ClinchRiverESPHFNPEm Resource

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From: Mallecia Sutton

Date: March 25, 2018

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March 23, 2018

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

FROM: Mallecia A. Sutton, Project Manager ***/RA/***
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Office of New Reactors

SUBJECT: SUMMARY REPORT FOR THE HYDROLOGY AND HEALTH PHYSICS SAFETY AUDIT (SECTIONS 2.4, 11.2 AND 11.3 OF THE SITE SAFETY ANALYSIS REPORT) FOR THE CLINCH RIVER NUCLEAR EARLY SITE PERMIT APPLICATION

By letter dated May 12, 2016, the Tennessee Valley Authority (TVA) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for an early site permit (ESP) for the Clinch River Nuclear (CRN) Site located in Oak Ridge, Tennessee. TVA subsequently provided supplemental information in support of the application 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 staff review, the Radiation Protection & Consequences Branch and Hydrology and Meteorology Engineering Branch in the Office of New Reactors conducted an audit of the documentation supporting Section 2.4, "Hydrology Engineering" and Sections 11.2.3, "Liquid Radioactive Releases" and 11.3.3, "Gaseous Radioactive Releases" and related sections of the CRN Site ESP Site Safety Analysis Report (SSAR). The staff also audited the methodology, models, assumptions and calculation packages in support of SSAR Chapter 2, "Site Characteristics" and Chapter 11, "Radioactive Waste Management." This two-phase audit took place at the following locations: 1) the Bechtel Power Corporation (Bechtel) office in Reston, Virginia from April 14-17, 2017, and 2) the TVA Knoxville Complex offices in Knoxville, Tennessee, as well as the Clinch River Nuclear Site and surrounding areas, from April 24-27, 2017. The audit agenda and a list of the audit participants is included as Appendix A and Appendix B, respectively.

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The audit plan used to support these interactions is located in NRC's Agencywide Documents Access and Management System (ADAMS) under Accession No. ML17069A045. The staff developed an initial list of 44 information identifying needs to gain a better understanding of the detailed analyses and bases underlining the application. During audit interactions staff discussed hydrology and health physics topics that included the site setting, and potential effects of floods, dam failures, ice effects, low water considerations, groundwater, radionuclide source terms and exposure pathway doses, and accidental releases of radioactive liquid effluent in groundwater and surface waters for the proposed site.

Subsequent to the October 27, 2017 audit closure, the applicant submitted supplemental information to the CRN Site ESP docket that was required by the staff to make safety findings. The staff reviewed the applicant's submittals and information and, where needed participated in follow up discussions with the applicant for clarification of the supplemental information provided.

The enclosed Audit Report contains in the audit agenda in, Appendix A, a list of the audit participants Appendix B, and Appendix C a description of audit activities and a summary of the issues discussed and the status/resolution of the information needs that were outlined in the audit plan.

Docket No. 52-047

Enclosures:
1. Summary Audit Report
2. TVA Safety Audit Report
3. Appendix A Audit Agenda
4. Appendix B Audit Participants
5. Appendix C: CRN Site Status

cc w/encl.: See next page

SUBJECT: SUMMARY REPORT FOR THE HYDROLOGY AND HEALTH PHYSICS SAFETY AUDIT (SECTIONS 2.4, 11.2 AND 11.3 OF THE SITE SAFETY ANALYSIS REPORT) FOR THE CLINCH RIVER NUCLEAR EARLY SITE PERMIT APPLICATION DATED: MARCH 23, 2018

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SUMMARY TENNESSEE VALLEY AUTHORITY CLINCH RIVER NUCLEAR EARLY SITE PERMIT APPLICATION HYDROLOGY AND HEALTH PHYSICS SAFETY AUDIT REPORT APRIL 17–19, 2017 AND APRIL 24–27, 2017

1.0 BACKGROUND

The Tennessee Valley Authority (TVA) submitted ground and surface water modeling documentation 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 staff reviewed the documentation within Sections 2.4, "Hydrologic Engineering" 11.2.3, "Liquid Radioactive Releases" and 11.3.3, "Gaseous Radioactive Releases" and related sections of the Site Safety Analysis Report (SSAR) and the Environmental Report (ER) and, identified information needs to gain a better understanding of the detailed analyses and bases underlying the application.

In conjunction with the audit, several members of the staff visited the proposed site location and surrounding area in an effort to become familiar with the site setting and layout. This provided the staff with additional insight as to the relevance of the information needs that were identified during the staff's initial review of Sections 2.0, "Site Characteristics", 2.4, 11.2.3, and 11.3.3 and related sections of the SSAR and ER. During the audit, the staff reviewed the normal and accidental radionuclide source terms, exposure pathway doses, ground and surface water models, supporting modeling documentation and calculation packages. The audit allowed the staff to better understand the bases of the radionuclide source terms and modeling results in order to reach safety conclusions concerning site characteristics, assess the radiological consequences of accidental releases to ground and surface water, and exposure pathway doses. It also assisted the staff in identifying a need for requests for additional information that may be needed for the staff's complete evaluation of the CRN Site ESP Application review.

2.0 REGULATORY BASIS

- 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”

- 10 CFR Part 50, Appendix I, “Numerical Guides for Design Objectives and Limiting”

- Conditions for Operation to Meet the Criterion "As Low as is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents”

- 40 CFR Part 190, “Environmental Radiation Protection”

3.0 DOCUMENTS REVIEWED

- TVA CRN Site ESP Application, Revision 0 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16144A074)

- See Appendix C: CRN Site Information Need Status for document submittals

4.0 AUDIT RESULTS

- A table outlining how information needs were addressed, and their resolution status is provided in Appendix C.

TENNESSEE VALLEY AUTHORITY CLINCH RIVER NUCLEAR EARLY SITE PERMIT APPLICATION HYDROLOGY AND HEALTH PHYSICS SAFETY AUDIT REPORT APRIL 17–19, 2017 AND APRIL 24–27, 2017

INTRODUCTION

For the hydrology and health physics, the staff conducted two audits with the applicant; on April 17-19, 2017, in Reston, Virginia, and on April 24 - 27, 2017, in Knoxville, Tennessee, as well as the Clinch River Nuclear (CRN) Site and environs. The U.S. Nuclear Regulatory Commission (NRC) staff first met with the applicant at the Bechtel Power Corporation offices in Reston, Virginia. The staff and the applicant met again to continue the audit at the Tennessee Valley Authority (TVA) Knoxville Office Complex in Knoxville, Tennessee. The audit agenda and a list of the audit participants is included as Appendix A and Appendix B, respectively. The primary focus of the April 17-19, 2017 audit was to discuss the accidental liquid effluent release source term, postulated accidental liquid radwaste tank failure analysis, and modeling methods related to groundwater transport described in Site Safety Analysis Report (SSAR) Section 2.4.13, "Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters". The discussions at the TVA Knoxville Office Complex transitioned into the descriptions of the site characteristics governing radionuclide transport and, the regional and local hydrologic characterizations described in SSAR Section 2.4, "Hydrology Engineering" and the bases for normal plant parameter envelope (PPE) and accidental liquid and gaseous effluent release source terms and exposure pathway dose analyses for the surrogate plant described in SSAR Sections 2.0, "Site Characteristics" 11.2.3, "Liquid Radioactive Releases" and 11.3.3, "Gaseous Radioactive Releases". The audit information needs, status and the corresponding supplemental information submitted by the applicant are included as Appendix C. While in Knoxville, Tennessee, the staff traveled to the CRN Site in Oak Ridge, Tennessee and visited the site and surrounding area. For ease of reference, this safety audit report is organized by topical area discussions (i.e., Surface Water Hydrology, Groundwater Hydrology and Health Physics rather than two separate audit discussions.

HYDROLOGY – SURFACE WATER

Surface Water Hydrology CRN Site and Surrounding Area Tours

Information needs listed in Appendix C were included in the request for discussions related to surface water hydrology. The staff met with the applicant TVA, and its contractors Barge Wagoner Summer Cannon (BWSC), from April 24–27, 2017, for auditing surface water hydrology, which is relevant to Sections 2.4.1 through 2.4.11 of the applicant's SSAR. The audit activities were conducted at TVA offices in Knoxville, Tennessee, as well as at four major dams and the CRN Site power plant site. In the TVA offices, the staff primarily discussed the hydrologic issues with applicant and contractor. Initially, the staff planned to view the shoreline by boat; however, the Clinch River flow velocities were too fast and shoreline access restricted by dense brush precluded shoreline access by boat. Field trips were conducted to various sites including Douglas, Cherokee, Norris, Melton Hill Dams, the CRN Site, and downstream Highway 58 Bridge. The field trips allowed the staff to make observations on the following key topics: (1) the hydraulic conditions controlled by the dams and their embankments, (2) the regional and local hydrologic characteristics of the CRN

Site power plant site, and (3) the Highway 58 Bridge as an obstruction against the Clinch River flow. During the visits either at the dams, or at the CRN Site power plant site, and at the Highway 58 Bridge the staff discussed its information needs (Agencywide Documents Access and Management Systems (ADAMS) Accession No. ML17069A045) with the applicant. The status of applicant's responses is included in Appendix C: "CRN Site Information Need Status."

SURFACE WATER HYDROLOGY AUDIT

After the audit exit briefing on April 27, 2017, the staff continued the audit as needed through teleconferences in order to communicate with TVA regarding some unresolved hydrologic issues. Between April 27, 2017, and the audit closing date on October 27, 2017, the applicant provided three submittals to NRC for the surface hydrology review, including SSAR mark-ups and digital files (ADAMS Accession Nos. ML17157B212, ML17171A335, and ML17206A090). These submittals are the applicant's responses to the hydrologic issues as indicated in the information needs (ADAMS Accession No. ML17069A045). The staff will evaluate these submittals as supplemental information to the SSAR. The details of the audit status and results for the surface hydrology are reported and categorized into the following 9 topics below.

