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2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

The purpose of this section is to establish whether the effects of potential accidents in the site vicinity from present and projected industrial, transportation, and military installations and operations should be used as design-basis events for plant design parameters related to the selected accidents. Facilities and activities within the 5-mile (mi) vicinity of the Clinch River Nuclear (CRN) Site were considered to meet the guidance in NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition*. Facilities and activities at greater distances were included as appropriate to their significance.

2.2.1 Locations and Routes

The approximate 935-acre CRN Site is located in the City of Oak Ridge, Tennessee (TN). The southern portion of the site, containing the power block area, is located on a peninsula bounded by the Clinch River arm of the Watts Bar Reservoir on the western, southern, and eastern sides. The northern portion of the CRN Site is bounded on the north by the Grassy Creek Habitat Protection Area and to the east by the U.S. Department of Energy's (DOE's) Oak Ridge Reservation and Management Area (ORR). Potential hazard facilities and routes within the 5-mile vicinity of the CRN Site, and airports within 10 mi of the site were identified along with significant facilities at a greater distance in accordance with the following:

- Regulatory Guide (RG) 1.206, *Combined License Applications for Nuclear Power Plants (LWR Edition)*,
- RG 1.91, *Evaluations 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
- Relevant sections of 10 CFR 50, 52, and 100.

An investigation of the identified potential external hazard facilities and operations (Figure 2.2-1) within the 5-mi vicinity of the CRN Site identified one significant industrial facility for assessment.

- DOE Oak Ridge National Laboratory (ORNL)-UT-Battelle LLC (Battelle) and URS (Reference 2.2-11)

An evaluation of the identified major transportation routes within the 5-mi vicinity of the CRN Site (Figure 2.2-2) identified one navigable waterway, one major highway, four major roads, one minor rail line, and two natural gas pipelines for assessment (References 2.2-1, 2.2-2 and 2.2-3):

- Clinch River arm of Watts Bar Reservoir (References 2.2-20 through 2.2-25 and Figure 2.2-2)
- Interstate 40 (I-40) (Reference 2.2-27 and Figure 2.2-2)
- Tennessee State Highway 1 (TN 1)/US11-70, and Tennessee State Highways 58 (TN 58), 95 (TN 95), and 327 (TN 327) (Reference 2.2-27)
- Heritage Railroad Corporation Railway (References 2.2-1 and 2.2-3)
- Two active natural gas transmission pipelines: East Tennessee Natural Gas Pipeline 1 (East) and Pipeline 2 (North) [Reference 2.2-5]

An evaluation of nearby industrial facilities and transportation routes beyond the 5-mi vicinity of the CRN Site was undertaken. In going beyond 10 mi of the CRN Site, particular attention was paid to identifying whether any facilities contain highly toxic, highly volatile chemicals with Risk Management Program (RMP) calculated endpoint distances of at least 25 mi (Reference 2.2-6). Four industrial facilities located beyond the 5-mi vicinity of the site were identified for assessment:

- Tennessee Valley Authority (TVA) Kingston Fossil Plant
- Oak Ridge Water Treatment Plant (WTP)
- TVA Bull Run Fossil Plant
- Hallsdale Powell Utility District Melton Hill WTP

The evaluation of transport routes beyond the 5-mi vicinity of the CRN Site identified both rail transport and roads. Rail transport within 5 to 10 mi of the site includes two major and one minor rail line. At closest approach, the two major rail lines operated by Norfolk Southern are 7 mi or more from the CRN Site. In addition to being farther than 5 mi, these rail lines are within complex intervening terrain and therefore accident scenarios on those lines are not evaluated further. The minor rail line, operated by EnergySolutions Heritage Railroad Corporation, is an extension of the EnergySolutions Heritage Railroad Corporation Railway identified within the 5-mi vicinity of the CRN Site. Materials transported on this rail line consist mostly of solid, low-level radioactive wastes, which do not pose a significant threat to the CRN Site due to their physical properties. Solids have a vapor pressure sufficiently low such that the formation of a vapor cloud is not likely. That is, the air dispersion hazard of the material is not a likely exposure route. Nor is the solid material considered explosive. Therefore, this railway is not considered further in this evaluation.

Roads identified beyond the 5-mi vicinity of the CRN Site included I-75 and other major roads. I-75 and other major roads located between 5 and 10 mi of the CRN Site are not considered further given that I-40 was identified within the 5-mi vicinity of the site, where plausible chemicals may be transported, and would, therefore, bound an analysis of roads located farther away.

There are no identified roads, railways or navigable waterways at distances greater than 10 mi that are significant potential hazards.

In summary, the evaluation identified five industrial facilities, one major highway, four major roads, and two natural gas pipelines that are significant enough to be considered for further review (Figures 2.2-1 and 2.2-2). These include:

Industrial Facilities

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

Transport Routes

- Clinch River arm of Watts Bar Reservoir
- I-40
- TN 1/US11-70, 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

Figure 2.2-3 illustrates the following identified airports and airway routes within 10 mi of the CRN Site (References 2.2-7 and 2.2-8):

- Big T
- Wolf Creek
- Cox Farm

- Will A Hildreth Farm
- Riley Creek
- Federal Airways V16 and J46

The Oliver Springs and Fergusons Flying Circus airports are within 10 to 15 mi of the CRN Site (Reference 2.2-7).

2.2.2 Descriptions

Descriptions of the industrial, transportation, and military facilities located in the vicinity of the CRN Site and identified in Subsection 2.2.1 are provided in the subsequent subsections in accordance with RG 1.206.

2.2.2.1 Descriptions of Facilities

The five facilities identified for further review are:

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

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 Description of Products and Materials

A more detailed description of offsite chemicals associated with each of the above facilities is provided in the following subsections. This description includes information about the products and materials regularly manufactured, stored, used or transported in the site vicinity. In keeping with the guidance of RG 1.78 and RG 1.206, chemicals stored or situated at distances greater than the 5-mi vicinity of the proposed CRN Site are not considered unless they are determined to potentially have a significant impact on the proposed CRN Site. The U.S. Environmental Protection Agency's (EPA's) Envirofacts/Enviromapper database was queried for facilities and sent to the Military Department of Tennessee in a request for the Superfund Amendments and Reauthorization Act (SARA) Title III, Tier II reports for the queried facilities (References 2.2-10 and 2.2-11). Only the five facilities identified herein were determined to have a possible significant impact on the CRN Site; therefore, further analysis of facilities other than these five is not required.

2.2.2.2.1 Offsite Chemicals

The chemicals stored at the offsite facilities identified in Subsection 2.2.2.1 are detailed in Table 2.2-2 and Table 2.2-5. Table 2.2-2 identifies the offsite facility in which each chemical is used and the maximum stored quantity reported. Table 2.2-5 provides the disposition for all the offsite chemicals identified for evaluation. The offsite chemicals with the potential to be toxic, flammable, and/or explosive were evaluated for possible effects on the safe operation or shutdown of the CRN Site.

2.2.2.2.2 Industrial Facilities

ORNL (Battelle and URS)

ORNL is located in Oak Ridge, TN, approximately 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 4400 employees (Reference 2.2-17).

