ClinchRiverESPHFNPEm Resource

From:	Fetter, Allen
Sent:	Friday, April 27, 2018 9:37 AM
To:	Nguyen, Quynh
Cc:	Tammara, Seshagiri; Dudek, Michael; Sutton, Mallecia; Wright, Megan; Taylor, Robert; Bradford, Anna; Schiele, Raymond Joseph; Stout, Daniel Paul; Muniz, Adrian; Rankin, Jennivine
Subject:	Emailing: Clinch River ESP Phase C SE Sections 2.1 & 2.2_Final_corrected.docx, TVA comments on SE Sections 2.1, 2.1, 3.5.1.6 & 15.03.docx, Clinch River ESP Phase B SE Section 15.0.3_Final_corrected.docx, Clinch River ESP Phase C SE Section 3.5.1.6_Final_c
Attachments:	Clinch River ESP Phase C SE Sections 2.1 & 2.2_Final_corrected.docx; TVA comments on SE Sections 2.1, 2.1, 3.5.1.6 & 15.03.docx; Clinch River ESP Phase B SE Section 15.0.3 _Final_corrected.docx; Clinch River ESP Phase C SE Section 3.5.1.6_Final_corrected.docx

Good Morning Quynh,

Attached are the Clinch River ESP SE sections 2.1, 2.2, 3.5.1.6, and 15.0.3 with minor corrections based on minor factual errors identified by TVA. Also attached is a TVA-provided table containing the factual errors they identified. This table was utilized by NRC staff for making the corrections. Note, however, that the staff made no changes related to the following TVA observations: 2.2.3.4.2 - third paragraph, and 2.2.3.4.6 - Permit Condition 2.2-2.

Also note that TVA did not identify any sensitive or proprietary information in the attached documents. Therefore, the OFFICIAL USE ONLY – PROPRIETARY INFORMATION marking in the headers and footers of the documents have been removed, obviating the need to encrypt this message or the files.

Please let me know if you have any questions.

Thanks,

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2.0 SITE CHARACTERISTICS

2.1 Geography and Demography

2.1.1 Site Location and Description

2.1.1.1 Introduction

The descriptions of the Clinch River Nuclear (CRN) Site area and small modular reactors (SMR) location are used to assess the acceptability of a nuclear reactor site. The U.S. Nuclear Regulatory Commission (NRC) staff's review covers the following specific areas: (1) the specification of SMR location with respect to latitude and longitude, political subdivisions, and prominent natural and manmade features of the area; (2) a map of the site area to determine the distance from the CRN power block area to the boundary lines of the exclusion area, including consideration of the location, distance, and orientation of plant structures with respect to highways, railroads, and waterways that traverse or lie adjacent to the exclusion area; and (3) any additional information requirements prescribed in the applicable subparts to Title 10 of the *Code of Federal Regulations* (10 CFR) 52.17, "Contents of Applications; Technical Information." The purpose of the review is to ascertain the accuracy of the applicant's description of the CRN Site for use in independent evaluations of the exclusion area authority and control, the surrounding population, and nearby manmade hazards.

2.1.1.2 Summary of Application

The applicant addressed the CRN Site location and description in Site Safety Analysis Report (SSAR) Section 2.1.1, "Site Location and Description," of the Early Site Permit (ESP) application (TVA, 2017 – ML18003A374), in which the applicant provided site-specific information related to the CRN Site location and description, including political subdivisions, natural and manmade features, population, highways, railways, waterways, and other significant features of the area. In SSAR Figure 2.1.3, "Vicinity Map," consisting of "5-Mile Radius," and SSAR Figure 2.1.4, "50-Mile Region," the applicant showed the CRN Site location and the surrounding area within 8 kilometers (km) (5 miles (mi)) and 80 km (50 mi), respectively, and identified the prominent natural and manmade features, including the Clinch River, towns, industrial, military facilities, and major transportation routes.

2.1.1.3 Regulatory Basis

The relevant requirements of NRC regulations for the site location and description and the associated acceptance criteria, are specified in NUREG−0800, Section 2.1.1.

The applicable regulatory requirements for identifying site location and description are:

- 10 CFR 50.34(a)(1) "Contents of Applications; technical information,"
  10 CFR 52.17(a)(1) "Contents of Applications; technical information," and
  10 CFR 52.79(a)(1) "Contents of Applications; technical information in final safety analysis report", as they relate to the inclusion in the safety analysis report (SAR) of a detailed description and safety assessment of the site where the facility will be located, with appropriate attention to features affecting facility design; and

- 10 CFR Part 100, “Reactor Site Criteria,” as it relates to the following: (1) defining an exclusion area and setting forth requirements regarding activities in that area (10 CFR 100.3, “Definitions”); (2) addressing and evaluating factors that are used to determine the acceptability of the site as identified in 10 CFR 100.20, “Factors to be considered when evaluating sites,” subpart (b); (3) determining an exclusion area such that certain dose limits would not be exceeded in the event of a postulated fission product release as identified in 10 CFR 50.34(a)(1), as it relates to site evaluation factors identified in 10 CFR Part 100; and (4) requiring that the site location and the engineered features included as safeguards against the hazardous consequences of an accident, should one occur, would ensure a low risk of public exposure.

2.1.1.4 Technical Evaluation

SSAR Section 2.1.1 addresses the following information:

The CRN Site is in Roane County within the city limits of Oak Ridge, Tennessee. The CRN Site consists of approximately 3.79 km^2 (935 acres) and is located on a peninsula formed by a meandering Clinch River arm of the Watts Bar Reservoir where there is approximately 4.86 km^2 (1200 acres) of Clinch River property. The property is bounded on the east, south, and west by the Clinch River arm of the Watts Bar Reservoir, and on the north by the U.S. Department of Energy’s Oak Ridge Reservation and Wildlife Management Area. The site is situated on the historical Clinch River Breeder Reactor Project (CRBRP) site.

Other communities located near the site include Kingston (west), Harriman (west-northwest), Lenoir City (southeast), and Knoxville (east-northeast), Tennessee, which are respectively located approximately 11.58 km (7.2 mi), 16.41 km (10.2 mi), 14.32 km (8.9 mi), and 40.55 km (25.2 mi) from the site center point. According to U.S. Census Bureau (USCS), the city of Oak Ridge had a 2010 population of 29,330 and is the largest city within 10 miles of the site. Lenoir City, Tennessee, the second largest city within 10 miles, had a population of 8,642 persons.

SSAR Figure 2.1-4 shows the CRN Site location and the surrounding area within 80 km (50 mi). The site location, natural and manmade features, including rivers and major transportation routes within 8 km (5 mi), are shown in SSAR Figure 2.1-3. The major transportation route in the vicinity of the site is U.S. Interstate (I) 40, which passes approximately 0.96 km (0.6 mi) to the southeast and serves as the primary east to west thoroughfare. At the closest approach, Tennessee State Route 58 is located about 1.45 km (0.9 mi) northwest of the site, and Tennessee State Route 95 is located about 4.18 km (2.6 mi) east of the site. There are no military facilities located within the vicinity of the site. There are also no regularly scheduled passenger transportation trains that pass through or service any cities within 80 km (50 mi) region. However, there are excursion trains providing entertainment in the region. There is a rail line located within the vicinity that is used for commercial purposes.

The CRN property is illustrated in SSAR Figure 2.1-1. The CRN property is the same as the owner controlled area. There are no public access roads that traverse the site and there are no commercial, institutional, recreational, or residential structures located on the site. There are no mineral resources, including oil and natural gas, within or adjacent to the site that are being exploited. The only known resource of value located within the property is limestone, and the U.S. Federal Government owns all of the mineral rights for the property. The topography of the property is characterized by a series of parallel ridges and valleys, generally oriented in a northeast to southwest direction. Elevations on the site range from 225 m (740 ft) msl to a high

of 341.4 m (1120 ft) msl.

The exclusion area boundary (EAB) is delineated by the boundaries of CRN and is designated to be the CRN property line as shown in SSAR Figure 2.1-5. However, an analytical EAB based on the shortest distance between the effluent release point and boundary of analytical EAB for each of 16 compass sectors is used conservatively as 1,100 ft, and is used for atmospheric dispersion (X/Q) modeling. This distance is established based on minimum distance between the release point and the analytical EAB such that an individual located at any point on its boundary would not receive a radiation dose in excess of 25 rem total effective dose equivalent (TEDE) over any 2 hour period following a postulated fission product release. The various analytical EABs can be encompassed by an ellipse fixed completely within the CRN property boundary. As the radiological dose is directly proportional to the X/Q value, and since the X/Q value decreases as a function of distance from the release point to the boundary of EAB, the analytical EAB dose bounds the dose at the encompassed ellipse shaped EAB and actual EAB. The detailed discussion of analytical EAB approach is presented in SSAR Sections 2.3.4 and 2.3.5.2. It was communicated by the staff to the applicant in a February 13, 2017 public meeting that an EAB designation should not be applied to various areas such as the site boundary, 1 mile CRN Site boundary and 1,100 ft analytical EAB (NRC, 2017 - Agencywide Documents Access and Management System (ADAMS) Accession Number ML17054D545). These designations need to be identified discretely in order to be clear about EAB, analytical EAB and site boundary designations. Therefore, during the public meeting, the applicant was asked to provide, and it subsequently provided, supplemental information (TVA, 2017 – ADAMS Accession Number ML17107A080) that referred to the EAB as the area that is delineated by the boundaries of CRN property as shown on updated SSAR Figure 2.1-5. The shortest distance between the effluent release point and boundary of 1,100 ft for each of 16 compass sectors is used as analytical EAB for short term meteorological dispersion and radiological dose evaluation purposes.

The staff reviewed SSAR Section 2.1.1 related to site location and description, including natural and manmade features, highways, railways, waterways, and other significant features of the area. The staff confirmed that the information in the application addresses the requirements for identifying the CRN Site location and description.

Using publicly available maps, the staff independently estimated and confirmed the latitude and longitude that the applicant supplied. The staff then converted this latitude and longitude to Universal Transverse Mercator (UTM) coordinates and verified the UTM coordinates of the CRN Site reference point in the SSAR.

The geodetic and UTM coordinates are as follows:

Geodetic	**UTM Coordinates (NAD83, Zone 16 (m))**		
Latitude	**Longitude**	**Northing**	**Easting**
N35° 53' 27.2"	W84° 22' 48.0"	3,974,815.26 m	736,407.14 m
		(13,040,732.48 ft)	(2,416,033.924 ft)

The staff reviewed the site map in the SSAR (Figure 2.1-1) for the proposed CRN Site to verify that the distance from the proposed power block to the boundary line of the exclusion area meets the guidance in NUREG−0800, Section 2.1.1. Based on its review of the information in the SSAR, and confirmatory review of prominent, natural, and manmade features of the area as found in publicly available documentation, the staff finds the information provided by the applicant with regard to the CRN Site location and description adequate and acceptable.