Low Flow Analysis

The staff noted that in the SSAR the applicant discussed that there is a 0.1 percent probability that a daily, average minimum flowrate of 400 cubic feet per second (cfs) could be released from the Melton Hill Dam into the Clinch River. The staff requested that the applicant clarify the development of the probability estimate associated with the 400 cfs flowrate. The staff checked TVA's 2008 Environmental Report (ADAMS Accession No. ML081850568) and found that the 400 cfs flowrate was the average 7-day, 10-year low flowrate resulting from a low flow frequency analysis. During the audit at TVA headquarters, the staff and the applicant discussed the applicant's detailed computations for the low flow probability. The staff requested that the applicant clarify the inconsistency associated with the probability of the 400 cfs flowrate between the 2008 ER and the SSAR. The applicant agreed to revise the SSAR Section 2.4.11.1.1 regarding development of the probability estimate associated with the 400 cfs flowrate. The staff will verify that this information as discussed during the audit is included in Section 2.4.11, "Low Water Considerations" of the Safety Evaluation Report (SER).

Stream Floods

The staff noted that in the SSAR the applicant addressed the flood history at the CRN Site. The staff requested that the applicant provide copies of the source information of the historical flood profiles, and the applicant's Clinch River Flood Report. The applicant provided the staff with the requested information during the site audit. The information detailed the historical flood profiles included engineering drawings of the maximum natural and regulated flood profiles prior to 1951. The applicant's Clinch River Flood Report contained information on how the historical flood elevations prior to 1959 were derived. The staff reviewed engineering drawings and the Clinch River flood report. The applicant agreed to revise SSAR Section 2.4.2.1 and Table 2.4.2-1 regarding the flood history at the CRN Site. The staff will verify that this information as discussed during the audit is included in Section 2.4.2, "Floods" of the SER.

Floods due to Hypothetical Dam Failures

The staff requested that the applicant provide a more detailed description about seismic and hydrologic failures of any dams that could impact the CRN Site. During the site audit and

reconnaissance at the dams, the applicant illustrated the hypothetical dam failure cases and indicated that the dams could hypothetically fail either in partial or in whole. The applicant explained the differences between the sunny day failure case and the seismic failure case and explained that those two cases would not be critical cases when compared to the case of dam failure due to a hydrologic event, such as a probable maximum flood (PMF) event. The staff discussed with the applicant the different dam failure cases that were related to the dam configurations, the flow control facilities, and the surrounding hydrologic and hydraulic conditions. The applicant agreed to revise SSAR Section 2.4.2.2. The staff will verify that this information as discussed during the audit is included in Sections 2.4.2 and 2.4.4, “Potential Dam Failures” of the SER.

The staff reviewed whether the Melton Hill Dam could have direct impacts on the CRN Site if the dam failed. The staff questioned how the applicant’s PMF analysis applied to the Melton Hill Dam. During the site audit and reconnaissance at the Melton Hill Dam, the staff were provided access to walk on the Melton Hill Dam and its embankments. The applicant explained the hypothetical dam breach conditions related to the configuration of the dam and the concrete navigation lock. The applicant indicated an overtopping flow of the PMF would cause the Melton Hill Dam failure. The staff will evaluate and compare the dam breach assumptions to the observed hydraulic conditions of the dam site in Section 2.4.4 of the SER.

The staff requested that during the dam reconnaissance the applicant explain the model development associated runoff and stream flows. The applicant illustrated the dam failure assumptions, including instantaneous failure, failure timing, and embankment breach parameters. The applicant included the dam failure assumptions, reservoir operational rules, and dam rating curves in the model development for the runoff and stream flow simulation. The staff asked questions about the accuracy of reservoir storage volume in the simulation and the computed storage volumes of the Cherokee and Douglas Dams. The applicant detailed that Geographical Information System tools and spreadsheets were used to check the storage volumes computed by the HEC-RAS model. The applicant provided a calculation package regarding the accuracy of the computed storage volumes. The staff will verify that this information as discussed during the audit is included in Sections 2.4.3, “Probable Maximum Flood (PMF) on Streams and Rivers” and 2.4.4 of the SER.

The staff noted the applicant adopted the Von Thun and Gillette method to determine the embankment breach configurations. The NRC staff requested that the applicant provide citations and references of that method. The applicant agreed to revise the SSAR with the supporting background information, and a general discussion of the method. The staff received a supplement detailing the SSAR revisions and will evaluate the Von Thun and Gillette method in Section 2.4.4 of the SER.

The staff noted that the applicant provided a schematic figure in the SSAR to locate the TVA’s dams associated with rivers and tributaries without a map scale. The staff requested that the applicant provide a geo-reference map in the SSAR that could show the relative positions among the dams and the stream-path lengths associated with the dams. The applicant agreed to revise the SSAR and replace the schematic figure with two geo-referenced maps. The staff received supplemental information from the applicant detailing the associated SSAR revisions.

The staff requested that the applicant discuss the methods and calculations for seismic and hydrologic dam failures as indicated in the SSAR. The applicant explained that the hydrologic failures were caused by overtopping flows during a PMF event, and the seismic failures were considered an extreme seismic event combined with a 500-year flood or a 25-year flood. The

staff asked how the 500-year flood was computed and how the applicant computed the outflows from the dams identified in the National Inventory of Dams (NID) for seismic failures. The applicant provided a calculation package and agreed to revise the SSAR for further staff review. The staff noted that the applicant used the Froehlich method to determine the peak of the breach outflows resulting from seismic failures. The staff will verify that this information as discussed during the audit is included in Section 2.4.4 of the SER.

The staff requested that the applicant discuss the flood wave routing coincident with dam failures. The applicant explained that the dam breach parameters were set up in the HEC-RAS model. The applicant provided the staff a calculation package and agree to revise its SSAR. The staff will verify that this information as discussed during the audit is included in Section 2.4.4 of the SER.

Local Drainage and Local Intense Precipitation

The staff asked the applicant for clarification on how it determined the adequacy of a drainage condition of the CRN Site as indicated in the SSAR. In response, the applicant clarified that the final grade design plan and drainage system would be provided to the staff for evaluation during the review of a Combined License (COL) Application and is not provided for review with the CRN Site early site permit (ESP) Application.

The staff asked the applicant to clarify the concave area shown in SSAR Figure 2.4.1-4, "Representative Site Grading Plan." The applicant clarified that Figure 2.4.1-4 shows a proposed water intake location and is not meant to demonstrate the proposed topography and the drainage condition. The applicant agreed to revise the SSAR to remove Figure 2.4.1-4.

The staff asked the applicant to discuss the methodology that supported the local intense precipitation (LIP) computations. The staff requested the detailed descriptions of the temporal distribution of LIP. The applicant agreed to revise SSAR Section 2.4.2.3.1 describing the detailed temporal distribution of LIP. The staff will verify that this information as discussed during the audit is included in Section 2.4.2 of the SER.

Watershed Hydrology and Probable Maximum Precipitation

In the SSAR, the applicant selected four different probable maximum precipitations (PMPs), but it did not provide sufficient details to describe how the PMPs were developed. The staff requested clarification during the audit and the applicant provided files in the applicant's electronic reading room (eRR) detailing the PMP development for the staff's review. The staff noted that the applicant described the same temporal distribution for all four PMPs. The staff discussed with the applicant the methods published in the National Weather Service Hydro-meteorological Reports (HMR) and the uses of the HMR methods in the development of the PMPs. The applicant agreed to revise SSAR Section 2.4.3.2 describing the PMP development and SSAR Table 2.4.3-1 to include PMP depths. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff asked the applicant how it determined the 7980 square-mile PMP depth of 17.05 inches in the watershed above Watts Bar Dam. In the response, the applicant provided details of calculation methods and procedures for the PMP development. The staff noted that the PMP development was based on the HMR methods and procedures. The applicant agreed to revise SSAR Section 2.4.3 and Table 2.4.3-3. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff noted that the applicant used the unit hydrograph method and the PMPs as input data to compute the surface runoffs. The staff requested that the applicant provide clarification and references regarding how the applicant developed and validated unit hydrographs. The NRC staff also discussed with the applicant the need of adding sub-basin unit hydrographs in the SSAR. The applicant agreed to revise its SSAR with how the unit hydrographs were developed and provide the sub-basin unit hydrographs. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

In the SSAR, the applicant addressed the non-linearity of the unit hydrographs while considering the sub-basin hydrologic conditions. The applicant adjusted the unit hydrographs for the hydrologic non-linearity in the sub-basins, using the procedures stated in NUREG/CR-7046, "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America" (ADAMS Accession No. ML11321A195). The staff requested that the applicant provide details of the adjustments and the applicant agreed to provide the detailed description of the adjustments in an SSAR revision. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

Stream Flow Simulations

The staff discussed with the applicant methods and calculations to support the applicant's hydrologic model development. Through the discussions, the staff gained a better understanding on how the model developed and how the PMF analysis applied to the CRN Site.

In the SSAR, the applicant addressed that the storage volumes of dams identified in the NID were included in the surface runoff and reservoir inflow computations and the NRC staff requested that the applicant clarify how the storage volumes were developed into the surface runoffs. The applicant provided a calculation package in its eRR which contained a description of the computational method and details. The staff reviewed the applicant's calculation package as a supporting information to the SSAR. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

In the SSAR the applicant described parameters used in the dam breach outflow computations for TVA dams. The staff asked the applicant for clarification on how the dam breach parameters were computed in hydrological failure cases for the dams identified in the NID which are not owned by TVA. The applicant clarified that dam breach outflows of dams identified in the NID not owned by TVA were computed by converting dam storage volumes into flow hydrographs and not by using dam breach parameters. The applicant agreed to revise the SSAR. The staff will verify that this information as discussed during the audit is included in Section 2.4.4 of the SER.