The transportation route used for shipping and receiving supplies at the plant may vary, and unless a material is prohibited on a route, there are no restrictions that would prevent the driver from taking another route. The I-40 corridor is identified as the most significant and closest highway to the CRN Site. Therefore, it is conservatively assumed that the chemicals stored at ORNL are transported along the I-40 corridor, in close proximity to the CRN Site, and are included in the evaluation of potential accidents associated with nearby transport routes.

The chemicals stored at ORNL identified for possible analysis are presented in Table 2.2-2. The disposition of hazards associated with these chemicals is summarized in Table 2.2-5 and the subsequent analysis of these chemicals is addressed in Subsection 2.2.3.

TVA Kingston Fossil Plant

TVA Kingston Fossil Plant is located in Kingston, TN, approximately 7.6 mi west of the CRN Site power block area. The plant operates nine coal-fired generating units, with a summer net capacity of 1398 megawatt-electric (MWe) (Reference 2.2-51). The plant uses approximately 14,000 tons (T) of coal each day when operating at full capacity. 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 (Reference 2.2-14).

As provided in RG 1.78, chemicals stored or situated at distances greater than 5 mi from the plant do not need to be considered because if a release occurs at such a distance, atmospheric dispersion will dilute and disperse the incoming plume to such a degree that either toxic limits will never be reached or there would be sufficient time for the control room operators to take appropriate action. Although TVA Kingston Fossil Plant is located greater than 5 mi from the CRN Site, it was identified for further analysis because of its use and storage of anhydrous ammonia. According to 40 CFR 68, anhydrous ammonia is a highly toxic/highly volatile chemical with greater toxic endpoints and requires an offsite consequence analysis with a worst-case release scenario for RMPs under the Clean Air Act.

The transportation route used for shipping and receiving supplies at the plant may vary, and unless a material is prohibited on a route, there are no restrictions that would prevent the driver from taking another route. The I-40 corridor is identified as the most significant and closest highway to the CRN Site. Therefore, it is conservatively assumed that the chemicals stored at TVA Kingston Fossil Plant are transported along the I-40 corridor, in close proximity to the CRN Site, and are included in the evaluation of potential accidents associated with nearby transport routes.

The chemicals stored at TVA Kingston Fossil Plant identified for possible analysis are presented in Table 2.2-2. The disposition of hazards associated with these chemicals is summarized in Table 2.2-5 and the subsequent analysis of these chemicals is addressed in Subsection 2.2.3.

Oak Ridge WTP

The Oak Ridge WTP is located in Oak Ridge, TN, approximately 10.3 mi northeast of the CRN Site power block area. The plant is owned and operated by the City of Oak Ridge Public Works Department which maintains the plant, reservoirs, storage tanks, distribution mains, service lines, pressure reducing valve stations and booster stations. The Public Works Department employs 94 employees. Oak Ridge WTP uses chlorine as a disinfectant in its water treatment process (Reference 2.2-16).

As provided in RG 1.78, chemicals stored or situated at distances greater than 5 mi from the plant do not need to be considered because if a release occurs at such a distance, atmospheric dispersion will dilute and disperse the incoming plume to such a degree that either toxic limits will never be reached or there would be sufficient time for the control room operators to take appropriate action. Although this facility is located greater than 5 mi from the CRN Site, it was identified for further analysis because of its use and storage of chlorine. According to 40 CFR 68, chlorine is a highly toxic/highly volatile chemical with greater toxic endpoints and requires an offsite consequence analysis with a worst-case release scenario for RMPs under the Clean Air Act.

The plant receives chlorine from its supplier by truck. The transportation route used for shipping and receiving supplies at the plant may vary, and unless a material is prohibited on a route, there are no restrictions that would prevent the driver from taking another route. The I-40 corridor is identified as the most significant and closest highway to the CRN Site. Therefore, it is conservatively assumed that the chemicals stored at Oak Ridge WTP are transported along the I-40 corridor, in close proximity to the CRN Site, and are included in the evaluation of potential accidents associated with nearby transport routes.

The chemicals stored at Oak Ridge WTP identified for possible analysis are presented in Table 2.2-2. The disposition of hazards associated with these chemicals is summarized in Table 2.2-5 and the subsequent analysis of these chemicals is addressed in Subsection 2.2.3.

TVA Bull Run Fossil Plant

TVA Bull Run Fossil Plant is located in Clinton, TN, approximately 15 mi northeast of the CRN Site power block area. The plant operates a single coal-fired generating unit, with a summer net capability of 881 MWe (Reference 2.2-52). The plant uses approximately 7300 T of coal per day. Bull Run Fossil Plant has 91 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 (Reference 2.2-12).

As provided in RG 1.78, chemicals stored or situated at distances greater than 5 mi from the plant do not need to be considered because if a release occurs at such a distance, atmospheric dispersion will dilute and disperse the incoming plume to such a degree that either toxic limits will never be reached or there would be sufficient time for the control room operators to take appropriate action. Although TVA Bull Run Fossil Plant is located greater than 5 mi from the CRN Site, it was identified for further analysis because of its use and storage of anhydrous ammonia. According to 40 CFR 68, anhydrous ammonia is a highly toxic/highly volatile chemical with greater toxic endpoints and requires an offsite consequence analysis with a worst-case release scenario for RMPs under the Clean Air Act.

TVA Bull Run Fossil Plant receives anhydrous ammonia from its supplier by truck. The transportation route used for shipping and receiving supplies at the plant may vary, and unless a material is prohibited on a route, there are no restrictions that would prevent the driver from taking another route. The I-40 corridor is identified as the most significant and closest highway to the CRN Site. Therefore, it is conservatively assumed that the chemicals stored at TVA Bull Run Fossil Plant are transported along the I-40 corridor, in close proximity to the CRN Site, and are included in the evaluation of potential accidents associated with nearby transport routes.

The chemicals stored at TVA Bull Run Fossil Plant identified for possible analysis are presented in Table 2.2-2. The disposition of hazards associated with these chemicals is summarized in Table 2.2-5 and the subsequent analysis of these chemicals is addressed in Subsection 2.2.3.

Hallsdale Powell Utility District Melton Hill WTP

Hallsdale Powell Utility District Melton Hill WTP is located approximately 18.2 mi northeast of the CRN Site power block area in Knoxville, TN. The plant was established in 1960’s and provides water distribution services to approximately 29,000 customers in north Knox, Anderson, and Union Counties, TN. Hallsdale Powell Utility District Melton Hill WTP uses chlorine as a disinfectant in its water treatment process (Reference 2.2-15).

As provided in RG 1.78, chemicals stored or situated at distances greater than 5 mi from the plant do not need to be considered because if a release occurs at such a distance, atmospheric dispersion will dilute and disperse the incoming plume to such a degree that either toxic limits will never be reached or there would be sufficient time for the control room operators to take appropriate action. Although this facility is located greater than 5 mi from the CRN Site, it was identified for further analysis because of its use and storage of chlorine. According to 40 CFR 68, chlorine is a highly toxic/highly volatile chemical with a greater toxic endpoint and requires an offsite consequence analysis with a worst-case release scenario for RMPs under the Clean Air Act.