2.1.1.5 Conclusion

As discussed above, the applicant presented and described information to establish the CRN Site location and description, which includes the information submitted by the applicant in response to public meeting discussions and updates to the SSAR. The staff reviewed the information that the applicant submitted and, for the reasons given above, concludes that the applicant has established site characteristics and design parameters acceptable to meet the requirements of 10 CFR 52.17(a)(1), 10 CFR 100.3, and the radiological consequence evaluation factors in 10 CFR 50.34(a)(1). The staff also affirms that the applicant provided sufficient details about the CRN Site location and site area, as documented in SSAR Sections 2.1.2, 2.1.3, and 13.3 and SSAR Chapter 15. These details allowed the staff to conclude that the applicant met the requirements in 10 CFR 52.17(a)(1) and 10 CFR Part 100 regarding site location and description.

2.1.2 Exclusion Area Authority and Control

2.1.2.1 Introduction

The descriptions of exclusion area authority and control are used to verify that the applicant's legal authority to determine and control activities within the designated exclusion area boundary, as provided in the application, is sufficient to allow reviewers to assess the acceptability of the site. The staff's review includes the following specific areas:

- Establishing the applicant's legal authority to determine all activities within the designated exclusion area;
- Validating the applicant's authority and control to exclude or remove personnel and property from the area in the event of an emergency;
- Establishing that proposed or permitted activities in the exclusion area that are unrelated to operation of the facility do not result in a significant hazard to public health and safety; and
- Requesting any additional information prescribed in 10 CFR 52.17.

2.1.2.2 Summary of Application

In the CRN Site SSAR, the applicant identified the exclusion area boundary and addressed the authority and control of the area in the case of an emergency. The applicant addressed the information pertaining to ownership, activities, authority and control, including arrangements for traffic control.

2.1.2.3 Regulatory Basis

The relevant requirements of NRC regulations for exclusion area authority and control and the associated acceptance criteria, are specified in NUREG−0800, Section 2.1.2, "Exclusion Area Authority and Control," as well as Review Standard (RS) 002, "Processing Applications for Early Site Permits."

The applicable regulatory requirements for verifying exclusion area authority and control are:

- 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1), as they relate to the inclusion in the site SAR of a detailed description and safety assessment of the site on which the facility is to be located, with appropriate attention to features affecting facility design; and

- 10 CFR Part 100, as it relates to the following: (1) defining an exclusion area and setting forth requirements regarding activities in that area (10 CFR 100.3); (2) addressing and evaluating factors that are used to determine the acceptability of the site as identified in 10 CFR 100.20(b); and (3) determining an exclusion area such that certain dose limits would not be exceeded in the event of a postulated fission product release as identified in 10 CFR 50.34(a)(1) as it relates to site evaluation factors identified in 10 CFR Part 100.

2.1.2.4 Technical Evaluation

The CRN Site consists of approximately 3.79 km^2 (935 acres) and is located on a peninsula formed by a meandering Clinch River arm of the Watts Bar Reservoir, within approximately 4.86 km^2 (1200 acres) Clinch River property owned by U.S. and managed by TVA. There are no public transportation routes crossing the site. There are no mineral resources, including oil and natural gas within, or adjacent to, the site that are being exploited. The only resource of value located within the property is limestone, and the U.S. Federal Government owns all of the mineral rights for the property. The CRN property will be clearly posted with "no trespassing" signs along the property border and river shorelines. All road access points will be controlled. Once inside the owner controlled area, access to the nuclear plant will be controlled with security check-points and barriers. The permanent population distribution within the EAB is zero. TVA controls all activities within the EAB including exclusion and removal of personnel and property from the area. TVA owns and maintains transmission lines and as well as maintains access control of the transmission rights-of-way that traverse the site.

There are no residences or commercial activities within the EAB. Recreational activities and hunting within the owner controlled area and the EAB are prohibited and are controlled by security personnel. No public highways or active railroads traverse the exclusion area. Barge traffic occurs adjacent to the EAB along the Clinch River arm of the Watts Bar Reservoir. There is one small family cemetery and one Native American burial mound located on the site; however, access to these are controlled by security personnel. Arrangements for traffic control or abandonment or relocation of roads are not required as no public roads cross EAB.

2.1.2.5 Conclusion

As discussed above, the applicant presented information pertaining to legal authority and control of all the activities within the designated EAB. The staff reviewed the information and, for the reasons stated above, concludes that the applicant's designated exclusion area is

reasonable and acceptable, and meets the requirements of 10 CFR 50.34(a)(1), 10 CFR 52.17(a)(1), 10 CFR Part 100, and 10 CFR 100.3 in determining the acceptability of the CRN Site. The staff based its conclusion on the determination that the applicant appropriately described the plant exclusion area and the authority under which all activities within the exclusion area can be controlled.

2.1.3 Population Distribution

2.1.3.1 Introduction

The description of population distributions addresses the need for information about the following:

- Population in the site vicinity, including transient populations;
- Population in the exclusion area;
- Whether appropriate protective measures could be taken on behalf of the populace in the specified low-population zone (LPZ) in the event of a serious accident;
- Whether the nearest boundary of the closest population center having 25,000 or more residents is at least one and one-third times the distance from the reactor to the outer boundary of the LPZ;
- Whether the population density in the site vicinity is consistent with the guidelines given in Regulatory Guide (RG) 4.7, "General Site Suitability Criteria for Nuclear Power Stations," Regulatory Position C.4; and
- Any additional information requirements prescribed in the applicable subparts to 10 CFR 52.17, "Contents of Applications; Technical Information."

2.1.3.2 Summary of Application

In the CRN Site SSAR, the applicant addressed the population distribution surrounding the CRN Site to an 80 km (50 mi) radius based on 2010 U.S. census data, which was the most recent data at the time of submission of the ESP application. The population distribution was estimated in 15 concentric rings for 16 cardinal directional sectors. The population projections were derived from county estimates obtained from the States and based on cohort component (Kentucky and Tennessee) and cohort survey (North Carolina) methodologies. Using linear or polynomial regression, an equation was derived to analyze population growth for each county, which was used in conjunction with 2010 census data to produce a growth ratio. These growth ratios calculated for each county were then weighted by area and summed into sectors and used further to produce a sector-level population projection ratio set for the 80 km (50mi) region. The years selected for the projection period represent the 2010 census, calculation development year 2013, projected start of construction year 2021, and projected commencement of operation date of 2027 with operational life of 40 years (2067). Projected permanent population for each sector out to 16 km (10 mi) and from 16 km (10 mi) out to 80 km (50 mi), for the years 2010, 2013, 2021, 2027, 2037, 2047, 2057, and 2067 was addressed along with estimated transient population. For the CRN Site, LPZ is defined as 1.6 km (1 mi) radius from the site center point. Based on the 2010 census there are 149 people living within

the LPZ. The distribution of people within the LPZ is presented in SSAR Table 2.1-7. There is one special facility identified as Kingston Academy, a 52-bed coed psychiatric residential treatment facility for children within the LPZ. There are no hospitals, prisons, or jails within the LPZ. Population center distance and population density are also addressed. The information in the application is reviewed and evaluated by the staff and presented below in Subsection 2.1.3.4 of this Safety Evaluation Report.

2.1.3.3 Regulatory Basis

The relevant requirements of NRC regulations for population distribution and the associated acceptance criteria are specified in NUREG−0800, Section 2.1.3, "Population Distribution," as well as RS-002.

The applicable regulatory requirements pertinent to the review of population distribution are:

- 10 CFR 50.34(a)(1), as it relates to consideration of the site evaluation factors identified in 10 CFR 100.3;
- 10 CFR Part 100 (including consideration of population density) and 10 CFR 52.17 as they relate to provision by the applicant in the SSAR of the existing and projected future population profile of the area surrounding the site; and
- 10 CFR 100.20, "Factors To Be Considered When Evaluating Sites," and
- 10 CFR 100.21, "Non-Seismic Site Criteria," requirements, as they relate to determining the acceptability of a site. In 10 CFR 100.3, 10 CFR 100.20(a), and 10 CFR 100.21(b), the NRC provides definitions and other requirements to determine an exclusion area, LPZ, and population center distance.

The related acceptance criteria from NUREG−0800, Section 2.1.3 and RS-002 are as follows:

Population Data: The information on population data that the applicant supplied in the SSAR is acceptable under the following conditions: SSAR (1) includes present and future population data for the life of the plant from the latest census data and projected population; (2) describes the methodology and sources used to obtain the population data, including the projections; and (3) includes information on transient populations in the site vicinity.

Exclusion Area: The exclusion area should not have any residents or such residents should be subject to ready removal if necessary.

Low-Population Zone: The specified LPZ is acceptable if it is determined that appropriate protective measures could be taken on behalf of the enclosed populace in the event of a serious accident.

Nearest Population Center Boundary: The nearest boundary of the closest population center having 25,000 or more residents is at least one and one-third times the distance from the reactor facility to the outer boundary of the LPZ.

Population Density: If the population density exceeds the guidelines given in RG 4.7, "General Site Suitability Criteria for Nuclear Power Stations," Regulatory Position C.4, the applicant must give special attention to considering alternative sites with lower population densities.

2.1.3.4 Technical Evaluation

The staff reviewed SSAR Section 2.1.3 and confirmed that the application addressed the required information relating to population distribution.

The staff reviewed the data on the population in the CRN Site environs, as presented in SSAR Sections 2.1.1, 2.1.2, and 2.1.3, to determine whether the exclusion area, LPZ, and nearest population center distance for the proposed site comply with the requirements of 10 CFR Part 100. The staff also evaluated whether, consistent with RG 4.7, Regulatory Position C.4, the applicant should consider alternative sites with lower population densities. Further, the staff reviewed whether appropriate protective measures could be taken on behalf of the enclosed populace within the Emergency Planning Zone (EPZ), which encompasses the LPZ in the event of a serious accident.

Based on the 2010 U.S. census data, an estimated 67,203 residents are located within 16.1 km (10 mi) of the CRN Site. About 149 people are within 1.61 km (1 mi) of the CRN Site, that being considered as the LPZ. Based on population projections, the population within 16.1 km (10 mi) of the CRN Site is expected to increase from 77,889 in 2027 (first year of operation) to 93,470 in 2067 (end of plant operating life). The population projections for residents within 16.1 km (10 mi) of the CRN Site for the years 2010 through 2067 are presented in SSAR Table 2.1-2. The transient population estimated within 16.1 km (10 mi) is presented in SSAR Table 2.1-4, and 2.1-5.

Based on the 2010 U.S. census data, an estimated 1,090,823 residents are located within 16.1 to 80 km (10 to 50 mi) of the CRN Site. The population within 16.1 to 80 km (10 to 50 mi) of the CRN Site is projected to increase from 1,298,708 in 2027 to 1,678,800 in 2067. The population projections between 16.1 and 80 km (10 and 50 mi) from the CRN Site for the years 2010 through 2067 are presented in SSAR Table 2.1-3. The transient population projections within 80 km (50 mi) are presented in SSAR Table 2.1-5.

