading Room	TVA clarified that the contents of Table 2.5.1-16 focused on rock fractures (both mechanical and natural), whereas the contents of Table 2.5.1-17 focused on observed shear zones with descriptions. NRC understood the distinctions between the tables and considered the information need **closed**.
VGM-01 (Vibratory Ground Motion)	Discuss how rates and recurrence values for the ETSZ are considered in CEUS-SSC and how the treatment of the ETSZ distributed seismicity might impact the site-specific PSHA	SMEs were available to discuss during the audit. TVA provided the applicable documents to the NRC Reading Room.	NRC staff considered that TVA addressed the matter adequately at the audit. The SME from TVA (Gabriel Toro) presented results from the CEUS-SSC study that detailed how rates and b-values for the ETSZ are adequately accounted for in the CEUS-SSC through the epistemic uncertainty within the model. **Closed.**
VGM-02 (Vibratory Ground Motion)	Discuss development of 1-D site response analysis profiles in consideration of local geology (e.g. single velocity profile adjusted up or down vs depth of formation-specific velocity profile, epistemic uncertainty).	SMEs were available to discuss during the audit.	NRC staff gained a technical understanding of the trade-offs and uncertainties that were considered by the TVA SME in the development of the 1-D site response analysis profiles. However, in order to support a safety finding, NRC issued an RAI (eRAI-8893) to support a safety finding on vibratory ground motion. **Closed.**

Information Need ID Number (Description)	Question/Request	Audit Item/Activity	Observations/Status
VG-03 (Vibratory Ground Motion)	Discuss total site variability considered in site response in comparison to the total observed variability in geophysical data collected at the site.	SMEs were available to discuss during the audit.	NRC staff considered that TVA addressed the matter adequately at the audit. TVA presented a comparison of the total site variability and the total variability of the site response analysis and confirmed that the total variability of the site response analysis is consistent with the observed variability as measured at the site. **Closed.**