The transportation route used for shipping and receiving supplies at the plant may vary, and unless a material is prohibited on a route, there are no restrictions that would prevent the driver from taking another route. The I-40 corridor is identified as the most significant and closest highway to the CRN Site. Therefore, it is conservatively assumed that the chemicals stored at Hallsdale Powell Utility District Melton Hill WTP are transported along the I-40 corridor, in close proximity to the CRN Site, and are included in the evaluation of potential accidents associated with nearby transport routes.

The chemicals stored at Hallsdale Powell Utility District Melton Hill WTP identified for possible analysis are presented in Table 2.2-2. The disposition of hazards associated with these chemicals is summarized in Table 2.2-5 and the subsequent analysis of these chemicals is addressed in Subsection 2.2.3.

2.2.2.3 Description of Pipelines

East Tennessee Natural Gas Pipelines 1 and 2

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 (in.) 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 pound-force per square inch gauge (psig) and are buried to a minimum depth of 3 feet (ft) (36 in.) below grade. The pipelines have various isolation (gate) valves located along the pipeline route which can be reached and operated within one hour of notification. The pipeline operating parameters are obtained from Spectra Energy, which is the parent company of East Tennessee Natural Gas (Reference 2.2-5 and Table 2.2-4).

The closest branch of the pipeline originates at approximately the intersection of TN 58 and TN 327 and extends south toward the Clinch River (Reference 2.2-5). This pipeline crosses the Clinch River and at its closest approach to the CRN Site power block area is approximately 1.1 mi away from the site. Figure 2.2-2 illustrates the natural gas pipelines located within 5 mi of the CRN Site.

2.2.2.4 Description of Waterways

There are 802 stream mi in the Lower Clinch River Watershed, which is located in east Tennessee and includes parts of Anderson, Campbell, Grainger, Knox, Loudon, Morgan, Roane and Union Counties (Reference 2.2-19). The Clinch River flows southwest from Tazewell, Virginia 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 only possible on the Clinch River arm of the Watts Bar Reservoir. Annual waterborne commerce data compiled by the United States Army Corps of Engineers' Waterborne Commerce Statistics Center, for the period of 2007 through 2012, indicate that there was inconsequential shipping on the river, that is 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 (References 2.2-20 through 2.2-25). As a result of this finding, waterborne shipping did not warrant further consideration in determining bounding accident scenarios involving transport of hazardous materials in the CRN Site vicinity.

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 mi from the CRN Site power block area. According to the National Bridge Inventory (NBI), a dataset maintained by the United States Department of Transportation's Federal Highway Administration, the average daily traffic for I-40 at the Clinch River crossing near Kingston, TN (approximately 9 mi west of the CRN Site) was 43,200 vehicles in 2012. Another estimate of traffic volume on I-40 is provided by the Interstate Brief, which reports the mean annual daily traffic on I-40 as 12,810 and 47,857 vehicles for rural and urban portions, respectively, based on data from 2011 (Reference 2.2-2). The portion of I-40 closest to the site is classified as rural (Reference 2.2-53).

Other larger roads near the site include TN 1/US11-70, TN 58, TN 95 and TN 327 (all located further from the CRN Site than I-40). TN 58 and TN 95 include bridges that cross the Clinch River. TN 58 is closer (approximately 2 mi) to the CRN Site than TN 95 and is connected to the site access road by Bear Creek Road. Average daily traffic data for this bridge are obtained from the NBI. For 2012, the average daily traffic reported for the bridge on TN 58 was 9800 vehicles. TN 95 crosses the Clinch River about 3 mi east of the CRN Site. For 2012, the average daily traffic crossing the TN 95 bridge was 6740 vehicles.

Minor roadways in the immediate vicinity of the CRN Site include Bear Creek Road and the site access road that runs along the perimeter of the peninsula prior to turning into the center of the site. This site access road is under the control of TVA with an access gate at its intersection with Bear Creek Road. Bear Creek Road runs approximately southwest along the Bear Creek Valley toward the Clinch River arm of the Watts Bar Reservoir, where it turns northwest. While several industrial facilities are located at the East Tennessee Technology Park (ETTP) off Bear Creek Road, as detailed in Subsection 2.2.2.2, a search of the SARA Title III, Tier II reports and EPA's Envirofacts/Enviromapper database did not reveal any ETTP industry that stored hazardous materials which may impact the CRN Site. (Reference 2.2-26) Bear Creek Valley is about 1.5 mi from the CRN Property on the side of Chestnut Ridge that bounds the property to the north (Reference 2.2-1).

I-40 was identified as a road within 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 to a storage site. To determine the plausible chemicals that may be transported along the I-40 corridor (the most significant and nearest highway) with frequency, offsite chemical storage nearby the CRN Site was first ascertained. Information obtained regarding offsite facilities took into account RG 1.206 requirements to "consider all facilities and activities within 5 mi of the nuclear plant and include facilities and activities at greater distances depending on their significance." Therefore, in going beyond 5 mi, particular attention was paid to identifying whether any of these facilities contained highly toxic, highly volatile chemicals with RMP calculated endpoint distances of at least 25 mi (Reference 2.2-6). Table 2.2-3 identifies the hazardous materials that may potentially be transported along I-40 in the CRN Site vicinity.

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 (References 2.2-3 and 2.2-27). At closest approach, this line is approximately 7 mi from the site (Figure 2.2-2). 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 9 mi from the site (Reference 2.2-3). Due to the large distances from these lines to the site and the complex intervening terrain (wooded ridges and valley), accident scenarios on these lines are not evaluated further.

The nearest minor rail line is operated by the EnergySolutions Heritage Railroad Corporation for both recreational and industrial uses. This 11.5 mi rail line runs from the northern Norfolk Southern line southward parallel to TN 327 to its terminus at the ETTP (References 2.2-1 and 2.2-3 and Figure 2.2-2). Shipping on the railway is comprised mostly of solid, low-level radioactive wastes. The volume of wastes shipped in the 2013 calendar year was 405,000 T. As presented in Subsection 2.2.1, these wastes do not pose a significant threat to the site due to the physical properties of the waste; therefore, accidents from the transport of hazardous materials in the vicinity of the CRN Site by rail are not considered further.

2.2.2.7 Description of Airports, Aircraft, and Airway Hazards

NUREG-0800 establishes that the risks as the result of aircraft hazards should be sufficiently low, in that each requires that aircraft accidents that could lead to radiological consequences in excess of the exposure guidelines of 10 CFR 50.34(a)(1) with a probability of occurrence greater than an order of magnitude of 10^{-7} per year should be considered in the design of the plant.

Further, Section 3.5.1.6 of NUREG-0800 provides that 10 CFR 100.20, 10 CFR 100.21, and 10 CFR 52.17 requirements are met if the probability of aircraft accidents resulting in radiological consequences greater than the 10 CFR 100 exposure guidelines is less than an order of magnitude of 10^{-7} per year. Additionally, these guidelines provide that the probability is considered to be less than an order of magnitude of 10^{-7} per year by inspection if the distances from the plant meet all of the criteria listed below:

1. The plant-to-airport distance, D, is between 5 and 10 statute miles, and the projected annual number of operations is less than 500 D^2, or the plant-to-airport distance, D, is greater than 10 statute miles, and the projected annual number of operations is less than 1000 D^2;

2. The plant is at least 5 statute miles from the nearest edge of military training routes, including low-level training routes, except for those associated with usage greater than 1000 flights per year, or where activities (such as practice bombing) may create an unusual stress situation;

3. The plant is at least 2 statute miles beyond the nearest edge of a Federal airway, holding pattern, or approach pattern.