In addition to the permanent residents within 16.1 km (10 mi) of the CRN Site, there are people who are considered transient that enter this area on a regular basis for employment, education, recreation, and medical care. SSAR Table 2.1-4 provides the sources of transient populations within 16.1 km (10 mi) of the CRN Site.

The transient population within 16.1 and 80 km (10 and 50 mi) include people attending various events and contributors as listed, with peak daily visitors in SSAR Table 2.1-4. Projected transient population is presented in SSAR Table 2.1-5.

The proposed LPZ consists of a 1.61 km (1 mi) radius around the center point of CRN power block as shown in SSAR Figure 2.1-3. The population projections within LPZ are presented in SSAR Table 2.1-2.

The 80 km (50 mi) radius from the center of the CRN Site comprises a total of 33 counties, two of which are in the state of Kentucky, three are in the state of North Carolina, and 28 are in the state of Tennessee as presented in SSAR Table 2.1-1. The staff obtained the U.S. census population data for the years 2000 and 2010 for each of the above counties. The population within an 80 km (50 mi) radius from the center of CRN is independently estimated by the staff based on using the fraction of the each county within 80 km (50 mi) by multiplying the respective county population and summing this product over all the counties considered within 80 km (50 mi) for the years 2000 and 2010, respectively. The total population value within 80 km (50 mi) for the year 2010 estimated by the staff compared well with that of the applicant generated the population values from SSAR Tables 2.1-2 and Table 2.1-3. The annual growth rate calculated for each of the counties considered based on above census data for the years 2000 and 2010 is also found to be comparable to the applicant reported growth rate values.

The CRN Site is located in Roane County, within the city limits of Oak Ridge, Tennessee. According to the USCB, the city of Oak Ridge had a 2010 population of 29,330 and was the largest city within 16.1 km (10 mi) of the site. It is an unusual situation for the consideration of addressing population center distance in assessing the application for compliance with NRC regulations. The population center distance, as defined in 10 CFR 100.3, must be at least one and one-third times the distance from the reactor to the outer boundary of LPZ. In this case, the site is within the officially designated political boundary of the city limit. Nevertheless, the regulatory requirement states that the boundary of the population center shall be determined upon consideration of population distribution, and political boundaries are not controlling in the application of the criterion. Therefore, in this case, the population center, which has a denser population, is farther away from the reactor and would not only address the intent of the regulatory requirement, but also would meet the site suitability criterion of population center distance. The majority of the population of the city of Oak Ridge is to the north through the east of the CRN site.

Based on the review of population distribution by sector and distance in these directions, out to 16.1 km (10 mi), it can be observed that the population contributing to more than 25,000 people is between 8 to 16.1 km (5 to 10 mi), and therefore, the staff finds that the population center distance of one and one-third times the distance of LPZ of 2.16 km (1.34 mi) is satisfied.

The regulatory requirement of 10 CFR 100. 21(b) related to population center distance, which is defined in 10 CFR 100.3 as the nearest population center having population of 25,000 or more people, requires it to be at least one and one-third times the distance from the reactor to the outer boundary of the LPZ. In meeting this requirement, the applicant used USCB census-delineated urban areas in the region based on population density. The two urban areas identified are the Knoxville (4.8 mi southeast) urban area with the combination of smaller cities including Lafollette, Oak Ridge, Clinton, Loudon, Lenoir City, Alcoa, Maryville, Farragut, Rockwood, Seymour, and Knoxville; and the Cleveland (45 mi south southwest) urban area with the combination of smaller cities including Calhoun, Charleston, Hopewell, and Cleveland, Tennessee. The Knoxville and Cleveland urban areas had 2010 populations of 558,696 and 66,777 persons, respectively. The applicant stated that the population center distance requirement in 10 CFR 100.21(b) is being met, as the distances of these identified urban areas are much greater than the one and one-third times the distance from the site center point to the outer boundary of the LPZ. The applicant, however, followed an approach by using urban area designation with combination of smaller cities for complying with the population center distance of one and one-third times the distance from the reactor to the outer boundary of LPZ. This approach differs from the regulatory requirement by considering and combining various small

cities of lesser than 25,000 people. Therefore, the staff requested the applicant in RAI Number 4 (eRAI-8857, ADAMS Accession Number ML17236A249) to revise the evaluation methodology in meeting the 10 CFR 100.21(b) regulatory requirement to solely base the evaluation methodology on consideration of the nearest city having population of 25,000 or more people. The applicant provided a response to the RAI on August 24, 2017 (TVA, 2017 – ADAMS Accession Number ML17236A249), and subsequently updated information in the SSAR. The applicant stated that the City of Oak Ridge, with a 2010 population of 29,330, is the closest city to the CRN Site that exceeds 25,000 people, based on political boundaries. The CRN Site is located within the southern extent of the City of Oak Ridge, with the city's territory primarily extending to the northeast of the CRN Site. The densely populated portions of the City of Oak Ridge are located in these northeast portions. This is illustrated in SSAR Figure 2.1-6 and Figure 2.1-9, which portray the distribution of population by sector and distance from the CRN Site. In these figures, the sectors in the northeast directions have low-populations from 0 to 6 mi. Therefore, densely populated portions of the City of Oak Ridge are located beyond the distance required by 10 CFR 100.21(b). Accordingly, the staff finds the applicant's methodology acceptable because it is consistent with the regulatory requirement. Also, this is further supported by the USCB which has delineated the densely populated portions of the City of Oak Ridge as part of the greater Knoxville urban area at approximately 5.9 mi from the CRN Site.

The applicant determined population density by using the estimated projected populations to the years 2021, 2027, and 2067. The relationship between population totals and distance from the site is presented SSAR Figure 2.1-8. The estimated population density within 32.2 km (20 mi) from the center of CRN Site for the years 2021, 2027, and 2067 are 295, 311, and 400 people per square mile, and is less than the guidance value of 500 people per square mile per RG 4.7.

2.1.3.5 Conclusion

As discussed above, the applicant provided an acceptable description of current and projected population distribution, LPZ, population center distances, and population densities in and around the CRN Site. The staff reviewed the information provided and, for the reasons stated above, concludes that the applicant has provided population data acceptable to meet the requirements of 10 CFR 50.34(a)(1), 10 CFR 52.17(a)(1)(viii), 10 CFR 100.20(a), 10 CFR 100.21(b), 10 CFR Part 100, and 10 CFR 100.3. This conclusion is based on the applicant providing an acceptable description and safety assessment of the CRN Site. The site area contains present and projected population densities that conform to the guidelines of RG 4.7, Regulatory Position C.4, and the applicant properly specified the LPZ and population center distance. Additionally, by assessing the population data independently, the staff reviewed and confirmed the applicant's estimates of the present and projected populations surrounding the CRN Site, including transients and found them reasonable and acceptable. The applicant also calculated the radiological consequences of design-basis accidents at the outer boundary of the LPZ (Chapter 15, Section 15.0.3) and has provided reasonable assurance that appropriate protective measures can be taken within the LPZ to protect the population in the event of a radiological emergency. Therefore, the staff finds that the CRN Site ESP applicant has provided adequate and acceptable information and description to comply with the requirements of 10 CFR 50.34(a)(1), 10 CFR 52.17(a)(1)(viii), and 10 CFR Part 100.

2.2 Nearby Industrial, Transportation, and Military Facilities

2.2.1 Locations and Routes

2.2.1.1 Introduction

In the identification of potential hazards in the site vicinity, the description of locations and routes refers to potential external hazards or hazardous materials that are present or may reasonably be expected to be present during the projected lifetime of the proposed plant. The purpose of the staff's review of this section is to determine the adequacy of information in meeting regulatory requirements concerning the presence and magnitude of potential external hazards so that the staff can perform its technical review and evaluation consistent with the guidance provided in NUREG−0800, Sections 2.2.1, 2.2.2, 2.2.3, 3.5.1.5, and 3.5.1.6. The staff's review covers the following specific areas: (1) the locations of, and separation distances to, transportation facilities and routes, including airports and airways, roadways, railways, pipelines, and navigable bodies of water; (2) the presence of military and industrial facilities, such as fixed manufacturing, processing, and storage facilities; and (3) any additional information requirements prescribed in the applicable subparts to 10 CFR 52.17.

2.2.1.2 Summary of Application

In the CRN Site SSAR, the applicant identified potential hazardous facilities and routes within the 8 km (5 mi) vicinity of the CRN Site and airports within 16.1 km (10 mi) of the CRN Site, along with significant facilities at a greater distance. The applicant provided detailed descriptions of these facilities and routes for further consideration of hazards evaluation. There are five industrial facilities, one major highway, four major roads, two natural gas pipelines, one waterway, a railroad, five small airports, and two airways.

2.2.1.3 Regulatory Basis

The acceptance criteria for identification of potential hazards in the site vicinity are based on meeting the relevant requirements of 10 CFR Part 50, 10 CFR 52.17 and 10 CFR Part 100, and also the information provided as per the following guidance:

- Regulatory Guide (RG) 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition),"
- RG 1.91, "Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants,"
- RG 4.7, "General Site Suitability Criteria for Nuclear Power Stations,
- RG 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," and

The staff also considered the following regulatory requirements in reviewing the identification of potential hazards in the CRN Site vicinity:

- 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"

- 10 CFR 52.17, as it relates to the requirement that the application contain information on the location and description of any nearby industrial, military, or transportation facilities and routes;

- 10 CFR 100.20(b), as it relates to the requirement that the nature and proximity of man-related hazards (e.g., airports, dams, transportation routes, and military and chemical facilities) be evaluated to establish site parameters for use in determining whether a plant design can accommodate commonly occurring hazards and whether the risk of other hazards is very low; and

- 10 CFR 100.21(e), as it relates to the requirement that the potential hazards associated with nearby transportation routes, industrial, and military facilities be evaluated and site parameters established such that potential hazards from such routes and facilities will not pose undue risk to the type of facility proposed to be located at the site.

Both NUREG−0800 and RS-002, Sections 2.2.1 and 2.2.2, specify that an applicant has submitted adequate information to meet the above requirements if the submitted information satisfies the following criteria:

- Data in the site safety assessment adequately describes the locations and distances of industrial, military, and transportation facilities in the vicinity of the plant, a nuclear power plant or plants of specified type that might be constructed on the proposed site, and agree with the data obtained from other sources, when available;

- Descriptions of the nature and extent of activities conducted at the site and nearby facilities, including the products and materials likely to be processed, stored, used, or transported, are adequate to permit identification of possible hazards; and

- Sufficient statistical data related to hazardous materials are provided to establish a basis for evaluating the potential hazard to a nuclear power plant or plants of specified type that may be constructed on the proposed site.

2.2.1.4 Technical Evaluation

The staff reviewed the CRN Site SSAR using the review procedures described in NUREG-0800, Sections 2.2.1 and 2.2.2. This section identifies and provides information that would help in evaluating potential hazards due to industrial, transportation, and military installations in the CRN Site area on the safe operation of the proposed nuclear facility.