The staff examined the applicant's HEC-RAS model (ADAMS Accession No. ML16216A115) and found that only one model cross-section was located at the CRN Site, so the staff requested that the applicant clarify the adequacy of the model cross-section interval at the CRN Site. At the audit, the applicant presented additional cross-sections in the upstream and downstream areas of the CRN Site. The applicant agreed to provide corrected cross-section layouts and intervals in the HEC-RAS model. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff asked the applicant for clarification on the proposed earth fill that will raise a flat terrain on the flood plain at the CRN Site to obstruct the overbank flow on the north bank. The applicant presented a USGS contour map of the CRN Site to indicate that the computed PMF

elevation would not be higher than original terrain elevation. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff asked the applicant for clarification on the adequacy of cross-section intervals in the area of the CRN Site, the warning notes relevant to the intervals in the HEC-RAS model output files, and the impact of reducing the cross-section interval on the computed PMF elevation at the CRN Site. The applicant responded that adding flow cross-sections to reduce the intervals would not significantly change the PMF elevation at the CRN Site. The applicant agreed to provide a technical memo and a calculation package regarding cross-section intervals for the staff to review. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff discussed with the applicant how the downstream Highway 58 Bridge and upstream Highway Bridge 95 bounding the CRN Site were considered in the PMF analysis. On April 26, 2017, the staff and the applicant made reconnaissance trips to these bridges. At the bridges, the staff observed stream flow conditions and discussed with the applicant the potential obstructions of the bridges against a high flow condition. The first stop was the Highway 95 Bridge upstream from the CRN Site, where the staff observed the sloped bridge abutments and bridge configuration and estimated the backwater effect on the bridge upstream. The second stop was the Highway 58 Bridge downstream from the CRN Site, where the staff could not access to the north abutment of the Highway 58 Bridge for an observation because of the dense bush around the bridge site. The staff requested that the applicant provide the Highway 58 Bridge profile and relevant hydraulic information shown on an engineering design drawing for the staff's review. The applicant agreed to revise the SSAR and provide the staff the bridge geometry files for the Highway Bridge 58. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff noted that the Highway 58 Bridge, located two miles downstream from the CRN Site, was not included in the HEC-RAS model (ADAMS Accession No. ML16216A115) for flood profile simulations. The NRC staff requested that the applicant provide reasons for this exclusion. The applicant responded that an informal sensitivity analysis showed insignificant increase of the PMF elevation by 0.1 feet (ft) at the CRN Site when the Highway 58 Bridge was included in the HEC-RAS model. The applicant agreed to revise the SSAR mark-ups, as well as provide the staff a calculation package of the sensitivity analysis to support the insignificant 0.1 ft increase of the PMF elevation. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 the SER.

The staff discussed with the applicant the methodology and the calculations that supported the development of the runoff and stream course models and asked how the inflows were calculated for the model calibration. The applicant agreed to revise its SSAR, including descriptions of how the inflows were calculated. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

Model Calibration

In the SSAR, the applicant indicated that the flood events in 1973 and 2003 were the largest floods in history at the CRN Site. The staff noted that one of the flood events in 2002 was used to calibrate the HEC-RAS model for the Clinch River and tributaries upstream of Norris Dam. The staff requested that the applicant clarify the rationale for not including the 2002 flood in the SSAR as one of the largest floods in history at the CRN Site. The applicant clarified that the 2002 flood used in the calibration of the Clinch River and tributaries upstream of Norris Dam

was not a large flood when compared to the 1973 and 2003 floods. Also, the applicant responded that the 1973 and 2003 floods had a more significant impact on the Watts Bar Reservoir than the 2002 flood did. The staff also requested that the applicant provide figures to show the calibration results and the calibration locations for the flood events in 1973, 2002, and 2003. The applicant provided a calculation package for the staff to review and agreed to revise the SSAR. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff requested clarification from the applicant regarding the elevation-storage curves of 12 reservoirs shown in in the SSAR. The applicant agreed to revise the SSAR to discuss the elevation-storage curves for the 12 reservoirs and provided the verification results of three elevation-storage curves, as examples, related with Norris, Melton Hill, and Watts Bar Reservoirs. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

In the SSAR, the applicant stated that the reservoir storage volume curves were verified against the known reservoir volumes. The staff requested that the applicant describe the method and the results of the reservoir volume verification. The applicant agreed to revise the SSAR to include a discussion on the method and figures of the verifications. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff noted that in the SSAR the applicant provided the elevation-storage volume curves of most reservoirs. The staff requested that the applicant provide a discussion and reference for the curves used in the HEC-RAS model calibration. The applicant agreed to revise the SSAR with the discussion and reference, including a calculation package as part of the reference, for the staff to review. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of its SER.

Hydraulic Parameters

In the SSAR, the applicant used the HEC-RAS model to simulate the flood profiles for the PMF and dam failure cases. The staff requested that the applicant provide the detailed information on how the hydraulic parameters were developed and used in the HEC-RAS model. The applicant provided the references to address the development of the cross-sections, dam rating curves, reservoir storage-elevation curves, and unsteady flow rules. The applicant agreed to revise its SSAR with discussions on ineffective flows, impacts of new fills on flood plain storage capacity, and new fills which are above PMF and away from the conveyance channel. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff noted that the applicant provided complex operational curves to reflect the operational rules for three dams that could directly affect the flood elevation at the CRN Site. The staff requested that the applicant provide a simplified illustration showing operational curves of Norris Dam and the applicant agreed to revise the SSAR to provide simplified illustrations of the complex operational curves. In addition, the staff requested that the applicant explain the dam rating curves and how the dam rating curves were applied to the flood mechanism. The applicant agreed to revise the SSAR with the updated the dam rating curves illustrating the relationship between the flood mechanism and the dam rating curve. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

The staff noted that the applicant provided the wind-induced wave height at the CRN Site for a PMF event. The staff requested that the applicant provide a figure to demonstrate the PMF elevation and the fetch length used in the wind wave calculations. The applicant agreed to revise the SSAR to provide a figure to illustrate the PMF elevation in the Clinch River and the fetch length. The staff will verify that this information as discussed during the audit is included in Section 2.4.3 of the SER.

Flood Frequency Analysis

The staff requested that the applicant provide a discussion regarding how a 25-year flood and a 500-year flood were computed.

In the SSAR, these floods were coincident events with the occurrence of the breach outflows from seismic dam failures. The applicant explained that the 25-year and 500-year flood hydrographs were first generated by the unit hydrograph method along with the input data from the NOAA Atlas 14 precipitations. Next, the applicant adjusted the volumes of the 25-year and 500-year hydrographs to approximately equal the volumes of the 25-year and 500-year flood volumes generated from flood volume frequency analysis. The applicant agree to revise the SSAR and provide a calculation package. The staff will verify that this information as discussed during the audit is included in Section 2.4.4 of the SER.

HYDROLOGY - GROUNDWATER

Groundwater Hydrology - CRN Site and Surrounding Area Tours

Info Need IDs 23 through 40 in Appendix C were included in the audit information requests for discussions related to groundwater hydrology. At the TVA Knoxville Complex, the applicant discussed the provided Audit Information Packet which described the hydrology and health physics agenda, maps describing the site tour routes and stops along the way including the site features. After providing a site safety briefing, the applicant provided transportation to the CRN Site and surrounding areas where the staff was given a guided tour of associated site features and dams within the watershed of the CRN site. The CRN Site feature stops included the Bear Creek Water Treatment Plant (WTP), the excavated area for the Clinch River Breeder Reactor Program (CRBRP), the site operation center trailers, the former meteorological tower area, site transmission lines, the Hensley Cemetery, the aquifer pump test area, and the discharge location and nearest residence for the postulated accidental liquid radwaste release. Subsequently, the staff returned to the TVA Knoxville Office Complex and continued discussions related to hydrologic site characteristics, normal PPE and accident liquid and gaseous effluent release source terms, and exposure pathway dose analyses.

GROUNDWATER HYDROLOGY AUDIT

Site Parameters

Site-specific distribution coefficients for retardation (i.e., Kd values) were used where available, others were taken from the available literature, many of which were available from the Oak Ridge National Laboratory (ORNL) Site in close proximity to the CRN Site. If no Kd value was available for a specific radionuclide, the applicant substituted a conservative value of zero (no retardation). In addition, the lowest flow rate of 400 cubic feet per second (cfs) was used for the dilution term at the Clinch River. The staff noted that the methodology used to derive the minimum flow was not described in the SSAR. The staff requested that the applicant describe how the 400 cfs and associated river flows described in SSAR Section 2.4.13 were derived. The applicant indicated that the 400 cfs was derived from a TVA Hydrologic Task Force Study. The applicant provided a SSAR markup to include a description of the basis for a 400 cfs river flow. The staff will verify that this information as discussed during the audit is included in Section 2.4.13 “Accidental Releases of Radioactive Liquid Effluents in Ground and Surface Waters” of the SER.

The staff noted that the closest WTP to the site is referred to by different names in the SSAR. The NRC staff requested that the naming of the plant be consistent throughout the SSAR and that the disposition of the plant operation described as “idle” in the SSAR be clarified to describe the operational status of the WTP and the permit status associated with an idled plant. The applicant provided a SSAR markup. The staff will verify that this information as discussed during the audit is included in Section 2.4.13 of the SER.