Therefore, utilizing the proximity criteria presented above, a screening analysis was first performed to establish whether the probability of aircraft accidents for the proposed CRN Site is considered to be less than an order of magnitude of 10^{-7} per year by inspection.

Five small privately-owned airports (Big T, Wolf Creek, Cox Farm, Will A Hildreth Farm, and Riley Creek) are located between 5 and 10 statute mi of the CRN Site (Figure 2.2-3). These airports have no Federal Aviation Administration (FAA) Terminal Area Forecast (TAF) data available due to their size and low number of operations; however, their projected number of operations, based on available data, is less than the significance factor (i.e., the allowable annual number of operations) called for by criterion 1 (Table 2.2-7).

Two small privately-owned airports, Oliver Springs and Fergusons Flying Circus, are within 10 to 15 statute mi of the CRN Site (Figure 2.2-3). No FAA TAF data is available due to their size and low number of operations. Based on available data, the projected number of operations for each airport is less than the significance factor (i.e., the allowable annual number of operations) by criterion 1, as specified in NUREG-0800 (Table 2.2-7). Airports located at distances greater than 15 statute mi were also evaluated to ensure that each would meet the significance factor specified in criterion 1 (Table 2.2-7).

The results, summarized in Table 2.2-7, indicate that the proximity screening criterion 1 is met for each evaluated airport; therefore, no nearby airports need further evaluation.

The probability of aircraft accidents at the CRN Site was evaluated to determine if the CRN Site met proximity screening criterion 2, defined previously. The centerline of the closest military training route, IR2, is located approximately 19.2 mi to the WNW (Figure 2.2-3). The Department of Defense Flight Information Publication, AP/1B, Area Planning Military Training Routes North and South America, also provides the width of each military training route segment. This publication denotes the width of IR2 as 5 nautical mi on each side of the centerline for the entire route. IR-type military training routes must be conducted on IFR flight plans regardless of weather conditions. The Department of Defense Flight Information publication also states that pilots must enter and exit the route via published entry and exit points or published alternate entry and exit points, and must have a specific air traffic control clearance prior to entering or exiting the route. Once on the route, the pilot must remain within the published route corridor (width and altitude). (Reference 2.2-33) The CRN Site is located about 19.2 statute mi from the centerline of this training route or approximately 13.4 statute mi from the edge of the training route.

The closest military operation area (MOA) is the Snowbird MOA located approximately 36 mi from the CRN Site (Figure 2.2-3). The primary users of the Snowbird MOA were Air National Guard units, which have since been relocated or converted from fighter aircraft to other missions. Relatively high terrain for the eastern part of the country (Snowbird overlies the Smoky Mountains) and altitude allocated to accommodate civil overflights severely limit the area’s flexibility and utility for military operations (Reference 2.2-9).

Given this separation distance between the CRN Site and the nearest military training route (greater than 5 mi from the nearest edge of a military training route), along with the distance to the nearest MOA, criterion 2 is met.

The probability of aircraft accidents at the CRN Site was also evaluated to determine if the CRN Site met proximity screening criterion 3, defined previously. There are two Federal airways, one victor (V) and one jet (J) route (V16 and J46, respectively) whose nearest edge lies within 2 statute mi of the CRN Site (Figure 2.2-3 and References 2.2-30 through 2.2-32). Thus, due to the proximity of Federal airways V16 and J46, the proposed CRN Site does not meet proximity screening criterion 3.

The CRN Site meets acceptance criteria 1 and 2. However, there are two Federal airways whose nearest edge lies within 2 statute mi of the CRN Site. Therefore, as required by Section 3.5.1.6 of NUREG-0800, a detailed review of aircraft hazards was required to determine the accident probability rate.

As discussed, aircraft accidents that could lead to radiological consequences in excess of the exposure guidelines of 10 CFR 100 with a probability of occurrence greater than an order of magnitude of 10^{-7} per year should be considered in the design of the plant. However, a conservative calculation showing that the probability of occurrence of doses in excess of the exposure guidelines, of about an order of magnitude 10^{-6} per year, is acceptable, in accordance with NUREG-0800, SRP Section 2.2.3, if, it can be shown with rigorous analysis, using realistic assumptions and reasonable arguments, that the estimated probability can be shown to be lower.

NUREG-0800 gives the following equation for estimating the probability per year of an aircraft crashing into the plant when Federal airways pass through the vicinity of the site:

$$P_{FA} = C \times N \times {}^{A}\!/_{W}$$ Equation 2.2-1

Where, P_{FA} is the probability of an aircraft crashing into the plant, C is the in-flight crash rate per mi for aircraft using the airway, N is the number of flights per year along the airway, A is the effective area of the plant in square mi, and W is the width of the airway (plus twice the distance from the airway edge to the site when the site is outside the airway) in mi.

To calculate the effective area (A) in the above equation for the CRN Site bounding building, the methodology provided in DOE Standard, DOE-STD-3014-96, (Reference 2.2-34) was used as shown below: (The bounding building is represented by the maximum area of the safety-related structures for the proposed CRN Site mapped into a rectangular building.)

$$A = A_f(effective\ fly - in\ area) + A_s(effective\ skid\ area)$$ Equation 2.2-2

Where:

$$A_f = (WS + R)Hcot\emptyset + {}^{(2L \times W_f \times WS)}\!/_{R + L \times W_f}$$ Equation 2.2-3

$$A_s = (WS + R) \times S$$ Equation 2.2-4

Where, WS is the aircraft wingspan, R is the length of the diagonal of the facility, H is the height of the facility, L is the length of the facility, W_f is the width of the facility, S is the aircraft skid distance and cotΦ is the mean of the cotangent of the aircraft impact angle. The input values WS, cotΦ, and S are provided in DOE-STD-3014-96 (Reference 2.2-34), and the input values R, H, W_f, and L are site (facility)-specific.

To maximize the effective area, A, determined from Equation 2.2-2, the maximum R value and the maximum volume for each of the considered designs were first assessed. The maximum R (589 ft) and maximum volume (21.23 x 10^6 cubic feet (ft^3)) were selected and then used to derive the length (533 ft) and width (249 ft) of a bounding building for the CRN Site that would yield the determined maximum R value and volume value.

The in-flight crash rate, C, per mi for aircraft using the airway for commercial aircraft was obtained directly from NUREG-0800 (4 x 10^{-10} per aircraft mi). Conservatively, a weighted value for the remaining aircraft classes was calculated using data in NUREG-0800. The number of operations, N, was derived from Federal Aviation Administration Terminal Area Forecast data (Reference 2.2-35).