In the SSAR, the applicant identified the following potential hazard facilities and operations within 8 km (5 mi) of the CRN Site for further analysis.

Industrial facilities:

- Oak Ridge National Laboratory (ORNL) (Battelle and URS)
- TVA Kingston Fossil Plant
- Oak Ridge Water Treatment Plant (WTP)
- TVA Bull Run Fossil Plant
- Hallsdale Powell Utility District Melton Hill WTP

Transportation Routes:

- Clinch River arm of Watts Bar Reservoir
- I-40
- Tennessee TN 1/US 11-70, and TN 58, TN 95, and TN 327
- Heritage Railroad Corporation Railway
- East Tennessee Natural Gas Pipeline 1 (East) and Pipeline 2 (North)

Airports and Airways:

- Big T
- Wolf Creek
- Cox Farm
- Will A Hildreth Farm
- Riley Creek
- Federal Airways V16 and J46

The Oliver Springs and Fergusons Circus airports are within 16.1 to 24.1 km (10 to 15 mi) of the CRN Site.

2.2.2 Descriptions

The applicant provided detailed descriptions of the identified facilities and routes in SSAR Section 2.2.2 in accordance with NUREG–0800, RS-002, and RG 1.206.

2.2.2.1 Descriptions of Facilities

The five facilities identified for further review for potential impact evaluation include:

- ORNL (Battelle and URS)
- TVA Kingston Fossil Plant
- Oak Ridge WTP
- TVA Bull Run Fossil Plant
- Hallsdale Powell Utility District Melton Hill WTP

The CRN Site SSAR Table 2.2-1 provides a concise description of each facility, including its primary function and major products, as well as the number of persons employed, if available.

2.2.2.2 Descriptions of Products and Materials

A more detailed description of offsite chemicals associated with each of the above facilities is provided in the following SSAR subsections. This description includes information about the products and materials regularly manufactured, stored, used or transported in the site vicinity. The chemicals stored at the offsite facilities identified in Subsection 2.2.2.1 above are provided in detail in SSAR Tables 2.2-2 and 2.2-5.

ORNL is located in Oak Ridge, TN, approximately 6.1 km (3.8 mi) northeast of the CRN Site power block area. ORNL conducts research and development relating to national energy and security issues and employs approximately 4,400 employees. The I-40 corridor is considered the most significant and the closest highway to the CRN Site and is evaluated as a potential

transport route for chemical supplies shipped to ORNL and other facilities. The chemicals stored at ORNL identified for possible analysis are addressed in SSAR Subsection 2.2.3.

TVA Kingston Fossil Plant is located in Kingston, TN, approximately 12.2 km (7.6 mi) west of the CRN Site power block area. The plant operates nine coal-fired generating units. The TVA Kingston Fossil plant employs 248 employees. The facility uses anhydrous ammonia in the coal burning process to remove nitrogen oxides that are produced during combustion in the course of producing electricity from coal.

The Oak Ridge WTP is located in Oak Ridge, TN, approximately 16.6 km (10.3 mi) northeast of CRN Site power block area. The plant is owned and operated by the City of Oak Ridge Public Works Department which employs 94 employees. The Oak Ridge WTP uses chlorine as a disinfectant in its water treatment process. The plant receives chlorine from its supplier by truck.

The TVA Bull Run Fossil Plant is located in Clinton, TN, approximately 24.1 km (15 mi) northeast from the CRN Site power block area. The plant uses anhydrous ammonia in the coal burning process to remove nitrogen oxides that are produced during combustion in the course of producing electricity from coal. The TVA Bull Run Fossil Plant receives anhydrous ammonia from its supplier by truck.

Hallsdale Powell Utility District Melton Hill WTP is located approximately 29.3 km (18.2 mi) northeast of the CRN Site power block area in Knoxville, TN. This plant uses chlorine as a disinfectant in its water treatment process, and is supplied by truck.

2.2.2.3 Description of Pipelines

The East Tennessee Natural Gas Company operates two natural gas pipelines within 5 mi of the CRN Site power block area. Pipeline 1 located east of the CRN Site has a 6-inch diameter and was constructed in 1957. Pipeline 2, located north of the CRN Site has a 22-in, diameter and was constructed in 1950. Both pipelines operate at a maximum allowable operating pressure of 720 psig and are buried to a depth of 0.9 m (3 ft). The pipelines have various isolation valves located along the pipeline route which can be reached and operated within one hour of notification. The closest branch of the pipeline originates at approximately the intersection of TN 58 and TN 327 and extends south towards the Clinch River. This pipeline crosses the Clinch River and its closest approach to the CRN Site power block area is approximately 1.8 km (1.1 mi) away from the site.

2.2.2.4 Description of Waterways

There are 802 stream miles in the lower Clinch River Watershed, which is located in east TN and includes parts of Anderson, Campbell, Grainger, Know, Loudon, Morgan, Roane, and Union Counties. The Clinch River flows southwest from Tazewell, VA, through the Great Appalachian Valley down to Kingston, just west of Knoxville, where it joins the Tennessee River. Significant waterborne transport in the CRN Site vicinity is possible on the Clinch River arm of the Watts Bar Reservoir. Annual waterborne commerce data compiled by the U.S. Army Corps of Engineers' Waterborne Commerce Statistics Center, for the period of 2007 through 2012, indicate that there was inconsequential shipping on the river, and that there was no transport of hazardous materials (e.g., chemicals and related products, petroleum, ordinance, etc.) that could pose a threat to operations at the CRN Site. Therefore, potential impacts due to water

transport of hazardous materials was not considered.

2.2.2.5 Description of Highways

The most significant highway near the site is I-40, which runs roughly east-west on the opposite side of the Clinch River arm of the Watts Bar Reservoir. At its closest point, I-40 is just over 1.61 km (1 mi) from the CRN Site power block area. Other larger roads near the site include TN 1/US 11-70, TN 58, TN 95 and TN 327 (all are farther than I-40). I-40 was identified as a road within 8 km (5 mi) of the site, on which chemicals may be transported. The analysis of chemical transport on I-40 bounds an analysis of other roads in the vicinity of the CRN Site because no closer roadway was identified on which chemicals may potentially be transported.

2.2.2.6 Description of Railroads

The nearest major rail line to the CRN Site is operated by Norfolk Southern and runs roughly northeast from Harriman, TN, parallel to TN 61 toward Oliver Springs, TN. At closest approach, this line is approximately 11.3 km (7 mi) from the site. A second major rail line operated by Norfolk Southern lies south of the site and also runs roughly northeast through Loudon, TN, and Lenoir City, TN, and on to Knoxville, TN. At closest approach this line is approximately 14.5 km (9 mi) from the site. Due to the large distance from these lines to the site and the complex intervening terrain, accident scenarios on these lines are not evaluated further. There is another minor rail line which is used for shipping of solid and low-level radioactive wastes. The applicant considered that these wastes do not pose a significant threat. The staff independently evaluated the information provided by the applicant and finds this acceptable as the materials are mostly solids having vapor pressure sufficiently low for vapor cloud formation for dispersion and explosion. Therefore, accidents from the transport of these hazardous wastes in the vicinity of CRN Site by rail are not considered further.

2.2.2.7 Description of Airports, Aircraft, and Airway Hazards

Five small privately owned airports (Big T, Wolf Creek, Cox Farm, Will A Hildreth Farm, and Riley Creek) are located between 8 and 16.1 km (5 and 10 statute mi) of the CRN Site. The closest military operation area (MOA) is the Snowbird MOA located approximately 57.9 km (36 mi) from the CRN Site. There are two Federal airways, one Victor (V) and one Jet (J) route (V16 and J46) respectively whose nearest edge lies within 3.2 km (2 statute mi) of the CRN Site. The details of the impacts addressed and evaluated are discussed and presented in Subsection 3.5.1.6 of this SER.

2.2.2.8 Projection of Industrial Growth

The East Tennessee Technology Park (ETTP) has begun a major environmental site cleanup with the long-term goal of converting the ETTP into a private industrial park called Heritage Center Industrial Park. The cleanup activities are currently being conducted and, as cleanup is completed, DOE will transfer ownership of the uncontaminated buildings to the community Reuse Organization of East Tennessee, who in turn leases this property for immediate private industrial use. Many of the buildings will be slated for potential reuse and the remediated land will be available for new construction. Additionally, the Metropolitan Knoxville Airport Authority working with community partners and DOE, has slated the Heritage Center Industrial Park, approximately 9.6 km (6 mi) from the CRN Site, as the potential site for a general aviation airport. Current site plans indicate future construction dates for the airport as approximately 2017-2022. No other projections of industrial growth within a 16.1 km (10 mi) radius of the CRN

Site were identified. If this airport comes into operation by the combined license (COL) stage, its impact evaluation should be included in the combined license application (COLA). The staff identifies this as Permit Condition 2.2-1 as described in Section 2.2.3.5.6 of this report.

2.2.2.9 Conclusion

As discussed above, the applicant presented the detailed information to establish the identification of potential hazards in the CRN Site vicinity. The staff reviewed the information provided, and concludes that the applicant has provided reasonable and appropriate information with respect to identification of potential hazards in conformance to the guidance in NUREG−0800, as described in the "Regulatory Basis" section above, and in compliance with the requirements of 10 CFR 52.17(a)(1)(vii), 10 CFR 52.17(a)(1)(ix), as well as 10 CFR 100.20(b) and 10 CFR 100.21(e). The nature and extent of activities involving potentially hazardous materials that are conducted at nearby industrial, military, and transportation facilities have also been evaluated to identify any such activities that have the potential for adversely affecting plant safety-related structures. On the basis of an evaluation of information in the SSAR, as well as information obtained independently, the staff concludes that all potentially hazardous activities on site and in the vicinity of the plant have been identified. The hazards associated with these activities have been reviewed and are discussed in Sections 2.2.3, and 3.5.1.6 of this report.

2.2.3 Evaluation of Potential Accidents

2.2.3.1 Introduction

The staff's evaluation of potential accidents considers the applicant's probability analyses of potential accidents involving hazardous materials or activities on the CRN Site and in the vicinity of the proposed CRN Site to confirm that appropriate data and analytical models have been used. The review covers the following specific areas: (1) hazards associated with nearby industrial activities, such as manufacturing, processing, or storage facilities; (2) hazards associated with nearby military activities, such as military bases, training areas, or aircraft flights; and (3) hazards associated with nearby transportation routes (aircraft routes, highways, railways, navigable waters, and pipelines). Each hazard review area includes consideration of the following principal types of hazards:

- Toxic vapors or gases and their potential for incapacitating nuclear plant control room operators;
- Overpressure resulting from explosions or detonations involving materials such as munitions, industrial explosives, or explosive vapor clouds resulting from the atmospheric release of gases (such as propane and natural gas or any other gas) with a potential for ignition and explosion;
- Missile effects attributable to mechanical impacts, such as aircraft impacts, explosion debris, and impacts from waterborne items such as barges; and
- Thermal effects attributable to fires.