The staff and the applicant discussed the characterization of the aquifer and derivation of the aquifer parameters based on the field program conducted by the applicant, the primary flow zones, decreasing fracture density frequency with depth, and methods of deriving permeability of the aquifer intervals. The staff and applicant also discussed construction dewatering and available information from the CRBRP. The applicant noted that very little to no dewatering was needed for CRBRP although the CRN Site excavation may require relatively more dewatering due to an anticipated deeper excavation. The staff will verify that this information as discussed during the audit is included in Section 2.4.12, “Groundwater” of the SER.

The staff and applicant discussed the last known status of the CRBRP. The Historical Site Assessment (HSA) redress plan developed by the TVA/Department of Energy (DOE) was made available for review. The staff reviewed the HSA redress plan and the Atomic Safety and Licensing Board’s (ALSB’s) 1985 order (ADAMS Accession No. ML16357A775) related to a review of the HSA redress plan which described the orderly shutdown of CRBRP site construction activities. The staff found that the HSA and the ASLB’s order described the last know status of the CRBRP, but the disposition of borings and wells used to characterize the CRBRP were not mentioned in the HSA redress plan or ALSB’s order. The applicant indicated that the disposition of the CRBRP wells and borings installed are unknown and no evidence of these were found during the CRNS site characterization and field study activities. The staff will verify that this information as discussed during the audit is included in Section 2.4.12 of the SER.

The staff and applicant discussed the inconsistencies in describing the backfill in the SSAR. While the backfill is specifically described as Tennessee Department of Transportation Type A aggregate in SSAR Section 2.5, the NRC staff requested that SSAR Sections 2.4.12 and 2.4.13 be consistent in describing the construction backfill and characterization of the

hydraulic properties of the backfill as described in SSAR Section 2.5. The applicant agreed to perform a consistency check and provide SSAR markups. The staff will verify that this information as discussed during the audit is included in Sections 2.4.12 and 2.4.13 of the SER.

The staff and the applicant discussed the applicability of using information from a June 23, 2011, DOE study to support the applicant's conceptualization of the Clinch River as a groundwater flow boundary. The staff noted that there is an additional and more recent 2013 DOE study (which remains in draft form) describing groundwater flow conditions in the CRN Site vicinity. The applicant has reviewed the draft report for the 2013 DOE study; however, as noted the draft report is not referenceable in its current form. The staff noted that the 2011 DOE report does not unequivocally state that there is no groundwater flow beneath the Clinch River and that more recent studies by the DOE, site data and relevant publications should be reviewed to fully bound the site conceptual flow model in the SSAR, as appropriate. The applicant agreed to evaluate the more recent reports, data and site information. The description of additional studies and information was included in a proposed SSAR markup (ADAMS Accession No. ML17237C084). The staff will verify that this information as discussed during the audit is included in Sections 2.4.12 and 2.4.13 of the SER.

The staff met with the Tennessee Department of Environment and Conservation (TDEC) and the DOE on May 16, 2017, concerning recent DOE studies that indicate potential groundwater flow under the Clinch River from the ORNL to an area approximately two miles east of the CRN Site. Based on these discussions, the information provided by TDEC and DOE, the staff confirmed that the applicant's understanding of the CRN Site should include a more in depth evaluation of the Clinch River as a hydrologic boundary for groundwater flow from the CRN Site. The staff will verify that this information as discussed during the audit (ADAMS Accession No. ML17237C084) is included in Sections 2.4.12 and 13 of the SER. Based on the staff's conversations with the DOE and TDEC, the DOE indicated that their study findings are currently being developed into a draft report which will not be finalized for at least one year and likely longer. During a subsequent staff conversation on September 13, 2017, the DOE and the USGS, the DOE indicated that over the next one to two years the USGS will be also be developing a refined groundwater modeling study of the ORR that will include the area of the CRN Site. The staff communicated this information to the applicant during a September 18, 2017, call requesting that that the applicant review the DOE study once available to evaluate any new and significant information that may affect the conceptual understanding of the CRN Site groundwater flow system.

While the applicant described community groundwater users in the site vicinity, the staff noted a lack of description in the SSAR regarding individual groundwater users in the area of the CRN Site. The staff noted that residential locations are shown on ER Figure 2.7.6-1 and had questions concerning the data used for the residential locations and how the data was collected. The applicant clarified that the data was collected through observations made by drive-by surveys using a hand-held global positioning system to locate the residential locations. The staff requested that the applicant gather the available information on individual residential users from databases such as those maintained by TDEC and ORNL and include this information in the SSAR Sections 2.4.1 and 2.4.12. The staff and applicant discussed potential sources of additional data on individual groundwater users, including information from ORNL and the TDEC. Based on these discussions with the staff, the applicant contacted TDEC to obtain and review sources of additional data and to update the SSAR with a discussion of these data sources and individual groundwater users in the vicinity of the site. The applicant provided

a SSAR markup with this information (ADAMS Accession No. ML17200C887). The staff will verify that this information as discussed during the audit is included in Section 2.4.12 of the SER.

Postulated Accidental Liquid Radwaste Tank Failure Analysis

As part of the CRN Site tour, the staff visited the discharge location for the postulated accidental liquid radwaste tank failure and observed the receptor location (nearest residence) in the southwest meteorological directional sector. The methodology, model, parameters, and assumptions considered in the accidental liquid effluent release source term and postulated accidental liquid radwaste tank failure analysis is described in SSAR Section 2.4.13.

The staff and applicant discussed the basis of the accidental liquid effluent release source term for the two proposed vendors. The applicant assigned alphabetical identifiers (i.e., Vendors A and B) in lieu of vendor names to avoid identification of trade names associated with the accidental liquid effluent release source terms is provided in SSAR Section 2.0, Tables 2.0-5, 2.4.13-1, and 2.4.13-2. The basis of the accidental liquid effluent release source term is described in the TVA letter to the NRC dated December 2, 2016 (ADAMS Accession No. ML16340A258).

The staff requested clarification from the applicant as to which vendor was considered for the postulated accidental liquid radwaste tank failure analysis, the failed fuel percentage used in the accidental liquid effluent release source term, and the volume of the liquid radwaste tank used. The applicant clarified that the accidental liquid effluent release source term based on one percent failed fuel was for Vendor A and the liquid radwaste tank volume was 10,000 gallons. The applicant explained the rationale for selecting the accidental liquid effluent release source term in the postulated accidental liquid radwaste tank failure analysis. The staff noted that the applicant used an one percent failed fuel fraction while the guidance in DC/COL-ISG-013, “Assessing the Radiological Consequences of Accidental Releases of Radioactive Materials from Liquid Waste Tanks for Combined License Applications” (ADAMS Accession No. ML12191A325, as incorporated into BTP 11-6, “Postulated Radioactive Releases Due to Liquid-containing Tank Failures” (ADAMS Accession No. ML15027A401)), suggests that radionuclide concentrations and the total inventory of radioactive materials used is based on an expected failed fuel fraction of 0.12 percent of the operating fission product core inventory being released to the primary coolant for a pressurized water reactor. The staff requested that the applicant identify the failed fuel fraction for the postulated accidental liquid radwaste tank failure analysis in the ESP Application. The applicant indicated that the vendor assumed this high failed fuel fraction in the accidental liquid effluent release source term for conservatism. The applicant provided a SSAR markup (ADAMS Accession No. ML17178A330) with this information. The staff will verify that this information as discussed during the audit is included in Section 2.4.13 of the SER.

The staff and applicant discussed the use of the dose conversion factors for ingestion from Federal Guidance Report (FGR) 11 (Environmental Protection Agency, EPA 520/1-88-020, “Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion” (1988)) and the dose conversion factors for ground deposition and immersion from FGR 12 (EPA, EPA-402-R-93-081, “Federal Guidance Report No. 12, External Exposure to Radionuclides in Air, Water, and Soil,” (1993)). The LADTAP II code calculates total body and organ doses; whereas, the pubic dose limit in 10 CFR 20.1301 is expressed in total effective dose equivalent (TEDE). The applicant provided the electronic files in native format for the hydrology and health

physics codes (ADAMS Accession No. ML16280A066). The staff will verify that this information as discussed during the audit is included in Section 2.4.13 of the SER.

The staff noted that the accidental liquid effluent release source term with one percent failed fuel results in a calculated exposure pathway dose of 93 millirem (mrem) TEDE using the guidance in Regulatory Guide (RG) 1.109, “Revision 1, “Calculation of Annual Doses to Man – From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I” and the dose conversion factors in FGRs 11 and 12, which is near the annual NRC dose limit of 100 mrem TEDE to a member of the public. The applicant acknowledged that this calculated dose is near the public dose limit, but given the conservative nature of the postulated accidental liquid radwaste tank failure analysis and its assumptions, the calculated dose complies with the NRC public dose limit.

The staff and applicant discussed the applicability of the radionuclide transport equations described in NUREG/CR-3332, “Radiological Assessment, A Textbook on Environmental Dose Analysis" (2009) (ADAMS Accession No. ML091770419) as applied in Equation 2.4.13-1 in SSAR Section 2.4.13 with the accidental liquid effluent release source term, radionuclide characteristics, and dilution parameters, and the correct groundwater dilution equation (Equation 4.41) in NUREG/CR3332. The applicant demonstrated how the NUREG/CR-3332 transport/dilution equations were translated to Excel spreadsheet calculations by stepping through the equations, parameters, and assumptions. The staff and applicant discussed SSAR Table 2.4.13-5 to gain a better understanding on how the radionuclide transport analysis was implemented. The applicant agreed with the staff’s request to include the S.W. Taylor and H. Guha reference (Groundwater 55, no. 1: 63–72) providing the applicability and methodology for the NUREG/CR-3332 radionuclide transport equations in a SSAR markup. In addition, the applicant agreed with the staff’s request to provide the Excel spreadsheet calculations in native format. The applicant provided the SSAR markup (ADAMS Accession No. ML17167A150) and Excel spreadsheet in native format (ADAMS Accession No. ML17143A417) for the staff to review. The staff will verify that this information as discussed during the audit is included in Section 2.4.13 of the SER.