This analysis calculated the probability of an aircraft crashing into the determined bounding building for the CRN Site to be 7.53 x 10^{-7}, which is over the order of magnitude of 10^{-7} per year. However, an expected rate of occurrence, about an order of magnitude of 10^{-6}, as it relates to radiological dose requirements in 10 CFR 50.34(a)(1) and 10 CFR 100.20 (b), is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower. The following bounding assumptions provided in the calculation provide for a rigorous qualitative argument as to the realistic probability being lower than that calculated above:

- The assumed bounding building height (H), 160 ft, is higher than any of the safety-related design structures. Additionally, the height value of 160 ft was also applied to the radwaste building which is expected to have a height that is less than the reactor building. Lowering the height would lower the probability. For example, a bounding building volume of 10.61 x 10^6 ft^3, while maintaining the maximum R, would lower the probability to an order of magnitude of 10^{-7} per year.
- Although its destruction is unlikely to result in radiological dose in excess of the 10 CFR 50.34(a)(1), the radwaste building was conservatively included in the selection of the structures, systems, and components (SSCs).
- The number of operations along the airways was conservatively estimated to be 50 percent of the total number of operations for the airports at the terminus of the airway. The conservative nature of this estimate is due to several factors such as the assumption that all operations are IFR (Instrument Flight Rules) when in reality a greater number of flights are becoming VFR (Visual Flight Rules) which fly point to point rather than on a specified airway. An additional factor is the placement of 50 percent of the total number of operations at the airports on just one airway. For example, the terminus of the J46 is Knoxville McGhee Tyson Airport (TYS) airport and this airport has 9 high altitude airways. To provide some context to the conservative estimate, if 30 percent of the total number of operations was placed on airways J46 and V16, while maintaining the bounding building assumptions, the probability would be lowered to an order of magnitude of 10^{-7} per year.
- No credit was taken for intervening structures (e.g., skid distance). Each of the considered designs bears an obstruction to at least one side of the selected SSCs which would effectively lower the skid distance.

Based upon the discussion above, the expected rate of occurrence of potential exposures resulting in radiological dose in excess of the 10 CFR 50.34(a)(1) has been shown to be on the order of magnitude of 10^{-6} per year and the realistic probability has been shown to be lower, based upon the qualitative arguments. Thus, the risk to plant safety from aircraft hazards is sufficiently low.

2.2.2.8 Projections of Industrial Growth

DOE 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 transfers 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 (Reference 2.2-26). Additionally, the Metropolitan Knoxville Airport Authority, working with community partners and DOE, 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 the future construction dates for the airport as approximately 2017–2022 (Reference 2.2-50). No other projections of industrial growth within a 10-mi radius of the CRN Site were identified.

2.2.3 Evaluation of Potential Accidents

Based upon the information provided in Subsections 2.2.1 and 2.2.2, the potential accidents that should be evaluated as design-basis events were identified. The potential effects of these accidents on the nuclear plant in terms of design parameters and physical phenomena were evaluated, using the guidance in RG 1.78, RG 1.91, RG 4.7, and RG 1.206.

2.2.3.1 Determination of Potential Accidents

RG 1.206 states that design-basis events, internal and external to the CRN Site, 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 in 10 CFR 100 could be exceeded. The following accident categories are considered in selecting design-basis events: explosions, flammable vapor clouds (delayed ignition), toxic chemicals, aircraft hazards, fires, collisions with the intake structure, and liquid spills. The postulated accidents within these categories were analyzed at the following locations:

Nearby Storage Facilities

- ORNL (Batelle and URS) (located 3.8 mi from the CRN Site power block area)
- TVA Kingston Fossil Plant (located 7.6 mi from the CRN Site power block area)
- Oak Ridge WTP (located 10.3 mi from the CRN Site power block area)
- TVA Bull Run Fossil Plant (located 15 mi from the CRN Site power block area)
- Hallsdale Powell Utility District Melton Hill WTP (located 18.2 mi from the CRN Site power block area)

Nearby Transportation Routes

- East Tennessee Natural Gas Pipelines 1 and 2
- I-40
- Federal Airways V16 and J46

2.2.3.1.1 Explosions

Accidents involving detonations of explosives, munitions, chemicals, liquid fuels, and gaseous fuels were considered for facilities and activities within the vicinity of the CRN Site, where such materials are processed, stored, used, or transported in quantity. The effects of explosions are a concern in analyzing the structural response to blast pressures. The effects of blast pressure from explosions located at nearby facilities and transportation routes to the CRN Site power block area boundary were evaluated to determine if the explosion would have an adverse effect on safety-related plant structures located within the CRN Site power block area which could affect plant operation or prevent safe shutdown of the plant.

The first postulated accident involving those hazardous materials determined to have the potential to explode is the rupture of a vessel whereby the entire contents of the vessel are released and an immediate deflagration/detonation ensues. That is, immediately upon release, the contents of the vessel are assumed to be capable of supporting an explosion upon detonation, e.g., flammable liquids are present in the gas/vapor phase between the upper flammability limits (UFL) and lower flammability limits (LFL).

The trinitrotoluene (TNT) mass equivalency methodology employed for determining the safe distances (the minimum separation distance required for an explosive force to not exceed 1 pound per square inch [psi] peak incident pressure) involves a compilation of principles and criterion, including RG 1.91, Fire Dynamics Tools (FDTs) Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program (NUREG-1805), and the National Fire Protection Association Code.

The allowable and actual distances of hazardous chemicals transported or stored were evaluated in accordance with RG 1.91, which cites 1 psi as a conservative value of peak positive incident overpressure below which no significant damage would be expected. Conservative assumptions were used in determining the safe distance (i.e., the minimum separation distance required for an explosive force to not exceed 1 psi peak incident pressure). RG 1.91 defines this safe distance by the Hopkinson Scaling Law relationship as (Reference 2.2-36):

$$R_{min} = Z \times W^{1/3}$$ Equation 2.2-5

Where R_{min} is the distance in feet (ft) from an explosive charge of W pounds (lb) of TNT, and Z is the scaled distance constant at a given overpressure. For 1 psi, Z is equal to 45 ft per $lb^{1/3}$.

The methodology for calculating W, and hence the safe distance, R, was selected depending upon the phase of the hazardous material during storage or transportation, i.e., solid, atmospheric liquid, or pressurized or liquefied gas.

Solids

For a solid substance not intended for use as an explosive but subject to accidental detonation, RG 1.91 states that it is conservative to use a TNT mass equivalent (W) in Equation 2.2-5 equal to the cargo mass.

Atmospheric Liquids

RG 1.91 guidance suggests that in determining W, the mass of the substance that will produce the same blast effect as a unit mass of TNT, for atmospheric liquid releases resulting in detonations of either confined or unconfined vapor clouds, W is based on the blast wave energy given by RG 1.91 and NUREG-1805:

$$E = \alpha \Delta H_c m_f$$ Equation 2.2-6

Where, E is the blast wave energy (British Thermal Unit (BTU)), α is the yield, ΔH_c is the theoretical net heat of combustion (BTU/lb), and m_f is the mass of flammable vapor released (pound-mass (lb_m)). The corresponding TNT equivalent mass in lb_m is:

$$W_{TNT} = \frac{E}{1900^{BTU}/_{lb_m}}$$ Equation 2.2-7

The methodology employed conservatively considers the maximum gas or vapor volume within the storage vessel as explosive. Thus, for atmospheric liquid storage, this maximum vapor or m_f would involve the container to be completely empty of liquid and filled only with air and fuel vapor at UFL conditions in accordance with NUREG-1805.