2.2.3.2 Summary of Application

In the CRN Site SSAR, the applicant evaluated potential accidents based on the information compiled for the identified facilities in Sections 2.2.1 and 2.2.2, in accordance with regulatory requirements in 10 CFR 52.17, 10 CFR 100.20, and 10 CFR 100.21 using the guidance in RG 1.78, Revision 1, RG 1.91, Revision 1, RG 4.7, Revision 2 and RG 1.206, Revision 0. The applicant performed an analysis of these accidents to determine whether any of them should be considered as design-basis events (DBEs). The DBEs are defined as those accidents that have a probability of occurrence on the order of magnitude of 10^{-7} per year or greater with potential consequences serious enough to affect the safety of the plant to the extent that the guidelines specified in 10 CFR Part 100 could be exceeded. The following accident categories are considered in selecting DBEs: explosions; flammable vapor clouds (delayed ignition); toxic chemicals; aircraft crashes; fires; collisions with intake structures; and liquid spills.

2.2.3.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of NRC regulations for the evaluation of potential accidents are given in NUREG–0800, Section 2.2.3 "Evaluation of Potential Accidents."

The staff considered the following regulatory requirements in evaluating the potentiality and consequences of accident sequences:

- 10 CFR 52.17(a)(1)(vii), as it relates to the requirement that the application contain information on the location and description of any nearby industrial, military, or transportation facilities and routes and the requirements of 10 CFR 52.17(a)(1)(ix) as it applies to 10 CFR Part 100;

- 10 CFR 100.20(b), as it relates to the nature and proximity of man-related hazards (e.g., airports, dams, transportation routes, and military and chemical facilities) that must be evaluated to establish site parameters for use in determining whether a plant design can accommodate commonly occurring hazards and whether the risk of other hazards is very low; and

- 10 CFR 100.21(e), as it relates to the requirement that the potential hazards associated with nearby transportation routes, industrial, and military facilities be evaluated and site parameters be established such that potential hazards from such routes and facilities will not pose undue risk to the type of facility proposed to be located at that site.

2.2.3.4 Technical Evaluation

The staff reviewed the information presented in SSAR Section 2.2.3, pertaining to potential accidents, as discussed below. The staff's review confirmed that the information in the application addressed is the required information relating to the evaluation of potential accidents.

The staff reviewed SSAR Sections 2.2.1 and 2.2.2 containing information related to industrial, military, and transportation facilities and routes to establish the presence and magnitude of potential external hazards that include accident categories, such as explosions, flammable vapor clouds (delayed ignition), toxic chemicals, fires, and airplane crashes addressed in SSAR Section 2.2.3.

2.2.3.4.1 Explosions and Flammable Vapor Clouds

Explosions: The applicant considered hazards involving potential explosions resulting in blast overpressure as a result of detonation of explosives, munitions, chemicals, liquid fuels, and gaseous fuels that are processed, stored, used, or transported near the CRN Site. The allowable and actual distances of potential hazardous explosive chemicals transported or stored are determined based on using 1 pound (lb) per square inch (psi) overpressure as a criterion for adversely affecting plant operation or preventing safe shutdown of the plant. In accordance with RG 1.91, peak positive incident overpressures below 1 psi are considered to cause no significant damage. The locations and quantities of chemicals that would be stored onsite at the CRN Site have not yet been determined, and therefore, the effects of potential explosion events from onsite storage should be evaluated in the COLA.

The nearby facilities' chemicals, natural gas transported by pipeline, and chemicals assumed to be transported by roadways near the CRN Site are evaluated by the applicant. Hazardous materials are stored at nearby facilities, transported on nearby roads, and by pipeline as shown in SSAR Tables 2.2-2, 2.2-3, and 2.2-4 respectively. The effects of limiting explosion events along with determined minimum safe distances are summarized in the SSAR Table 2.2-9.

The chemicals at the nearby offsite facilities identified for explosion analysis include 30,000 gal, 9,999 lb and 999 lb anhydrous ammonia, 4,249 lb ethanol, 750 lb gasoline blend A and 999 lb gasoline blend B. The applicant's results indicate that the calculated safe distances are less than the actual distance from the source to the center of CRN Site and pose no adverse impact on the safe operation of the proposed plant.

The chemicals potentially transported on I-40 that are further evaluated by the applicant for potential explosion are butane (11,500 gal) tanker truck, gasoline (8,500 gal) tanker truck, and hydrogen (15,032 ft^3 per tube). The largest minimum safe distance of 1,130 m (3,708 ft) resulted for butane transport which is less than the actual distance of 1,768 m (5,800 ft) from center of CRN Site to the closest distance to I-40.

Natural gas (methane) is transported by 6 inch (in) and 22 in. pipelines with a potential release at the source over 5 seconds of 1,960 lb and 26,400 lb due to postulated complete rupture of each pipe considered, respectively. The minimum safe distance to 1 psi overpressure is determined to be 381 m (1,250 ft) for the 6 in. pipeline which is less than the actual distance of 1,768 m (5,800 ft) from the center of the CRN Site to the closest distance to the pipeline, and 905 m (2,970 ft) for the 22 in. pipeline that is less than 4,816 m (15,800 ft) from the center of CRN Site to the closest distance to the 22 in. pipeline. Overpressure of 1 psi or greater is not expected at the CRN Site due to the natural gas transport via pipelines. Based on the review of the applicant's information as well as the staff's independent assessment, the staff considers the information provided in the SSAR is reasonable and acceptable as it satisfies the guidance in NUREG−0800.

Flammable Vapor Clouds (Delayed Ignition): Flammable gases in the liquid or gaseous state can form an unconfined vapor cloud that could drift toward the plant before ignition occurs, and then can burn or explode when the vapor concentration is within flammable range. For those chemicals with an identified flammability range, an air dispersion model based on the methods and equations in RG 1.78 and NUREG−0570, "Toxic Vapor Concentration in the Control Room Following a Postulated Accidental Release," is used to determine the distance that the vapor cloud can travel before the concentration is less than Lower Explosive Level. The analyzed

effects of flammable vapor clouds and vapor cloud explosions from internal and external sources are summarized in the SSAR Table 2.2-10.

The chemicals at the nearby offsite facilities identified for flammable vapor clouds (delayed ignition) and vapor cloud explosion analysis include 30,000 gal, 9,999 lb and 999 lb anhydrous ammonia, 4,249 lb ethanol, 750 lb gasoline blend A and 999 lb gasoline blend B. The applicant's analysis results indicate that the calculated safe distance for each of the chemicals considered is less than the actual distance from the source to the center of the CRN Site and pose no adverse impact on the safe operation of the proposed plant. Based on its review of the applicant's information as well as the staff's independent assessment, the staff considers the information provided in the SSAR is reasonable and acceptable as it satisfies the guidance in NUREG−0800.

The chemicals potentially transported on I-40 that are further evaluated by the applicant for potential flammable vapor clouds (delayed ignition) and vapor cloud explosion are butane (11,500 gal) tanker truck and gasoline (8,500 gal) tanker truck. The largest minimum safe distance of 1,178 m (3,864 ft) resulted for butane transport which is less than the actual distance of 1,768 m (5,800 ft) from center of the CRN Site to the closest distance to I-40.

The natural gas (methane) is transported by 6 in. and 22 in. pipelines with a potential total release over one hour of 683,023 lb and 9,866,045 lb respectively, due to complete rupture of each pipeline with an unbroken end connected to an infinite source. The minimum safe distance to 1 psi overpressure, to 1 psi vapor cloud explosion, to lower flammability limit (LFL), and to heat flux of 5 kW/m^2 is determined by the applicant for the 6 in. pipeline to be less than the actual distance of 1,768 m (5800 ft) from the center of the CRN Site to the closest distance to the 6 in. pipeline, and is also determined for the 22 in. pipeline to be less than actual distance of 4,816 m (15,800 ft) from the center of CRN Site to the closest distance to the 22 in. pipeline. Therefore, potential adverse impacts are not expected on the proposed plant, due to potential flammable vapor clouds (delayed ignition) and vapor cloud explosion, and heat flux. Based on its review of the applicant's information as well as the staff's independent assessment, the staff considers the information provided in the SSAR is reasonable and acceptable as it satisfies the guidance in NUREG−0800.

2.2.3.4.2 Toxic Chemicals

The hazards due to potential accidents involving the release of toxic or asphyxiating chemicals from nearby facilities and transportation sources that may have a potential for impact on the CRN Site are considered. These hazards include chemicals processed, stored, used, or transported near the CRN Site. The chemicals stored at nearby facilities (SSAR Table 2.2-2), potentially transported along I-40 (SSAR Table 2.2-3) and by pipelines (SSAR Table 2.2-4) are evaluated with respect for their potential to form a toxic or asphyxiating vapor cloud following an accidental release. However, the control room habitability is not evaluated for this ESP application as the ESP application does not specify a reactor design technology, and the control room characteristics are unknown. Each identified chemical is evaluated based upon the chemical's properties, quantities, and distance in relation to the power block area without consideration of plant design factors, such as control room ventilation. Because TVA has not selected a reactor technology, control room characteristics (e.g., the control room volume and outside air infiltration and circulation rates) are unknown. Therefore, the potential chemical concentration at the closest point on the power block area of the CRN Site (power block boundary) is estimated for the purposes of this evaluation. The chemicals that lead to

concentration above the respective chemical Immediately Dangerous to Life and Health (IDLH) concentration at the edge of CRN site power block boundary are further evaluated at the COL stage as part of COLA. The locations and quantities of chemicals that would be stored onsite at the CRN Site have not yet been determined. The effects of toxic chemical releases from onsite chemical storage will be evaluated by the applicant and provided to the staff at the COLA stage, as required by 10 CFR 52.79, to provide a detailed control room habitability assessment.

The chemicals stored at nearby facilities with regard to toxicity potential include anhydrous ammonia at TVA Bull Run Fossil Plant and TVA Kingston Fossil Plant; anhydrous ammonia, argon, carbon dioxide, chloroform, chromic chloride, ethanol, gasoline, hydrogen fluoride, nitrogen, and sulfur hexafluoride at ORNL (Battelle); nitric acid at ORNL (URS); and chlorine at Hallsdale Power Utility District Melton Hill WTP and Oak Ridge WTP. The results of the analyses using the stored amounts of each chemical presented in SSAR Table 2.2-11 indicate that the distance to reach IDLH concentration of each of the chemicals analyzed is less than that of the distance from that chemical source location to the CRN Site power block area. This confirms that the potential control room concentration of that chemical does not reach the limiting IDLH concentration.