The staff and applicant discussed the additional conservatisms and the approach used in the radionuclide transport analysis. Conservatisms outlined by the applicant included decaying terms to 50 years to allow selection of the peak daughter product activities for use in the resulting dose calculations. Time to peak activity concentrations were evaluated based on a transport travel time to the receptor of less than one year for all peak activity concentrations regardless of when the time to peak concentrations were calculated providing additional conservatisms. Therefore, all peak activity concentrations are assumed to arrive at the receptor simultaneously with peak activity concentrations coinciding with the travel time (less than one year).

The methodology of the NUREG/CR-3332 radionuclide transport equations and assumptions is used in the radionuclide transport analysis to calculate the exposure pathway dose to a member of the public at the nearest unrestricted area. The staff will verify that this information as discussed during the audit is included in Section 2.4.13 of the SER.

HEALTH PHYSICS

Health Physics - CRN Site and Surrounding Area Tours

In addition to the discussion and areas toured as described above in Groundwater Hydrology – CRN Site and Surrounding Area Tours, the staff also visited the discharge location for normal liquid effluent releases at the Clinch River Mile 15.5 and receptor locations for the nearest beef cattle, nearest garden and nearest residence used in calculating the exposure pathway doses from normal PPE and accidental liquid and gaseous effluent releases.

The CRN Site Land Use Survey conducted on January 7-10, 2014 (completed on April 21-22, 2014), is used for determining the receptor locations in the exposure pathway analyses for calculating the maximally exposed individual (MEI) and population doses described in RG 1.109. Results from the CRN Site Land Use Survey identified the nearest beef cattle, nearest garden and nearest residence, and did not show any dairy cows and goats within a 5 mile radius surrounding the CRN Site. For the purpose of calculating the population dose at the 50 mile boundary, the applicant conservatively considered dairy cows and dairy goats within a 50 mile radius. Receptor locations for the nearest beef cattle, nearest garden and nearest residence comprise three physical locations in the ER Chapter 2, "Environmental Description" Figure 2.7.6-1, "Location of Sensitive Receptors (Land Use Survey) show receptor locations in close proximity with one another and in the same west northwest directional sector.

Information from the CRN Site Land Use Survey is used in the exposure pathway dose analyses for calculating the MEI and population doses SSAR Sections 11.2.3, "Liquid Effluent Releases" and 11.3.3, "Gaseous Effluent Releases." The staff will verify that this information as discussed during the audit is included in Sections 11.2.3 and 11.3.3 of the SER.

HEALTH PHYSICS AUDIT

Info Need IDs 41 through 44 in Appendix C were included in the audit information requests for discussions related to health physics. In support of the staff's review of the ESP Application and the safety audit, the applicant submitted electronic files in native format for the health physics codes (LADTAP II, GASPAR II, and XOQDOQ) with the TVA letter to the NRC dated September 30, 2016 (ADAMS Accession No. ML16280A066), and submitted supplemental information in the TVA letter to the NRC dated December 2, 2016 (ADAMS Accession No. ML16340A258).

Normal PPE Liquid and Gaseous Effluent Release Source Terms and Exposure Pathway Doses

The staff and applicant discussed the basis of the normal PPE liquid and gaseous effluent release source term developed from the four potential vendors identified in SSAR Section 1.11, "Overview of Reactor Types." The applicant assigned numerical identifiers (i.e., 1 through 4) in lieu of vendor names to avoid identification of trade names. The basis of the normal effluent release source term is described in the TVA letter to the NRC dated December 2, 2016 (ADAMS Accession No. ML16340A258).

In the December 2, 2016 submittal, the applicant provided unit average annual normal liquid and gaseous effluent release rates for radionuclides in Curies per year (Ci/y) for Vendors 1 through 4 in Table 10-A, "One Unit Average Annual Normal Liquid Radioactive Release" of Attachment 2, "Basis of Source Term for Normal Liquid Radioactive Effluent Release" and Table 7-A, "One Unit Average Annual Normal Gaseous Radioactive Release" of Attachment 3,

“Basis of Source Term for Normal Gaseous Radioactive Effluent Release,“ respectively. Composite Tables 10-A of Attachment 2 and Table 7-A of Attachment 3 show the selected average annual normal liquid and gaseous effluent release rates on a per unit basis for each vendor.

The staff and applicant discussed the design information (e.g., number of units, power levels) used for calculating the site effluent release rates for each vendor. Site average annual normal liquid and gaseous effluent release rates that apply the vendor design information are provided in Table 10-B, “Site Average Annual Normal Liquid Radioactive Release” of Attachment 2 and Table 7-B, “Site Average Annual Normal Gaseous Radioactive Release” of Attachment 3, respectively. Composite Tables 10-B and 7-B show the selected average annual normal liquid and gaseous effluent release rates, respectively, on a site basis for each vendor, which represent the normal PPE liquid and gaseous effluent release source terms that bound the surrogate plant.

From the staff’s confirmatory analyses, it was observed that the highest unit and site average annual liquid effluent release rates for Te-129 and Te-131 were not selected in Composite Tables 10-A and 10-B, which impacts SSAR Tables 2.0-6, “Annual Normal Liquid Radioactive Release (Ci/y)“ and 11.2-4, “Projected Liquid Radioactive Effluent Concentrations in Watts Bar Reservoir“ and ER Chapter 3, Tables 3.5-1, “CRN Site Projected Average Normal Liquid Radioactive Release“ and 3.5-2, “Liquid Effluent Activities Per Reactor.“ The staff and applicant discussed the unit and site average annual Te-129 and Te-131 liquid effluent release rates and the dose consequence. The applicant agreed to evaluate the unit and site average annual Te-129 and Te-131 liquid effluent release rates and its calculated exposure pathway dose. The staff will verify that this information as discussed during the audit is included in Section 11.2.3 of the SER.

The applicant used the site average annual liquid and gaseous effluent release rates for developing the surrogate plant considering the guidance in Nuclear Energy Institute 10-01, Revision 1, “Industry Guidance for Developing a Plant Parameter Envelope in Support of an Early Site Permit” (2012). Site average annual effluent release rates for the surrogate plant (i.e., normal PPE liquid and gaseous effluent release source terms) are given in SSAR Section 2.0, “Plant Parameter Envelope,” Table 2.0-6,” Annual Normal Liquid Radioactive Release (Ci/y)” and in Table 2.0-4, ”Annual Normal Gaseous Radioactive Release (Ci/y).” Normal PPE liquid and gaseous effluent release source terms are used in SSAR Sections 11.2.3 and 11.3.3 to calculate exposure pathway doses with the LADTAP II (NUREG/CR-4013, “LADTAP II – Technical Reference and User Guide” (1986) (ADAMS Accession No. ML14098A069) and GASPAR II (NUREG/CR-4653, “GASPAR II – Technical Reference and User Guide” (1987) (ADAMS Accession No. ML14098A066) codes.

The staff discussed with the applicant its evaluation of vendor provided information in selecting the unit and site average annual normal liquid and gaseous effluent release rates. As described in Attachments 2 and 3 of the December 2, 2016 submittal, and noted in the composite tables, adjustments are made on a case-by-case basis to exclude, reduce, or increase release rates for certain radionuclides based on the amount of conservatism and maturity of the source terms available from the vendors. An evaluation is performed on the adjusted release rates to ensure that the dose consequences are conservative compared to source terms for large light water reactors scaled to a comparable thermal power output for the CRN Site, and are reasonable for use. The staff will verify that this information as discussed during the audit is included in Section 11.4, “Technical Evaluation” of the SER.

Accidental PPE Liquid Effluent Release Source Terms and Exposure Pathway Dose

In support of the Groundwater Hydrology portion of the audit, the staff and applicant discussed the basis of the accidental liquid effluent release source term, radionuclide transport equations, and the applicant's calculation of the exposure pathway dose to a member of the public which is described above in Postulated Accidental Liquid Radwaste Tank Failure Analysis.

The staff noted that Tc-99 is identified as a radionuclide in the unit and site average annual liquid effluent release rates and composite tables in Tables 10-B and 10-A of Attachment 2, and SSAR Table 2.0-6 for the normal PPE liquid effluent release source term; however, Tc-99 is not identified in Tables 11-A and 11-B of Attachment 4, and SSAR Tables 2.0-5, 2.4.13-1, and 2.4.13-2 for the accidental PPE liquid effluent release source term. The guidance in DC/COL-ISG-013 (ADAMS Accession No. ML12191A325, as incorporated into BTP 11-6 (ADAMS Accession No. ML15027A401)) describes long-lived, hard-to-detect, radionuclides such as Tc-99 that are highly mobile in the environment should be included in any assessment of an accidental release of radioactive material from liquid radwaste tanks. Therefore, the staff requested that the applicant include Tc-99 in the accidental PPE liquid effluent release source term and exposure pathway dose analysis or justify its exclusion. The applicant agreed to evaluate the inclusion or exclusion of Tc-99 in the accidental PPE liquid effluent release source term. The staff will verify that this information as discussed during the audit is included in Section 2.4.13 of the SER.