The yield factor, α, is an estimation of the explosion efficiency, or a measure of the portion of the flammable material participating in the explosion. An explosion yield factor of 100 percent was applied to account for a confined explosion. In reality, only a small portion of the vapor within the flammability limits would be available for combustion and potential explosion, and a 100 percent yield factor is not achievable (Reference 2.2-36). Therefore, this is a conservative assumption.

Pressurized or Liquefied Gases

For pressurized and liquefied gases, the entire mass of the pressurized or liquefied gas was considered flammable because a sudden tank rupture would involve the release of a majority of the contents in the vapor phase. Therefore, in the case of pressurized or liquefied gases, the entire mass was conservatively considered as available for detonation, and the equivalent mass of TNT, W_{TNT}, was calculated in accordance with RG 1.91 where the m_f is the flammable mass (lb) and the entire mass of the pressurized or liquefied gas is considered flammable. Again, an explosion yield factor of 100 percent was conservatively assumed to account for a confined explosion.

The locations and quantities of chemicals that would be stored onsite at the CRN Site have not yet been determined. The effects of explosion events from onsite chemical storage will be evaluated in the combined license application (COLA). The materials stored at nearby facilities (Table 2.2-2) and potentially transported along I-40 (Table 2.2-3) and by pipeline (Table 2.2-4) are evaluated to ascertain whether they have the potential to explode. The effects of these explosion events from external sources are summarized in Table 2.2-9, and are described in the following subsections relative to the release source.

2.2.3.1.1.1 Nearby Facilities

ORNL–Battelle, located approximately 3.8 mi (20,200 ft); TVA Kingston Fossil Plant, located approximately 7.6 mi (40,100 ft); and TVA Bull Run Fossil Plant, located approximately 15 mi (79,400 ft) from the CRN Site power block area, were identified as facilities of concern with regard to storage of materials with the potential for explosion within the vicinity of the CRN Site (see Subsection 2.2.2.2.2).

Each material stored at the identified offsite facilities was evaluated with respect to explosion potential. Each material was then dispositioned based on the identified physical properties of the material and whether a bounding analysis exists. The results of this evaluation are found in Table 2.2-5 (for explosive materials not carried forward for further analysis, footnotes indicating the reason for the disposition are provided). The materials stored at the ORNL–Battelle identified for further analysis with regard to explosion potential are anhydrous ammonia, ethanol and gasoline (gasoline blend A and gasoline B). ORNL–Battelle identified the storage of an ethanol/gasoline blend (85:15). Conservatively, two analyses were performed: (1) ethanol as 85 percent of the total mass, and (2) gasoline blend A (analyzed as n-Heptane) as 15 percent of the total mass. ORNL–Battelle also identified the separate storage of gasoline. For clarity this storage is identified as gasoline B (analyzed as n-Heptane). The material stored at TVA Kingston Fossil Plant and TVA Bull Run Fossil Plant identified for further analysis was anhydrous ammonia.

A conservative analysis using the TNT equivalency methods described in Subsection 2.2.3.1.1 was used to determine safe distances for the identified potentially explosive materials. The results indicate that the safe distances are less than the minimum separation distances from the CRN Site power block area to the storage locations for any of the identified materials (Table 2.2-9). Anhydrous ammonia stored at TVA Bull Run Fossil Plant resulted in the largest safe distance, 270.9 ft, which is less than the distance of 79,400 ft to the CRN Site power block area.

Therefore, damaging overpressures from an explosion resulting from a complete failure of the total stored quantity for each material evaluated at each of the identified facilities of concern with regard to the storage of materials with the potential for explosion would not adversely affect the operation or shutdown of units located within the power block area at the CRN Site.

2.2.3.1.1.2 Nearby Transportation Routes/Roadways

Table 2.2-3 details the hazardous materials potentially transported on I-40. The nearest approach from I-40 to the CRN Site power block area is approximately 1.1 mi (5800 ft).

Each material potentially transported on I-40 (Table 2.2-3) was evaluated with respect to explosion potential. Each material was then dispositioned based on the identified physical properties of the material and whether a bounding analysis exists. The results of this evaluation are found in Table 2.2-6 (for explosive materials not carried forward for further analysis, footnotes indicating the reason for the disposition are provided). The hazardous materials that are identified for further analysis with regard to explosion potential were butane, gasoline, and hydrogen (Table 2.2-6).

An analysis for the identified chemicals was conducted using the TNT mass equivalency methodologies as described in Subsection 2.2.3.1.1. A postulated scenario involving the transport and ensuing explosion of butane results in the largest safe distance of 3708 ft, which is less than the minimum separation distance, 5800 ft, from the CRN Site power block area to I-40 for the identified materials (Table 2.2-9). Therefore, an explosion from materials transported along nearby highways with the potential for explosion would not adversely affect the safe operation or shutdown of units located within the power block area at the CRN Site.

2.2.3.1.1.3 Nearby Transportation Routes/Pipelines

There are two natural gas transmission pipelines within the vicinity of the CRN Site. The closest approach from the nearest natural gas transmission pipeline, East Tennessee Natural Gas Pipeline 1 (6-in.), to the edge of the CRN Site power block area is approximately 1.1 mi (5800 ft) and the closest approach from the East Tennessee Natural Gas Pipeline 2 (22-in.) to the edge of the power block area is approximately 3 mi (15,800 ft).

A natural gas pipeline explosion occurring in the vicinity of the release point would be unconfined. A damaging detonation from an unconfined natural gas release is not credible according to the NRC Safety Evaluation Report for Hartsfield Nuclear Power Plant (NUREG-0014). However, ignition of a natural gas release near the release point could result in a less damaging deflagration explosion or jet fire. Experiments conducted in Germany

(Reference 2.2-37) and by the Institution of Gas Engineers (Reference 2.2-38) have indicated that detonations of mixtures of methane (greater than 85 percent) with air do not present a credible outdoor explosion event (Reference 2.2-36). Further, there have been no reported vapor cloud explosions involving natural gas with high methane content; whereas, there have been numerous reports of vapor clouds igniting resulting in flash fires without overpressures (Reference 2.2-36). Thus, the dominant hazards from natural gas pipelines are from the heat effect of thermal radiation from a sustained jet fire and from explosions where the natural gas vapor cloud becomes confined either outside or by migration inside a building. Even though the immediate ignition of natural gas resulting in overpressure events resulting from a ruptured gas pipeline was considered an unlikely event, an evaluation was conservatively conducted to evaluate a potential explosion from the natural gas transmission pipeline.

The worst case scenario considered the immediate detonation of the released natural gas. That is, upon immediate release, the contents of the pipeline are assumed to be capable of supporting an explosion upon detonation (i.e., the gas is present in concentrations between the UFL and LFL). In this scenario, it was assumed that the pipe had burst open, leaving the full cross-sectional area of the pipe completely exposed to the air. It was also assumed that the ignition source existed at the break point. The safe distance to 1 psi overpressure was calculated by determining the mass of natural gas released, whereby the TNT mass equivalency methodology can then be employed as described in Subsection 2.2.3.1.1.

In order to determine the mass of natural gas released, the maximum release rate was determined. The release rate from a hole in a pipeline will vary over time; however, for safety assessments, it is useful to calculate the maximum release rate of gas from the pipeline. A standard procedure for representing the maximum discharge is to represent the discharge through the pipe as an orifice. The orifice method always produces a larger value than the adiabatic or isothermal pipe methods, ensuring a conservative safety design (Reference 2.2-49).