The chemicals that are transported on I-40, which are identified having a toxicity potential include anhydrous ammonia (11,500 gal), butane (11,500 gal), chlorine (22 T or 44,000 lb), gasoline (8,500 gal), nitric acid (6,000 gal), and sulfur hexafluoride (50,000 lb). The results indicated that, except for anhydrous ammonia and chlorine, the distances to the identified toxicity limit for any plausible vapor cloud that could form following an accidental release at the closest distance from the transportation route (I-40) are less than the minimum distances from the CRN Site power block area to I-40 of 1,768m (5,800 ft). The staff's confirmatory analysis not only confirmed the exceedance of toxicity limit for anhydrous ammonia and chlorine but also nitric acid at the CRN Site power block area. A release of anhydrous ammonia resulted in a distance of 4,184 m (13,728 ft) to the toxicity limit and a release of chlorine resulted in a distance of 7,242 m (23,760 ft). The staff's analysis for a release of nitric acid resulted in a distance of 2,575 m (8,448 ft). As detailed design information of control room and operational characteristics are not available at the ESP stage, the main control room habitability will be evaluated at the COLA stage. The staff identifies this as Permit Condition 2.2-2 as described in Section 2.2.3.5.6 of this report.

The distances to the asphyxiating limit analyzed by the applicant for the East Tennessee Pipeline 1 and East Tennessee Natural Gas Pipeline 2 under worst case meteorological conditions are 282 ft and 846 ft, respectively. These distances are less than the separation distance from either pipeline to the CRN Site power block area, thereby having no adverse effect on control habitability.

2.2.3.4.3 Fires

The locations and quantities of chemicals that would be stored onsite at the CRN Site have not yet been evaluated. Therefore, the effects of fires from onsite chemical storage and brush or forest fires will be evaluated by the applicant and provided to the staff in the COLA, as required by 10 CFR 52.79.

Those chemicals stored at nearby facilities and transported by roadway I-40 are evaluated by the applicant for potential effects of accidental releases to a delayed ignition due to formation of a vapor cloud. The results indicate that the vapor cloud distance to reach to LFL is less than the

actual distance from the source to CRN Site power block area, thereby confirming no adverse effects from fires or heat fluxes to the proposed units at CRN Site.

The applicant's evaluation results of heat flux due to jet fire analysis for the pipelines conclude that distance to 5 kW/m^2 for 6-in pipeline is 95.1 m (312 ft) which is less than separation distance of 1,768 m (5,800 ft) between the CRN Site power block and the pipeline break; and for 22-in pipeline is 367 m (1,203 ft) which is less than separation distance of 4,816 m (15,800 ft). Therefore, the applicant considers that there would be no adverse effects expected on the proposed units at the CRN Site power block area. The staff finds the applicant's conclusion and approach acceptable, as a heat flux of 5 kw/m^2, independently verified by staff, would not extend to the CRN Site power block area.

2.2.3.4.4 Collisions with Intake Structure

Because the raw water makeup system intake structure for the CRN Site is not safety-related nor anticipated to be required for the mitigation of design-basis accidents, an evaluation that considers the probability and potential effects of impact on the plant cooling water intake structure and enclosed pumps is not required.

2.2.3.4.5 Liquid Spills

The accidental release of oil or liquids that are corrosive, cryogenic, or coagulant were considered to determine whether they will be drawn into the plant's raw water system's intake structure and circulating water system or otherwise affect the plant's safe operation or shutdown. In the event that these liquids would spill into the Clinch River, they would not only be diluted by the large quantity of river water, but the raw water makeup system intake is not necessary for the safe operation or shutdown of the plant, as the intake structure is a non-safety-related structure. Therefore, the applicant considers that any spill in the Clinch River will not affect the safe operation or shutdown of units at the CRN Site. The staff finds this approach reasonable and acceptable, as the intake structure is not safety-related.

2.2.3.4.6 Permit Conditions

Permit Condition 2.2-1

Based on the regional government projections of industrial growth, the Metropolitan Knoxville Airport Authority has selected the Heritage Center Industrial Park, approximately 6 mi from the CRN Site, as the potential site for a general aviation airport. Current site plans indicate that construction may be completed by the year 2022. Therefore, the applicant shall evaluate this airport for potential aircraft crash impact probability in the COLA and address it in FSAR Section 3.5.1.6.

Permit Condition 2.2-2

Since location and design of the control room has not been established for the ESPA, an applicant for a COL referencing this ESP shall evaluate and demonstrate compliance with NRC regulations for the potential toxic chemicals for the control room habitability from the onsite storage of chemicals (to be identified in COL or CP) and also for the transported chemicals anhydrous ammonia, chlorine and nitric acid from highway I-40, where the concentration of these chemicals exceeded the respective IDLH limit at the CRN Site power block area.

2.2.3.4.7 Conclusion

Based on the aforementioned discussions, and subject to Permit Conditions 2.2-1 and 2.2-2, the staff finds that the CRN Site ESP applicant has identified and evaluated potential accidents related to the presence of hazardous materials or activities in the CRN Site vicinity that could affect a nuclear power plant or plants that might be constructed on the proposed site. The staff notes that from these potential accidents, the applicant has selected those that should be considered DBEs at the COLA stage. The staff reviewed the information provided and, for the reasons discussed above, subject to Permit Conditions 2.2-1 and 2.2-2, concludes that the CRN Site ESP applicant has established site characteristics and design parameters acceptable to meet the requirements of 10 CFR 52.17(a)(1)(vii), 10 CFR 52.17(a)(1)(ix), 10 CFR 100.20(b), and 10 CFR 100.21(e) for determining the acceptability of the CRN Site.

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

Mr. Joseph Shea
Vice President, Nuclear Regulatory Affairs and Support Services
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402

SUBJECT: CLINCH RIVER NUCLEAR EARLY SITE PERMIT APPLICATION SAFETY EVALUATIONS WITH NO OPEN ITEMS FOR SECTION 2.1, "GEOGRAPHY AND DEMOGRAPHY", SECTION 2.2, "NEARBY INDUSTRIAL, TRANSPORTATION AND MILITARY FACILITIES", SECTION 3.5.1.6, "AIRCRAFT HAZARDS", AND SECTION 15.0.3, "RADIOLOGICAL CONSEQUENCES OF DESIGN BASIS ACCIDENTS"

Dear Mr. Shea:

The U.S. Nuclear Regulatory Commission (NRC) staff is preparing safety evaluations (SEs) with no open items for the Clinch River Nuclear (CRN) Site early site permit (ESP) application. These SEs will document the staff's review of your ESP application dated May 12, 2016, for the CRN Site ESP application.

The staff's SEs for Section 2.1, "Geography and Demography", Section 2.2, "Nearby Industrial, Transportation and Military Facilities", Section 3.5.1.6, "Aircraft Hazards", and Section 15.0.3, "Radiological Consequences of Design Basis Accidents" are being provided to the Advisory Committee on Reactor Safeguards Subcommittee to support a future meeting of the ACRS Subcommittee.

The enclosed SEs is being provided only to TVA for review of proprietary information pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 2.390 "Public Inspections, Exemptions, Requests for Withholding." The staff concludes that the enclosed SEs do not contain any information for which exemption from public disclosure has been sought or approved or any factual errors. However, the NRC will withhold the enclosed SEs from public disclosure for 10 business days from the date of this letter to allow you the opportunity to verify the staff's conclusion that the SE contains no such exempt information or any factual errors. If within that 10 day period, you do not request that all or portions of the SEs be withheld from public disclosure, the enclosures will be made available for public inspection through the NRC Public Document Room and the Publicly Available Records component of NRC's Agencywide Documents Access and Management System and placed on the NRC's public web page for this application.

If you have any questions or comments concerning this matter, I can be reached at 301-415-8556 or via e-mail address at Allen.Fetter@nrc.gov

Sincerely,

Allen Fetter, Lead Project Manager
Licensing Branch 3
Division of New Reactor Licensing
Office of New Reactors

Docket No.: 52-047

Enclosures:
As stated

cc: w/o encl. See next page

SUBJECT: CLINCH RIVER NUCLEAR EARLY SITE PERMIT APPLICATION SAFETY EVALUATIONS WITH NO OPEN ITEMS FOR SECTION 2.1, "GEOGRAPHY AND DEMOGRAPHY", SECTION 2.2, "NEARBY INDUSTRIAL, TRANSPORTATION AND MILITARY FACILITIES", SECTION 3.5.1.6, "AIRCRAFT HAZARDS", AND SECTION 15.0.3, "RADIOLOGICAL CONSEQUENCES OF DESIGN BASIS ACCIDENTS": April 12, 2018

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Clinch River ESP Mailing List (Revised 11/17/2017)

15 ACCIDENT ANALYSIS

15.1 Accident Analysis

15.1.1 Introduction

This section of the safety evaluation report describes the U.S. Nuclear Regulatory Commission (NRC) staff's evaluation of the information provided in Chapter 15, "Accident Analysis," of the Site Safety Analysis Report (SSAR), contained in Part 2 of the Clinch River Nuclear (CRN) Site early site permit (ESP) application. The information in Chapter 15 describes the radiological consequences of design basis accidents (DBAs) using information based on four conceptual small modular reactor (SMR) designs under consideration for the site as included in the plant parameter envelope (PPE) to demonstrate that two or more new SMR unit(s) with a maximum rated thermal power for a single unit of 800 thermal megawatts (MWt) could be sited at the proposed ESP Site without posing an undue risk to the health and safety of the public, in compliance with the requirements in Title 10 of the *Code of Federal Regulations* (10 CFR), 52.17, "Contents of Applications," and 10 CFR Part 100, "Reactor Site Criteria."

15.1.2 Summary of Application

In SSAR Section 1.11, "Overview of Reactor Types," the four conceptual SMRs considered in the development of a surrogate plant for the PPE are described. Each of the designs is a pressurized water reactor, with three of the designs being of an integral pressurized water reactor type. All four designs are described as passively safe designs with minimal or no reliance on offsite power, offsite water, or operator action for safety. The four designs and associated vendors are:

- BWXT mPower™ (Generation mPower, LLC);
- NuScale (NuScale Power, LLC);
- SMR-160 (Holtec SMR, LLC); and
- Westinghouse SMR (Westinghouse Electric Company, LLC).

SSAR Chapter 15 describes the applicant's assessment of the offsite radiological consequences of DBAs for a surrogate plant, as bounded by the PPE. The U.S. Nuclear Energy Institute 10-01, "Industry Guidance for Developing a Plant Parameter Envelope in Support of an Early Site Permit," notes that accident analyses model the time-dependent transport of radionuclides out of the reactor core through several pathways, each with different time-dependent removal mechanisms for radionuclides. As the applicant notes in SSAR Section 15.1, "Accident Selection," different reactor designs have different release pathways, and each pathway has different release rates and different radionuclide removal mechanisms. Given these differences, the applicant chose to use the DBA radiological consequence analyses from the design that resulted in the highest post-accident offsite doses in its assessment of the radiological consequences of DBAs at the CRN Site.

The applicant's DBA radiological consequence analysis used, as input, the site characteristic short-term accident atmospheric dispersion factors (χ/Qs) at the Exclusion Area Boundary (EAB) and Low-Population Zone (LPZ) provided in SSAR Section 2.3.4. In SSAR Table 2.0-3, the applicant provided the bounding DBA source term (release rates of radioactive materials to the environment). The applicant also presented the DBA dose assessment results at the proposed EAB and the LPZ in SSAR Table 15-1, which demonstrates that the potential doses

would be within the radiological consequence evaluation factors set forth in 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1).