As a result of staff and applicant discussions during the health physics audit, the applicant submitted SSAR markups and additional information in the TVA letters to the NRC dated May 11, 2017 (ADAMS Accession No. ML17143A417), June 16, 2017 (ADAMS Accession No. ML17167A150), and June 26, 2017 (ADAMS Accession No. ML17178A330). The staff will verify that this information as discussed during the audit is included in the respective sections of the SER.

APPENDIX A: HYDROLOGY AND HEALTH PHYSICS SAFETY AUDIT AGENDA
APRIL 17–19, 2017 AND APRIL 24–27, 2017

APRIL 17–19, 2017

April 17, 2017

Audit at TVA (Bechtel) offices - All
Application overview – TVA
Begin Audit – All
Breakout sessions - All
Daily debrief – NRC and TVA

April 18, 2017

Breakout sessions continue
Lunch
Daily debrief – NRC and TVA

April 19, 2017

Breakout sessions continue
Lunch
Daily debrief – NRC and TVA

APRIL 24–27, 2017

April 24, 2017

Audit at TVA offices – All
Application overview – TVA
Begin Audit – All
Breakout sessions – All
Daily debrief – NRC and TVA

April 25, 2017

Meeting with Site Tours
Breakout sessions continue
Lunch
Daily debrief – NRC and TVA

April 26, 2017

Breakout sessions continue
Lunch
Daily debrief – NRC and TVA

April 27, 2017

Breakout sessions continue
Lunch
Final briefing and closeout- NRC

APPENDIX B: AUDIT PARTICIPANTS

April 17–19, 2017

Name	Affiliation
Clement, Richard	NRC
Giacinto, Joseph	NRC
Sutton, Mallecia	NRC
Bogema, Harrison	TVA
Brellenthin, Jack	TVA
Casey, Kevin	TVA
Hastings, Peter	TVA
Holcomb, John	TVA
Horton, Ruth	TVA
Justice, Wally	TVA
Klein, Spencer	TVA
Lundy, Dennis	TVA
Montague, Kelvin	TVA
Perry, Jeff	TVA
Schiele, Ray	TVA
Scott, Roger	TVA
Shirk, Susan	TVA
Stout, Dan	TVA
Thomas, John	TVA
Young, Alex	TVA
Cahill, Tim	Bechtel Power Corporation
Carr, Becky	Bechtel Power Corporation
Carson, Alice	Bechtel Power Corporation
Guha, Hillol	Bechtel Power Corporation
Hummer, Kim	Bechtel Power Corporation
Jha, Ken	Bechtel Power Corporation
Taylor, Stewart	Bechtel Power Corporation

APPENDIX B: AUDIT PARTICIPANTS

April 24–27, 2017

Name	Affiliation
Breithaupt, Stephen	NRC
Cheng, Yuan	NRC
Clement, Richard	NRC
Giacinto, Joseph	NRC
Sutton, Mallecia	NRC
Brellenthin, Jack	TVA
Casey, Kevin	TVA
Carboni, Karen	TVA
Hastings, Peter	TVA
Holcomb, John	TVA
Hasan, Husein	TVA
Klein, Spencer	TVA
Lundy, Dennis	TVA
Montague, Kelvin	TVA
Montgomery, Colleen	TVA
Perry, Jeff	TVA
Schiele, Ray	TVA
Scott, Roger	TVA
Smith, Shandon	TVA
Stout, Dan	TVA
Thomas, John	TVA
Young, Alex	TVA
Criscenzo, Stephen	AMEC
Carr, Becky	Bechtel Power Corporation
Carson, Alice	Bechtel Power Corporation
Guha, Hillol	Bechtel Power Corporation
Taylor, Stewart	Bechtel Power Corporation
Cropp, Trevor	BWSC
Henry, Stu	BWSC
Murr, Andrew	BWSC
Taylor, Kevin	AECOM

Appendix C: CRN Site Information Need Status

Info Need ID	Information Need Description	Status	Comments
Hydrology – Surface Water			
1-a	The "former Oak Ridge Water Treatment Plant" is described as having an "active surface water withdrawal permit". Please provide an SME to discuss the disposition of the active permit with respect to the former plant. The Oak Ridge Bear Creek Plant is not listed in Table 2.4.1. Although this plant appears to be the closest to the CRN Site based on Figure 2.4.1-1, the SSAR text indicates that the former Oak Ridge Water Treatment Plant is the closest withdrawal permit. Please provide an SME to clarify which permitted surface water withdrawal location is closest to the CRN Site and actively withdrawing water.	Closed through audit activities	Review team clarified understanding of TVA's water withdrawal permit description through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
1-b	The Oak Ridge Bear Creek Plant is not listed in Table 2.4.1. Although this plant appears to be the closest to the CRN Site based on Figure 2.4.1-1, the SSAR text indicates that the former Oak Ridge Water Treatment Pl ant is the closest withdrawal permit. Please provide an SME to clarify which permitted surface water withdrawal location is closest to the CRN Site and actively withdrawing water.	Closed through audit activities	Review team clarified understanding of TVA's water treatment plant naming convention through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)

1-c	Please provided an SME to discuss the allowed uses of an industrial water permit and if such a permit could include potable water uses within the permitted facility	Closed through audit activities	Staff clarified its understanding of industrial waste water permit uses through audit discussions and document reviews.
1-d	There seems to be two figures with the same figure number; one within "TVA_CR_ESPA_SSAR_CHAP02_SEC02-03.pdf" as "Figure 2.3.2-1. Local Topography in the Clinch River Nuclear Site Vicinity." and one within "TVA_CR_ESPA_PART07A.pdf"; as "Figure 2.3.2-1. Surface Water Intakes near the CRN Site in Anderson, Knox, Loudon, Meigs, Morgan, Rhea, and Roane Counties." Please clarify or correct the figure number(s) and identify the surface water intake labeled as "9723" shown the second Figure 2.3 .2-1 above.	Closed through audit activities	Staff clarified its understanding of the figure titles through audit discussions and document reviews.
1-e	The SSAR discussion provides information on surface water aspects of the hydrosphere but no information on groundwater. Please provide a discussion of the groundwater portion of the hydrosphere in the SSAR.	Closed through audit activities	Review team clarified understanding of TVA's groundwater information sources through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17200C887)
1-f	The SSAR discusses the Reservoir Operations Study (ROS) that included changes in minimum flow requirements and flood control operations on releases. Please provide a copy of the ROS and identify pertinent sections ROS relevant to the CRN Site.	Closed through audit activities	Review team clarified understanding of TVA's ROS through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17158B342, ML17206A090)

2	The SSAR provides a brief discussion of the flood history at the CRN Site including a table of historic floods on the Clinch River Arm of Watts Bar Reservoir (Table 2.4.2-1 of SSAR.) The staff note that two of the flood elevations are derived from model calibration, while others are derived from historic flood profiles and a Clinch River flood report. For the historical flood profiles, please provide the source of the information. For the flood report, please provide discussion about how these elevations were developed.	Closed through audit activities	Review team clarified understanding of TVA's flood elevations and profiles through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
3	The SSAR provides a discussion of potential flooding events that could affect the CRN Site. Clarify why the discussion of "Flooding from Dam Breaches and Failures" only includes sunny day dam failures when hydrologic and seismic dam failures are also important.	Closed through audit activities	Review team clarified understanding of TVA's flooding from dam breaches through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
4-a	The SSAR states that site drainage "can reasonably take full advantage of the current topography and provide more than adequate runoff capability... with flow directed to Clinch River arm of Watts Bar Reservoir." Since the CRN Site drainage plan has not been provided, please clarify how it can reasonably be assumed from the current topography that adequate drainage during local intense precipitation (LIP) can be achieved.	Closed through audit activities	Review team clarified understanding of TVA's site drainage plan with respect to LIP through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
4-b	The SSAR provides a brief discussion of precipitation distribution. Provide a detailed discussion in the SSAR on the development of the precipitation distribution at the CRN Site. Provide a Subject Matter Expert (SME) who can discuss the methods supporting estimation of LIP.	Closed through audit activities	Review team clarified understanding of TVA's precipitation distributions through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)

5-a	The SSAR discusses several PMP storms that were analyzed for the probable maximum flood (PMF) analysis, including their temporal distribution; however, discussion of the methods in sufficient detail is not included in the SSAR for staff evaluation. Please provide a discussion of the methods and calculations of the PMP development for the four types of events in the SSAR. The discussion in the SSAR should be in sufficient detail for staff to evaluate the PMP development.	Closed through audit activities	Review team clarified understanding of TVA's PMP storms for PMF analysis through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
5-b	The SSAR states that the PMP storm has a depth of 17.5 inches in the watershed upstream Watts Bar Dam. Please provide a discussion of sufficient detail in the SSAR on how this depth was determined, since the reference provided (HMR-41) only provides the depth for a 7980 mi^2 basin, which can be moved along the primary axis of the Tennessee River.	Closed through audit activities	Review team clarified understanding of TVA's PMP storm depth through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
6	Please clarify why nonlinear adjustment of unit hydrographs (UHs) is included in the SSAR as a component of precipitation losses.	Closed through audit activities	Review team clarified understanding of TVA's UHs and precipitation losses through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
7-a	The SSAR states the UHs are used in the runoff model; however, no discussion or reference is provided as to how the UHs were developed. Please provide a discussion or a reference to a document in the SSRA of how the UH's were developed including the validation of the UHs.	Closed through audit activities	Review team clarified understanding of TVA's UH development and validation through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)