Once it was verified that choked flow conditions would occur for a postulated break in the East Tennessee Natural Gas Pipelines 1 and 2, the maximum gas discharge rate from the break in the pipeline was calculated using the following equation which represents the release from the pipeline as an orifice (Reference 2.2-49):

$$Q_{max} = CAP_0\sqrt{\frac{\gamma g_c MW}{RT}\left(\frac{2}{\gamma+1}\right)^{\left(\frac{\gamma+1}{\gamma-1}\right)}} \qquad \text{Equation 2.2-8}$$

Where, C is the discharge coefficient (1 for maximum case), A is the area of the hole in square ft, g_c is the gravitational constant (ft·lb_m/lb-foot (lb_f) second $(s)^2$), MW is the molecular weight (lb/lb-mole (lb_{mol})), R is the ideal gas constant (ft·lb_f/lb_{mol}·°Rankine (R)), P_0 is the pipeline pressure, γ is the heat capacity ratio for natural gas, and T is the initial pipeline temperature (°R) (Reference 2.2-49).

Due to the nature of a high pressure release through a pipeline, upon a complete pipeline rupture, the release rate of the gas (lb/s) will initially be very large, but within seconds the release rate will drop to a fraction of the initial release rate. Therefore, to estimate the amount of gas discharged for an instantaneous release, the maximum discharge rate was conservatively assumed to occur for a period of 5 s. This duration maintained the intent of the instantaneous detonation as applied in the TNT analysis—any longer and atmospheric dispersion effects will predominate resulting in a traveling vapor cloud—while maximizing the amount of gas released for the TNT analysis. This is also a conservative assumption given that the discharge rate will begin to decrease significantly immediately after the break occurs. The amount of gas released was then determined by:

$$Mass(lb) = Q_{max}\left({}^{lb}/_{s}\right) \times Time(s) \qquad \text{Equation 2.2-9}$$

Using the flammable mass calculated by the above methodologies, the equivalent mass of TNT was calculated using Equations 2.2-6 and 2.2-7.

The results indicated that the safe distances (the distance to where the peak incident pressure does not exceed 1 psi) are less than the minimum separation distance from the CRN Site power block area to the respective pipelines (Table 2.2-9). The determined safe distances for the East Tennessee Natural Gas Pipeline 1 and East Tennessee Natural Gas Pipeline 2 are 1250 ft and 2970 ft, respectively. These distances are less than the separation distance from either pipeline to the CRN Site power block area. The results indicated that overpressures from an explosion from a rupture in either the East Tennessee Natural Gas Pipeline 1 or East Tennessee Natural Gas Pipeline 2 will not adversely affect the safe operation or shutdown of units within the CRN power block area.

2.2.3.1.2 Flammable Vapor Clouds (Delayed Ignition and Jet Fire)

Flammable materials in the liquid or gaseous state can form unconfined vapor clouds that can drift toward the plant. As the formed vapor cloud travels downwind across terrain, it disperses before an ignition event. The portion of the cloud with a chemical concentration within the flammable range (i.e., between the LFL and UFL) may burn if the cloud encounters an ignition source. The speed at which the exothermic reaction propagates through the cloud determines whether it is considered a deflagration or a detonation. If the cloud burns quickly enough, greater than sonic velocity, to create a detonation, an explosive force is generated (References 2.2-36 and 2.2-39).

Two possible events were evaluated for the delayed ignition scenario. The two invents include the possible effects from a flash fire resulting from the ignition of a flammable vapor cloud (deflagration of the vapor cloud) and the pressure effects resulting from a vapor cloud explosion (detonation of the vapor cloud). An additional scenario was evaluated for the postulated release scenarios involving the natural gas pipelines, a jet fire resulting from the rapid release of gas from the pipeline. The materials stored at nearby facilities (Table 2.2-2) and potentially transported along I-40 (Table 2.2-3) and by pipeline (Table 2.2-4) were evaluated to ascertain whether they have the potential to form flammable and/or explosive vapor clouds (Tables 2.2-5 and 2.2-6).

The first event evaluated, for those chemicals with identified flammability limits, is a postulated scenario resulting in a flammable vapor cloud deflagration. This entails the determination of the distances at which portions of the vapor cloud could exist within the flammability range, thus presenting the possibility of ignition. The Areal Locations of Hazardous Atmospheres (ALOHA) dispersion model was used to determine the safe distance for each postulated flammable vapor cloud scenario. The safe distance was measured as the distance to the outer edge of the LFL section of the vapor cloud. Guidance concerning flammable vapor clouds indicates that it is appropriate to consider the distance to the LFL as the safe distance for flammable vapor clouds. Generally, for flash fires, the controlling factor for the amount of damage that a receptor will suffer is whether the receptor is physically within the burning cloud. This is because most flash fires do not burn very hot and the thermal radiation generated outside of the burning cloud will generally not cause significant damage due to the short duration. (References 2.2-40 and 2.2-41)

A second event was also evaluated for those chemicals with identified flammability limits to determine the possible effects of a flammable vapor cloud detonation. The ALOHA dispersion model was also used to determine the safe distances of the worst-case accidental vapor cloud explosion for the identified chemicals. The safe distance was measured as the distance from the spill site to the location where the pressure wave is at 1 psi overpressure.

Conservative assumptions were used in the ALOHA analyses regarding both meteorological inputs and identified scenarios for both events. Each postulated event was evaluated under a spectrum of meteorological conditions, in accordance with RG 1.206, to determine the worst-case meteorological condition. The spectrum of meteorological parameters chosen for the meteorological sensitivity analysis was selected based on the defined Pasquill meteorological stability classes (Table 2.2-8). The meteorological sensitivity analysis included the most stable meteorological class, F, allowable with the ALOHA model. Generally, independent of the chemical release rate, under more stable meteorological classes and at lower wind speeds, a formed chemical vapor cloud will disperse less with the air around it. Consequently, the dispersion model will predict higher concentrations in the formed cloud before reaching safety-related structures or the control room (located in the CRN Site power block area boundary). Additionally, as cited in RG 1.78, the Pasquill Stability Category F represents the worst 5^{th}-percentile meteorology observed at the majority of the nuclear power plant sites.

Other assumptions in the ALOHA model include:

- For each of the identified chemicals in the liquid state (i.e., under the atmospheric release conditions for that scenario, the physical state of the substance is expected to be a liquid), it was conservatively assumed that the entire contents of the vessel are released, instantaneously forming a 1-centimeter (cm)-thick puddle. This provided a significant surface area from which to maximize evaporation and formation of a vapor cloud.
- For each of the identified chemicals in the gaseous state, or for those chemicals that are normally gases at ambient temperatures (i.e., under the atmospheric release conditions for that scenario, the physical state of the substance is expected to be a gas), it was assumed that the quantity released from the vessel/pipeline is released over a 10-minute (min) period into the atmosphere as a continuous direct source (40 CFR 68.25).
- To model the worst-case scenario for flammable vapor cloud explosions in ALOHA, detonation was chosen as the ignition source.