Because the reactor design technology is not selected and the orientations of plant structures on the site are not known, the detailed accident analyses and resulting post-accident doses for control habitability and the Technical Support Center will be performed at the combined license application (COLA) stage, consistent with SRP Guidance, Chapter 2.0, Table 1.

15.1.3 Regulatory Basis

The applicable NRC regulatory requirements for the radiological dose consequences analyses of DBAs include the following:

- 10 CFR 52.17, "Contents of applications; technical information," as it relates to the assessment that must contain analysis and evaluation of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site under the radiological consequence evaluation factors identified in paragraphs (a)(1)(ix)(A) and (a)(1)(ix)(B) of this section;

- 10 CFR Part 100, "Reactor Site Criteria," as it relates to considering evaluation factors for stationary power reactor Site Applications on or after January 10, 1997, to demonstrate that the radiological dose consequences of postulated accidents shall meet the criteria set forth in 10 CFR 50.34(a)(1) for type of facility proposed to be located at the CRN Site; and

- 10 CFR 50.34, "Contents of applications; technical information," as it relates to a description and safety assessment of the site and safety assessment of facility.

The acceptance criteria adequate to meet the above requirements are located in the following guidance and reference documents:

- Review Standard (RS)-002, "Guidance for Processing Applications for Early Site Permits," as it relates to providing guidance on the staff's process for reviewing an ESP application and developing the Safety Evaluation Report (SER) with specific technical and format guidance; and

- NUREG–0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: Light-Water Reactor (LWR) Edition," as it relates to providing guidance to staff to perform safety reviews of applications to construct or operate nuclear power plants and the review of applications to approve standard designs and sites for nuclear power plants, to assure the quality and uniformity of staff safety review.

As required in 10 CFR 52.17(a)(1), ESP applications must contain an analysis and evaluation of the major systems, structures, and components (SSCs) of the facility that bear significantly on the acceptability of the site under the radiological consequence evaluation factors identified in the requirements of 10 CFR 52.17(a)(1)(ix). In addition, the ESP site characteristics must comply with the requirements of 10 CFR 100.21, "Non-Seismic Siting Criteria," which states that radiological dose consequences of postulated accidents shall meet the criteria set forth in 10 CFR 50.34(a)(1). The radiological dose reference values in 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1) for a postulated fission product release based on a major accident are as follows:

- An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release would not receive a radiation dose in excess of 25 roentgen equivalent man (rem) total effective dose equivalent (TEDE); and

- An individual located at any point on the outer boundary of the LPZ who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a radiation dose in excess of 25 rem TEDE.

15.1.4 Technical Evaluation

Using the guidance listed above, the staff reviewed SSAR Chapter 15 for compliance with the applicable regulations. Although the applicant is using the PPE approach, for the DBA radiological consequence analysis with the loss of coolant accident (LOCA) source term is selected based upon vendor information, and presents the design with the highest resulting dose at the EAB and LPZ from four SMR designs under consideration. The applicant evaluated the suitability of the site using this bounding LOCA DBA source terms and radiological consequences, as well as site characteristic atmospheric dispersion factor (χ/Q) values.

15.1.4.1 Selection of Design Basis Accidents and Source Term

The applicant assessed the LOCA DBA in the design control document for an SMR with vendor provided PPE source terms. This DBA is addressed in SSAR Sections 15.1 and 15.2. The staff independently analyzed the information provided by the applicant and finds that the applicant selected DBA is consistent with the DBAs listed in NUREG-0800, Chapter 15 for large light-water reactors.

Each of the four small modular PWR designs under consideration for the CRN Site is expected to include advanced features that would further minimize accident consequences, as addressed in SSAR Section 1.11. As such, TVA anticipates that the consequences of a LOCA will be less than those for large PWR designs and that no events of greater consequence will be identified.

Thus, the analysis of postulated DBAs other than a LOCA is not necessary for this ESP, because the maximum potential offsite doses have been evaluated, demonstrating the ability of the site to comply with the dose limits in 10 CFR 52.17. In accordance with 10 CFR 52.79(b)(1), the COLA will verify that the accident doses provided in the ESPA are bounding or will provide an evaluation of accident radiological consequences. The staff finds this applicant's approach reasonable and acceptable.

The staff's experience with other PWR designs, as documented in other ESPAs to date (examples provided by applicant in SSAR Section 15.1), has shown that offsite doses due to a postulated LOCA are expected to more closely approach 10 CFR 52.17 dose criteria than other DBAs that may have greater probability of occurrence but a lesser magnitude of activity release.

The LOCA source term (radionuclide activity released to the environment) selected for inclusion in the PPE is based upon vendor input and represents the design with the highest resulting dose at the EAB and the LPZ boundary from the four SMR designs under consideration. Key parameters associated with the accident source term in the PPE have been evaluated by the applicant to assess their reasonableness for and representativeness of SMR designs.

The PPE LOCA source term is based on a design that uses standard light-water reactor fuel, which is representative of the SMR designs under consideration, and assumes a core power

level for a single module at 800 MWt. As a comparison, for the other three SMR designs considered in the PPE, the values for the rated core thermal power per single unit are 160, 525 and 530 MWt. TVA anticipates that comparable methodologies and techniques that are used for the development of the source terms for large light water reactors will be used also in the development of the SMR accident source terms to be presented by SMR design documents.

The source terms developed for the surrogate SMR plant (the design parameters represented by the PPE in lieu of a specific reactor design) are representative of the potential SMR designs considering core power and average burnup. The maximum average burnup for the surrogate SMR is 51 gigawatt-day/metric-ton of Uranium (GWD/MTU), while for remaining SMRs is 41 GMD/MTU. Although it is recognized that core power and burnup would not necessarily result in one-to-one ratios to activity releases, it is anticipated the larger core power and burnup would result in larger activity releases than those associated with the remaining designs. The bounding design basis accident LOCA source term is provided in SSAR Table 2.0-3.

To assess reasonableness, the applicant also provided a comparison of the PPE LOCA source term to that of the AP1000 design, scaling the source term by a factor 0.235 (800 MWt/3400 MWt) to account for the smaller core thermal power of the SMR designs being considered for the CRN Site. The worst 2-hour EAB dose is approximately 25 percent greater for the scaled AP1000 design than that for the surrogate plant (as provided in the PPE). The applicant considers that this difference is reasonable given that SMR designs contain additional safety features that are expected to result in enhanced safety features and reduced accident releases as compared to the AP1000 design. The applicant acknowledged approximately 25 percent greater total activity release for the scaled down-AP1000 source term than that for the surrogate plant (as provided in the PPE) for the worst 2-hour period. However, an independent staff evaluation resulted in higher activity release using same 0.235 scale down ratio for all radionuclides for all time periods except for noble gases. This higher release may be attributed to the staff-determined source term that is reduced from the known large LWR release source term by a megawatt ratio that may have not been exactly representative due to unaccounted for fuel and core design differences between the large (AP1000 core) and small (SMR core) fission product inventories. In addition, the bounding SMR source terms used as the basis for the PPE LOCA source term may reflect SMR design enhanced removal mechanisms and advanced engineering features for larger retention times that are not accounted for in the assumption that the accident release source terms from a large LWR can be reduced in direct relationship to the reduction of the core power. Therefore, the staff's assessment potentially overestimates the potential source term for any specific SMR rated at a core power of 800 MWt. However, this evaluation only ensures that the applicant's PPE LOCA source term is representative and not unreasonable. Moreover, the LOCA source term for the selected SMR for the COLA, the applicant is required (10 CFR 52.79 (a)(1)) to demonstrate that the selected SMR LOCA source term is bounded by the PPE LOCA source term. If not the applicant shall opt for variance and demonstrate NRC regulatory compliance with radiological dose criteria for site suitability. As such, the staff finds the applicant's bounding source term based on the ratio is not unreasonable, and the bounding vendor provided SMR source term is also not unreasonable.

Therefore, based on its evaluation of the applicant's information and its own independent analysis to scope the PPE source term, the staff finds the CRN Site SSAR DBA source terms to be not unreasonable as part of the PPE for showing compliance with requirements of 10 CFR 52.17(a)(1)(ix). However, it should be noted that if the bounding DBA source term provided by the applicant does not bound the actual source term for a design selected for the CRN Site, then the radiological consequences of DBAs for the combined license (COL) may exceed the dose results determined in the SSAR. They may also potentially exceed the

regulatory dose reference values in 10 CFR 50.34(a)(1) and 10 CFR 52.79(a)(1). Therefore, the applicant's PPE source term information in SSAR Table 2.0-3 shall be compared with the COL DBA source term for the design that may be selected for the CRN Site at the time of COL review in accordance with 10 CFR 52.79(b)(1). Also, the applicant shall ensure that the radionuclide releases of the PPE bounds the SMR design selected for the CRN Site in meeting the regulatory requirements of 10 CFR 52.79(c)(1) and (d)(1).

15.1.4.2 Site Characteristic Short-Term Atmospheric Dispersion Factors

Site characteristic short-term (accident) atmospheric dispersion factors (χ/Qs) are used in the radiological consequences analyses to characterize the effect of the site-specific meteorological conditions, topography, and distance to either EAB or LPZ on dose at the offsite receptors for purposes of siting. The applicant calculated accident χ/Qs using RG 1.145 methodology and site-specific meteorological data. The staff's evaluation of the site characteristic short term χ/Q values is described in Section 2.3.4 of this report. The site characteristic accident χ/Q values calculated by the applicant are given in SSAR Table 2.0-1.

15.1.4.3 Radiological Consequences

Doses for LOCA are evaluated at the EAB and LPZ boundary using site characteristic short-term (accident) χ/Q values for the CRN Site. Site-specific dose results were calculated by the applicant by adjusting the vendor-provided dose results for each time period by the ratio of the site-characteristic χ/Q values to the vendor-provided χ/Q values, then adding the dose results for each time period together to get a resulting total dose. The CRN Site site-specific doses are presented in SSAR Table 15-1.

For the LOCA radiological consequence analysis referenced by the CRN Site ESP applicant, the vendor's analyses used the design-specific source term assumptions and inputs and reference site parameter values for the accident χ/Qs in lieu of site-specific values. The χ/Q values are the only input to the DBA radiological consequences analysis that are affected by the site characteristics. The estimated DBA dose calculated for a particular site is affected by the site characteristics through the calculated χ/Q input to the analysis; therefore, the resulting dose would be different than that calculated generically by the vendor with assumed reference χ/Qs. Smaller χ/Q values are associated with greater dilution capability, resulting in lower radiological doses. The applicant also stated that all other inputs and assumptions in the radiological consequences analysis remain the same as in the vendor-provided analysis.