7-b	The SSAR states that storage volumes from projects identified in the National Inventory of Dams (NID) were included in runoff and inflow hydrograph development. Please clarify in the SSAR how the storage volume from NID dams was used to develop inflow hydrographs.	Closed through audit activities	Review team clarified understanding of TVA's storage volume from NID dams and inflow development through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
7-c	Provide an SME who can discuss the methods supporting dam breach outflow estimates for NID dams.	Closed through audit activities	Review team clarified understanding of TVA's methods supporting dam breach outflow estimates through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
8-a	The staff's examination of the HEC-RAS model found only one cross section located at the CRN Site. Please explain the adequacy of the HEC-RAS model cross sections interval in relation to the geometry of the CRN Site.	Closed through audit activities	Review team clarified understanding of TVA's HEC-RAS model through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212, ML17171A335)
8-b	The staff's examination of the HEC-RAS model found that the cross sections are placed in the vicinity of the CRN Site at approximately 2-mile intervals. Explain the how the model geometry accurately sufficiently describes the Clinch River geometry in the vicinity of the CRN Site.	Closed through audit activities	Review team clarified understanding of TVA's model geometry through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212, ML17171A335)

8-c	The staff's examination of the HEC-RAS model found that the Highway 58 Bridge and its abutments were not included, though they could produce a backwater effect on the PMF elevation at the CRN Site. Please explain why the bridge was not included in the model.	Closed through audit activities	Review team clarified understanding of TVA's representation of the Highway 58 bridge through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212, ML17206A090)
8-d	The SSAR provides a brief description of the HEC-RAS model used for PMF and dam failure analyses. Please provide a discussion in the SSAR with sufficient detail on the development of the HEC-RAS model. The discussion should include (but not be limited to) development of cross sections and their layout, dam rating curves, elevation-storage curves, and dam operations rules.	Closed through audit activities	Review team clarified understanding of TVA's PMF and dam failure analysis through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
8-e	Please provide an SME who can discuss the methods and calculations supporting runoff and stream course model development, as well as the methods and calculations for dam operations.	Closed through audit activities	Staff clarified its understanding of this topic through audit discussions and document reviews.
9-a	The SSAR states that storage volume curves were verified against the known reservoir volume. Please provide a discussion in sufficient detail in the SSAR that describes the methods and results of the reservoir volume verification. Also, provide figures in the SSAR that show the methods and results.	Closed through audit activities	Review team clarified understanding of TVA's storage volume verifications through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)

9-b	The staff noted that figures in SSAR Section 2.4.4 provided the elevation-storage curves for most (if not all) the reservoirs included in the CRN Site analysis. Please provide a reference and discussion in the SSAR of those figures as it pertains to calibration of the HEC-RAS model.	Closed through audit activities	Review team clarified understanding of TVA's reference to elevation-storage curves through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
9-c	The SSAR states that flood elevations were calibrated in three different model sections. For the first two sections, from the confluence of the Clinch River with the Tennessee River to Melton Hill Dam and from Melton Hill Dam to Norris Dam, the calibration was at three locations for the 1973 and 2003 floods. Please: (1) Clarify that these flood events were previously presented in SSAR Section 2.4.2.1 Flood History; (2) Provide a figure in the SSAR showing the calibration point locations; and, (3) Provide figures in the SSAR showing the calibration results for both of the flood events. For the upstream sections from Norris Dam to the tributaries of the Clinch River, the floods from 2002 and 2003 were used for calibration. Please: (1) Clarify why the 2002 flood was not included in Section 2.4.2.1; (2) Provide a figure in the SSAR showing the calibration point locations; and, (3) Provide figures in the SSAR showing the calibration results for both of the flood events.	Closed through audit activities	Review team clarified understanding of TVA's flood evaluations through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)

10	The SSAR provides a general discussion of the inclusion of operational rules and rating curves for the three dams that directly affect the water surface elevation at the CRN Site. SSAR Figures 2.4.3-4 through 2.4.3-6 provide the illustration of the operational rules. The staff notes that these are relatively complex figures illustrating the anticipated operations during a flood event. SSAR Figures 2.4.3-7 through 2.4.3-9 provide the rating curves for various cases. However, these cases are not discussed in this section. In the SSAR, please provide a discussion as an example that follows the operational curve of the Norris Dam. Also, provide a discussion in the SSAR of the various cases presented in the rating curve figures and state which of those were applied to the flood mechanisms evaluated.	Closed through audit activities	Review team clarified understanding of TVA's operational and rating curves through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
11	Please provide an SME familiar with the methods and calculations supporting runoff and stream course model development who can assist in showing how the PMF analyses applies to the CRN Site.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
12	Please provide an SME to explain how bridges bounding the CRN Site, (Highway 58 Bridge downstream and Highway 95 Bridge upstream), are considered in the PMF analyses.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
13	Please provide an SME familiar with the methods and calculations supporting runoff and stream course model development who can assist in showing how the PMF analyses applies to the Melton Hill Dam site.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
14	Please provide an SME familiar with the methods and calculations supporting runoff and stream course model development who can relate the analyses to the site-associated dam sites.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.

15	Please provide citations and references for the Von Thun and Gillette method used in the hydrologic dam failure analysis.	Closed through audit activities	Review team clarified understanding of TVA's citations and references through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
16	The SSAR provides the PMF elevation at a location just upstream of the intake. The staff's examination of the HEC-RAS model found only one cross section located at the CRN Site. Explain the adequacy of the HEC-RAS model cross sections interval in relation to the Clinch river geometry of the CRN Site.	Closed through audit activities	Review team clarified understanding of TVA's HEC-RAS cross section intervals through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
17	The SSAR provides a discussion of the calculation of wind wave elevation during the PMF. Please provide a figure in the SSAR that illustrates the PMF elevation in the Clinch River and the estimation of the fetch length used in the wind wave calculations.	Closed through audit activities	Review team clarified understanding of TVA's wind fetch length and PMF elevation through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
18-a	The SSAR cites a schematic figure of the dams in the TVA system. Please provide a Geographical Information System (georeferenced) map in the SSAR that shows the location of all dams upstream of Watts Bar Dam in relation to the layout of the Tennessee River and its tributaries.	Closed through audit activities	Review team clarified understanding of TVA's dam locations through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)

18-b	The SSAR includes Figure 2.4.4-1 illustrating the elevation-storage curves for 12 reservoirs examined in the flooding analysis at the CRN Site. The figure is cited but is not discussed. The staff note that this important information is relevant to the analyses discussed in SSAR Section 2.4.3. Please provide a reference to the SSAR Figure 2.4.4-1 in discussions in SSAR Section 2.4.3 on the set up of the river course model.	Closed through audit activities	Review team clarified understanding of TVA's river course set up reference through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
19-a	Please provide an SME who can discuss the methods and calculations for seismic and hydrologic dam failure.	Closed through audit activities	NRC staff clarified its understanding of this topic through audit discussions and document reviews.
19-b	Provide an SME who can discuss the methods supporting dam breach outflow estimates for NID dams.	Closed through audit activities	Review team clarified understanding of TVA's methods of dam breach outflow estimates for NID dams through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
20	The SSAR states that either a 25-year or 500-year coincident flood events were assumed to occur with seismic dam failure. Please provide discussion in the SSAR with sufficient detail of the methods and inflows for each of the assumed flood events.	Closed through audit activities	Review team clarified understanding of TVA's methods for the 25-year and 500-year coincident flood events through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
21-a	Provide an SME who can discuss the methods supporting calculations of flood wave routing with dam failures.	Closed through audit activities	NRC staff clarified its understanding of this topic through audit discussions and document reviews.

21-b	Please provide an SME who can discuss the methods supporting calculations of 25-year and 500-year floods.	Closed through audit activities	Review team clarified understanding of TVA's supporting calculations for the 25-year and 500-year coincident flood events through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
22	The SSAR provides a discussion of the calculation of wind wave elevation during the controlling flood event. Please provide a figure in the SSAR that illustrates the PMF elevation in the Clinch River and the estimation of the fetch length used in the wind wave calculations.	Closed through audit activities	Review team clarified understanding of TVA's PMF and wind wave elevation through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17157B212)
Hydrology – Groundwater			
23	The SSAR discussion includes information that includes "fresh groundwater withdrawals totaled about 82 mgd in 1985." Please provide the rationale for including the discussion of 1985 groundwater withdrawals and, the relevance to current groundwater withdrawals and site conditions versus a discussion of more recent estimates of groundwater totals and usage in this SSAR section.	Closed through audit activities	Review team clarified understanding of TVA's groundwater information through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17200C887)

24	The staff requests the consistent use of unit nomenclature throughout Section 2.4 and elsewhere to avoid confusion of observed, measured, and calculated values (e.g., Section 2.4.12.1.2.1 contains text using only feet to describe stratigraphic thicknesses and in other related subsections uses feet and meters).	Closed through audit activities	Review team clarified TVA's use of unit nomenclature through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17158B342, ML17234A004, ML17237C084)
25-a	The SSAR states that the CRBRP wells were "likely destroyed and/or removed when the excavation and subsequent site redress for the CRBRP was performed". Were TVA well abandonment procedures or other procedures in place during the CRBRP site redress?	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
25-b	Please provide an SME to discuss the implications to radionuclide transport analysis considering a short-circuit travel pathway through improperly abandoned shallow and/or deep boreholes potentially remaining from the CRBRP site characterization studies and redress.	Closed through audit activities	Review team clarified TVA's CRBRP site closure activities through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17234A004, ML17237C084)
25-c	Please provide an SME to discuss the status of the Tennessee Department of Environment and Conservation determination regarding the disposition of OW-422L in relation to the petroleum product found in this well during well completion activities.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.