To determine the potential doses resulting from DBA at the proposed site, the applicant used the site characteristic χ/Q values in conjunction with the DBA doses calculated using site parameter χ/Q values (based on PPE) that were provided by the vendor for the plant design used in the bounding analysis. The estimated site characteristic χ/Q values for the proposed site are higher for EAB and lower for LPZ than the corresponding site parameter χ/Q values, as summarized in Table 15-1 of this report.

Table 15-1 Site Parameter Short Term χ/Q Values for Vendor Deign Site Parameter and Comparison to Site Characteristic χ/Qs

Location	Release Time (hr)	Site Characteristic $\chi/Q(sec/m^3)$	Vendor Design Site Parameter $\chi/Q(sec/m^3)$	χ/Q Ratio Characteristic/Parameter	Dose(rem TEDE) vendor	Dose(rem TEDE) Site
EAB	0-2	4.96×10^{-3}	1.0×10^{-3}	4.96	4.35	21.6
LPZ	0-8	3.10×10^{-4}	5.0×10^{-4}	0.620	4.44	2.75
	8-24	2.26×10^{-4}	3.0×10^{-4}	0.753	0.20	0.15
	24-96	1.14×10^{-4}	1.5×10^{-4}	0.76	0.05	0.038
	96-720	4.30×10^{-5}	8.0×10^{-5}	0.538	0.06	0.032

The radiological consequence results of a LOCA at the CRN Site, using the PPE and site characteristic accident χ/Q values are 21.6 rem TEDE at the EAB and 2.97 rem TEDE total at the LPZ. The calculated radiological consequences at the proposed site are within the regulatory dose criteria of 25 rem TEDE for the maximum 2-hour period at the EAB and 25 rem TEDE at the outer boundary of the LPZ for the duration of the accident release,

Based on its evaluation of the applicant's DBA radiological consequences analysis methodology and the inputs to that analysis, the staff finds that the applicant correctly concluded that the radiological consequences for the considered PPE design technology comply with the radiological dose reference values set forth in 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1).

15.1.5 Conclusion

As set forth above, the applicant presented the radiological consequence analysis using PPE values of source terms for the standard design and site characteristic χ/Q values; the applicant concluded that the proposed site meets the radiological dose reference values identified in 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1) for the vendor provided PPE source terms and site parameter χ/Q values. Based on the technical evaluation presented in Section 15.1.4 of this report, the staff finds that the applicant's PPE values for source terms are not unreasonable. Furthermore, the staff finds the applicant's dose consequence evaluation methodology acceptable. In accordance with 10 CFR 52.79(b)(1), a COL applicant referencing this ESP must either include or incorporate by reference the ESP SSAR, and the COLA must contain, in addition to the information and analyses otherwise required, information sufficient to demonstrate that the design of the facility falls within the site characteristics and design parameters specified with respect to radionuclide releases and site characteristics provided in the ESP.

The staff further concludes that the applicant's determined site characteristic distances to the EAB and the LPZ outer (i.e., outermost) boundary of the proposed ESP site in SSAR Table 2.0-1, in conjunction with the PPE design parameter source terms, are adequate to provide reasonable assurance that the radiological consequences of postulated DBA for a SMR

design similar to those used as a basis for the PPE will be within the radiological dose reference values set forth in 10 CFR 50.34(a)(1) and 10 CFR 52.17(a)(1).

3.0 DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT, AND SYSTEMS

3.5.1.6 Aircraft Hazards

3.5.1.6.1 Introduction

For the Clinch River Nuclear (CRN) Site early site permit (ESP) application, the applicant provided information evaluating the potential hazards associated with aircraft. The U.S. Nuclear Regulatory Commission (NRC) staff reviewed these evaluations to ensure that the risks associated with potential aircraft hazards would be sufficiently low.

3.5.1.6.2 Summary of Application

In Site Safety Analysis Report (SSAR), Section 2.2.2.7, "Descriptions of Airports, Aircraft, and Airway Hazards," the applicant presented information concerning the airports, airways and military training routes in the vicinity of the site to evaluate potential hazards with respect to nuclear units that might be constructed on the proposed CRN Site.

The applicant stated that five small privately-owned airports, Big T, Wolf Creek, Cox Farm, Will A Hildreth Farm, and Riley Creek, are located between 8 to 16.1 km (5 and 10 statute mi) from the CRN Site. Two small privately-owned airports, Oliver Springs and Fergusons Flying Circus are within 16.1 to 24.1 km (10 to 15 mi) of the CRN Site. These airports with estimated number of flight operations are listed in the SSAR Table 2.2.7. Airports located beyond 24.1 km (15 miles) are also considered and are listed in the SSAR Table 2.2-7.

There is one Federal airway route V16 and one high altitude route J46, whose nearest edge lies within 2 statute mi of the CRN Site. The closest military route is located approximately 31 km (19.2 mi) to the west-northwest (WNW) of the site. The closest military operations area (MOA) is the Snowbird MOA located approximately 58 km (36 mi) from the CRN Site.

3.5.1.6.3 Regulatory Basis

The acceptance criteria for aircraft hazards are based on meeting the relevant requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 52.17, "Contents of Applications, Technical Information," and 10 CFR Part 100, "Reactor Site Criteria." The staff considered the following regulatory requirements and guidance in reviewing the site location and area description:

- 10 CFR 52.17, as it relates to the requirement that the applicant provide the location and description of any nearby military or transportation facilities and routes.

- 10 CFR Part 100, as it relates to the following:

    - 10 CFR 100.20(b), which states that the nature and proximity of man-related hazards (e.g., airports, transportation routes, and military facilities) must be evaluated to establish site characteristics for use to determine whether a plant design can accommodate commonly occurring hazards, and whether the risk of other hazards is very low.

    - 10 CFR 100.21(e), which states that the potential hazards associated with nearby

transportation routes, industrial, and military facilities must be evaluated and site characteristics established such that potential hazards from such routes and facilities will pose no undue risk to the type of facility proposed to be located at the site. Review Standard (RS)-002, Section 3.5.1.6, "Guidance for Processing Applications for Early Site Permits," Regulatory Guide (RG) 1.206, "Regulatory Guide for Combined License Applications for Nuclear Power Plants," and NUREG–0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," specify that the above regulatory requirements are met if the probability of aircraft accidents having the potential for radiological consequences greater than the 10 CFR Part 100 exposure guidelines is less than about 10^{-7} per year. The probability is considered to be less than about 10^{-7} per year if the distance to an airport, or a to a military route, or to a federal airway from the site meets the appropriate following criteria:

- The site-to-airport distance (D) is between 5 and 10 statute mi and the projected annual number of operations is less than 500 D^2, or the D is greater than 10 statute mi, and the projected annual number of operations is less than 1000 D^2.

- The site is at least 5 statute mi from the edge of military training routes, including low-level training routes, except for those associated with usage greater than 1,000 flights per year, or where activities (such as practice bombing) may create an unusual stress situation.

- The site is at least 2 statute mi beyond the nearest edge of a Federal airway, holding pattern, or approach pattern.

If the above proximity criteria are not met, or if sufficiently hazardous military activities are identified, then a detailed review of aircraft hazards should be performed. The guidance on the performance of such reviews appears in RS-002, Section 3.5.1.6, RG.1.206, and NUREG–0800.

3.5.1.6.4 Technical Evaluation

In SSAR Section 3.5.1.6, the applicant addressed the aircraft hazards evaluations. There are five airports within 8 to 16.1 km (5 to 10 mi) of the CRN Site. The airports have small number of flight operations annually (less than allowable number of flight operations based on 500 D^2, where D is the distance in miles from the site to airport) that would not contribute to exceeding the acceptable aircraft hazards probability of 10^{-7} per year, and therefore, are not considered a safety hazard based on guidance. Based on the review of the information provided by the applicant and the information obtained from sources available in the public domain, the staff considers the applicant's conclusion acceptable.

There are two airports within 16.1 to 24.1 km (10 to 15 mi) having projected number of flights from each of the airports much less than the respective plant-to-distance criterion of 1000 D^2, where D is the distance in miles from the site to the airport. Therefore, the aircraft crash probability is considered to be acceptable as less than about 10^{-7} per year. Based on the review of the flight data information, the staff considers the applicant's approach and conclusion acceptable as it meets the acceptance criteria.

The applicant addressed a military training route and MOA, which were not evaluated further as they are much farther away (58 km (36 mi)) from the CRN Site and meet the above proximity screening criterion.

The applicant addressed and evaluated the airways for the aircraft hazards probability. The applicant identified two airways (V16 and J46) that are within 3.2 km (2 mi) of the site. The applicant performed aircraft hazard probability analysis using the U.S. Department of Energy's (DOE's) four-factor formula that uses crash rates for non-airport operations referenced in DOE-STD-3014-96, "Accident Analysis for Aircraft Crash into Hazardous Facilities." The staff considers the applicant's approach and methodology reasonable and acceptable in determining the aircraft hazard calculations as it conforms to the staff review guidance. The applicant used calculated effective area based on assuming maximum R (length of diagonal of the facility) value of 179.5 m (589 ft) and maximum length of 162.45 m (533 ft), width of 75.9 m (249 ft) and building height of 48.8 m (160 ft). The staff considers this reasonable and acceptable as the methodology satisfies the requirements and guidance. Based on using these data and assumption, the applicant determined the aircraft crash probability of 7.53×10^{-7} per year.

The staff reviewed the applicant's assumptions and calculations and finds them reasonable, consistent and acceptable, as they comply with the requirements of 10 CFR 52.17, 10 CFR 100.20(b), and conform to the guidance in RS-002, RG 1.206, and NUREG–0800. The staff performed independent confirmatory aircraft crash probability calculations, using the highest of the most recent 5-year (2011-2015) Federal Aviation Administration (FAA) supplied flight operations data within 8 km and 16.1 km (5 mi and 10 mi) of the site. The potential aircraft crash probability of 1.5×10^{-8} per year is estimated by the staff, conservatively assuming that all the flights within 10 mi of CRN Site from FAA data follow these two airways. Therefore, the staff considers that the probability of aircraft accidents, resulting in radiological consequences greater than 10 CFR Part 100 exposure guidelines, is approximately less than an order of magnitude of 10^{-7} per year for the CRN Site, and agrees with applicant's conclusion.

3.5.1.6.5 Conclusion

The staff reviewed the applicant's aircraft hazard analysis using the guidelines in RS-002, Section 3.5.1.6, RG 1.206, and NUREG–0800. As discussed above, the staff independently verified the applicant's assessment of aircraft hazards at the CRN Site and concludes that the estimated probability of an accident having the potential for radiological consequences in excess of the exposure criteria contained in 10 CFR Part 100 approximately less than an order of magnitude of 10^{-7} per year.

Based on these considerations, the staff concludes that aircraft hazards do not present an undue risk to the safe operation of nuclear units at the CRN Site, and finds the CRN Site acceptable. The staff also concludes that the CRN Site meets the relevant requirements related to aircraft hazards of 10 CFR Part 52 and 10 CFR Part 100 for compliance with respect to determining the acceptability of the site.