26	Table 2.4.12-4. Some "geologic units" specified in this table are either briefly introduced in the context of well screen intervals or not described (e.g., Rockdell) in the text of Section 2.4.12, but rather refer to Reference 2.4.12-13 from a footnote in the table, refer to a reference from Figure 2.4.12-9 or, are described in a figure (e.g., Figure 2.4.12-10). Because monitoring wells are screened over these geologic units and observations are recorded from these screened intervals and used for site characterization studies, staff requests that a hydrologic description and/or references for these unit descriptions be included in the SSAR text of 2.4.12.	Closed through audit activities	Review team clarified TVA's geologic unit descriptions through audit discussions and review of supplemental information provided to the CRN Site ESP docket. (ML17158B342, ML17178A330)
27	Reference 2.4.12-14 (aka Reference 2.4.12C-5) does not seem to be publicly accessible or available to the staff. Please provide the staff with a copy of this reference or provide a means for the staff to obtain this reference.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
28-a	The SSAR text indicates "locations for two SMR reactors; however, the number of proposed reactors is not specified elsewhere in the SSAR. Is it TVA's intention to initially place two SMR reactors at the proposed CRN Site?	Closed through audit activities	Review team clarified TVA's description of the SMRs through audit discussions and information provided to the CRN Site ESP docket. (ML17178A330, ML17158B342)
28-b	Please provide an SME to discuss: a) the spatial pattern of pumping test drawdowns across the monitoring well set, and if that pattern is consistent with orientations of observed and known fracture trends and higher permeability zones; and, b) the larger vertical gradients among the well clusters groups and if these patterns are consistent with fracture trends and/or higher permeability zones.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
29-a	The SSAR states that "Of these tests, 5 exhibited flow by-passing around the packers." Please provide an SME to discuss the potential or probable causes of the by-pass identified (e.g., formation voids, faulty packers, packer seating etc.).	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.

29-b	Please provided an SME to comment on the potential or probable causes of why "the results from five wells (OW-409U, OW-415L, OW-421L, OW-423D, and OW-429U) had one test (falling or rising head) that could not be interpreted."	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
29-c	Table 2.4.12-4. Please explain the basis and rationale for using a value of 155 ft (i.e., water table to bottom of "primary flow zone") to derive hydraulic conductivities for the aquifer pumping test of PT-PW given that observation well screen intervals seem to be on the order of approximately 20 feet.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
30	Please identify the references used for the "Nuclear Energy Institute (NEI) groundwater initiatives" referred to in the SSAR text and include these in the SSAR.	Closed through audit activities	Review team clarified TVA's description of the NEI initiatives through audit discussions and information provided to the CRN Site ESP docket. (ML17178A330, ML17158B342)
31	Please provide an SME to discuss the rationale for the statement "The head relationships observed at the Melton Valley Exit Pathway monitoring wells (Reference 2.4.12-14) suggest that there is no credible pathway involving flow underneath the Clinch River arm of the Watts Bar Reservoir and exposure to water users on the opposite side of the river." As noted above, Reference 2.4.12-14 does not seem to be publicly available.	Closed through audit activities	Review team clarified TVA's description of the reference through audit discussions and information provided to the CRN Site ESP docket. (ML17234A004, ML17237C084)
32	Please provide an SME to define the word "idle" in the context of the City of Oak Ridge's West End Water Treatment plant's operational life cycle.	Closed through audit activities	Review team clarified TVA's description of the waste water treatment plant's disposition through audit discussions and information provided to the CRN Site ESP docket. (ML17157B212)

33-a	Although discussed in the SSAR Section 2.5.4.5.3, the backfill that would be placed around the proposed power block does not seem to be represented in the conceptual model, but seems to be included in the "soil, residuum fill" category. Please comment on the anticipated hydrologic properties of the granular backfill as compared to those of the "soil, residuum fill" properties and how the transport analyses might be affected by inclusion of the hydrologic properties of the backfill as described in Section 2.5.4.5.3. The staff understands that "A detailed field and laboratory test program is conducted, during the COLA design stage, to evaluate backfill sources and their engineering properties," per Section 2.5.4.5.3.	Closed through audit activities	Review team clarified TVA's description of the backfill to be used for the proposed site through audit discussions and information provided to the CRN Site ESP docket. (ML17158B342, ML17178A330)
33-b	Please provide an SME to discuss the potential presence of chelating agents and the effects of chemicals (e.g., chelating agents, if present in soils or liquids) that could comingle with liquid radionuclides and increase the mobility of radionuclides in the environment.	Closed through audit activities	Staff clarified its understanding of this topic through audit discussions and document reviews.
34	Please make the corresponding calculation package for Equation 4.4.13-1 available to staff and an SME to discuss the parameters and methods used for the calculations.	Closed through audit activities	Review team clarified TVA's methodology and assumptions in radionuclide transport analysis and accidental liquid effluent release source term through audit discussions and information provided to the CRN Site ESP docket. (ML17167A150, ML17143A417)
35	Please provide an SME to; a) discuss the data and calculation package used to derive the average weekly discharges that were used to determine the mean value of the average weekly discharge from the Melton Hill Dam over its lifetime as approximately 4800 cfs; and, b) the probability of occurrence of 0.1 percent for a required minimum flow value of 400 cfs average daily flow from Melton Hill Dam continuing for 7 days.	Closed through audit activities	Review team clarified TVA's description of the low flow used through audit discussions and information provided to the CRN Site ESP docket. (ML17158B342, ML17178A330)

36	Please provide an SME to discuss radionuclide dispersion and to clarify if the dispersion was included in the calculation of radionuclide concentrations in the reservoir at the receptor point.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
37	Please provide an SME to discuss dewatering plans for the excavated areas and the areal extent of the projected drawdown due to the dewatering and if, any potential existing or future users could be impacted by the dewatering and/or drawdown and the associated rationale for associated conclusions. The staff notes that construction dewatering is not discussed in SSAR Section 2.4.12 and requests that this be included in this section.	Closed through audit activities	Review team clarified TVA's description of the dewatering through audit discussions and information provided to the CRN Site ESP docket. (ML17237C084)
38	Page 2.4.12C-11, item 9. Last sentence seems to be a text fragment. Please clarify.	Closed through audit activities	Review team clarified TVA's description of the correction through audit discussions and information provided to the CRN Site ESP docket. (ML17158B342, ML17178A330)
39	Please provide an SME to discuss the groundwater model setup, sensitivity runs and calibration and, the rationale for selection of the calibrated model runs for Profiles A and C.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.
40-a	Is the "site layout drawing" as referred to in the SSAR text SSAR Figure 2.4.1-4? If so, how was the groundwater model modified to account for the site grading plan and associated surface elevations shown in this figure?	Closed through audit activities	Review team clarified TVA's description of the proposed site grading through audit discussions and information provided to the CRN Site ESP docket. (ML17158B342, ML17178A330)
40-b	The SSAR indicates that "The grade elevations are approximate and may change when a specific technology is selected for the Combined License Application (COLA)." Please confirm that the finished plant grade elevation of 821 ft NAVD88 is either final or approximate.	Closed through audit activities	The staff clarified its understanding of this topic through audit discussions and document reviews.

40-c	The SSAR text indicates that construction fill material was assumed to representative of a clean sand while in Section 2.5.4.5.3 the backfill is described as "Granular backfill consists of a processed graded aggregate meeting the gradation requirements of Type A aggregate of the Tennessee Department of Transportation (TDOT) Standard Specifications for Road and Bridge Construction (Reference 2.5.4-37) Section 303, Table A2-6." Please provide a comparison of the representative hydraulic properties of the backfill used for the groundwater model against those used for a Type A aggregate per the SSAR text, and provide the rationale for the Section 2.4.12C.7.2 statement that "A construction backfill of 10-3 cm/s (2.835 ft/day) typically represents an uncompacted backfill material." This and other SSAR sections should be made consistent when describing the material and hydraulic properties of proposed backfill material.	Closed through audit activities	Review team clarified TVA's description of the backfill characteristics through audit discussions and information provided to the CRN Site ESP docket. (ML17158B342, ML17178A330)
Health Physics			
41	The staff review of originating documents (i.e., Generation mPower, NuScale Power, Holtec, Westinghouse) containing the BWXT mPower, NuScale, SMR-160, and Westinghouse SMR source terms used in development of the CRN Site PPE source terms (Note: f or efficiency purposes, staff suggests uploading documents to the eRR).	Closed through audit activities	The staff gained an understanding on PPE source term development through audit discussions and review of supporting documents.
42	Using information from above, staff requests a discussion with the cognizant SME (TVA's contractor) concerning the development of the CRN Site PPE source terms, and the NRC staff's confirmatory analyses (Note: for efficiency purposes, staff suggests a face-to-face discussion with SME either at CRN Site or at SME's office in Reston, VA).	Closed through audit activities	TVA updated supplemental information related to PPE source terms through audit discussions and information provided to the CRN Site ESP docket. (ML17167A150, ML17178A330)

43	The staff requests a discussion with the cognizant SME (TVA's contractor) concerning the calculations of normal liquid and gaseous effluent releases and doses, and the NRC staff's confirmatory analyses (Note: for efficiency purposes, staff suggests a face-to-face discussion with SME either at CRN Site or at SME's office in Reston, VA).	Closed through audit activities	TVA revised radionuclide activities and evaluated doses through audit discussions and information provided to the CRN Site ESP docket. (ML17167A150)
44	The staff requests a discussion with the cognizant SME (TVA's contractor) concerning the calculation of accidental liquid effluent releases to ground and surface water and dose, and the NRC staff's confirmatory analysis.	Closed through audit activities	Review team clarified TVA's methodology and assumptions in radionuclide transport analysis and accidental liquid effluent release source term through audit discussions and information provided to the CRN Site ESP docket. (ML17167A150, ML17143A417)

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