The locations and quantities of chemicals that would be stored onsite at the CRN Site have not yet been determined. The effects of flammable vapor clouds and vapor cloud explosions from onsite chemical storage will be evaluated in the COLA. The effects of flammable vapor clouds and vapor cloud explosions from external sources are summarized in Table 2.2-10 and are described in the following subsections relative to the release source.

2.2.3.1.2.1 Nearby Facilities

ORNL–Battelle located approximately 3.8 mi (20,200 ft); TVA Kingston Fossil Plant located approximately 7.6 mi (40,100 ft); and TVA Bull Run Fossil Plant located approximately 15 mi (79,400 ft) from the power block area for the CRN Site were identified in Subsection 2.2.2.2.2 as facilities of concern with regard to storage of materials with the potential for formation of flammable/explosive vapor clouds within the nearby CRN Site.

Each material stored at the identified offsite facilities was evaluated with respect to its potential for formation of flammable/explosive vapor clouds. Each material was then dispositioned based on the identified physical properties of the material and whether a bounding analysis exists. The results of this evaluation are found in Table 2.2-5 (for flammable/explosive materials not carried forward for further analysis, footnotes indicating the reason for the disposition are provided in the table). The materials stored at ORNL identified for further analysis with regard to the potential formation of flammable/explosive vapor clouds were: anhydrous ammonia, ethanol and gasoline (gasoline blend A and gasoline B) (Table 2.2-5). The material stored at TVA Kingston Fossil Plant and TVA Bull Run Fossil Plant identified for further analysis was anhydrous ammonia.

As described in Subsection 2.2.3.1.2, the ALOHA dispersion model was used to determine the distance a vapor cloud could travel to reach the LFL boundary once a vapor cloud has formed from an accidental release of the identified chemical. The results indicated that any plausible vapor cloud that could form and mix sufficiently under stable atmospheric conditions would be below the LFL boundary before reaching the CRN Site power block area. The distance to the LFL boundary for an anhydrous ammonia release is 924 ft, 345 ft, and 126 ft from TVA Bull Run Fossil Plant, TVA Kingston Fossil Plant, and ORNL–Batelle, respectively. The distance to the LFL boundary for a postulated release of either a release of ethanol or gasoline (gasoline blend A or gasoline B), is less than 33 ft. Each of these chemicals is stored at a greater distance from the CRN Site power block area than the calculated distance to the LFL boundary (Table 2.2-10).

A vapor cloud explosion analysis was also completed following the methodology as detailed in Subsection 2.2.3.1.2 in order to obtain safe distances. The results conclude that the safe distances (the minimum distance required for an explosion to have less than a 1 psi peak incident pressure) are less than the shortest distance to the CRN Site power block area and the storage location of these chemicals. The safe distance for anhydrous ammonia is 2601 ft, 918 ft, and 342 ft for a postulated release from TVA Bull Run Fossil Plant, TVA Kingston Fossil Plant, and ORNL–Batelle, respectively. For gasoline blend A, the safe distance is 75 ft; for gasoline B, 81 ft; and for ethanol, no explosion occurs. Each of these chemicals is stored at a greater distance from the CRN Site power block area (Table 2.2-10).

Therefore, a flammable vapor cloud with the possibility of ignition or explosion formed from the storage of chemicals at offsite facilities will not adversely affect the safe operation or shutdown of units within the CRN Site power block area.

2.2.3.1.2.2 Nearby Transportation Routes/Roadways

The nearest approach from I-40 to the CRN Site power block area is approximately 1.1 mi (5800 ft). Table 2.2-3 details the hazardous materials potentially transported on I-40.

Each material potentially transported on I-40 (Table 2.2-3) was evaluated with respect to its potential for formation of flammable/explosive vapor clouds. Each material was then dispositioned based on the identified physical properties of the material and whether a bounding analysis exists. The results of this evaluation are found in Table 2.2-6 (for flammable/explosive materials not carried forward for further analysis, footnotes indicating the reason for the disposition are provided in the table). The materials identified for further analysis with regard to flammable vapor clouds were butane and gasoline (Table 2.2-6). It was conservatively assumed that the maximum quantity of the butane potentially transported on the roadway is 11,500 gallons (gal), which represents the maximum transport quantity in an MC-331 high pressure tank truck (49 CFR 173.315 and Reference 2.2-42). For gasoline, it is conservatively assumed that 8500 gal is potentially transported on I-40. Both quantities are greater than 50,000 lb which is the maximum probable solid cargo highway transport quantity identified in RG 1.91.

An analysis for the identified chemicals was conducted using ALOHA as described in Subsection 2.2.3.1.2. The results indicate that any plausible vapor cloud that could form and mix sufficiently would be below the LFL boundary before reaching the CRN Site power block area. The safe distances are less than the minimum separation distances from the CRN Site power block area to I-40 for each of the identified chemicals. Butane results in the longest flammable plume of 1827 ft which is less than the distance of 5800 ft to the nearest approach of the CRN Site power block area. (Table 2.2-10)

A vapor cloud explosion analysis was also completed as detailed in Subsection 2.2.3.1.2 to obtain safe distances. The results indicate that the safe distances, the minimum distances required for an explosion to have less than a 1 psi peak incident pressure are less than the shortest distance to the power block area to I-40. The safe distance for butane is 3864 ft; and for gasoline 618 ft. (Table 2.2-10)

Therefore, a flammable vapor cloud formed from the release of chemicals transported along nearby highways, with the possibility of ignition or explosion, will not adversely affect the safe operation or shutdown of units within the CRN Site power block area.

2.2.3.1.2.3 Nearby Transportation Routes/Pipelines

There are two natural gas transmission pipelines within the vicinity of the CRN Site. The closest approach from the nearest natural gas transmission pipeline, East Tennessee Natural Gas Pipeline 1, to the edge of the CRN Site power block area is approximately 1.1 mi (5800 ft) and the closest approach from the East Tennessee Natural Gas Pipeline 2 to the edge of the power block area is approximately 3 mi (15,800 ft). To conservatively evaluate the consequences from a potential flammable vapor cloud or vapor cloud explosion from a natural gas transmission pipeline, a worst-case scenario was considered involving the release of natural gas directly into the atmosphere resulting in a vapor cloud.

Two scenarios were considered for the postulated natural gas pipeline rupture. The first scenario considered a release from the pipeline whereby a vapor cloud forms and travels toward the CRN Site power block area. As the vapor cloud travels toward the CRN Site, it is plausible that the chemical concentration in the vapor cloud could become flammable along its path, i.e., reaches concentrations between the LFL and UFL. The analysis included two plausible delayed ignition events: an event resulting in a flash fire from the ignition of the flammable vapor cloud and an event resulting in the detonation of the vapor cloud.

As described in Subsection 2.2.3.1.2, the ALOHA dispersion model was used to determine the distance a vapor cloud could travel to reach the LFL boundary once a vapor cloud has formed from an accidental release of natural gas (as methane) from the pipeline. The pipeline release source module was selected in the ALOHA program to model the natural gas release. To model the pipeline release, additional assumptions in the ALOHA model included:

- The pipeline characteristics presented in Table 2.2-4 were used as inputs.
- It was conservatively assumed that the pipeline length is equivalent to 200 times the diameter of the pipe, 100 ft and 367 ft for Pipeline 1 and Pipeline 2, respectively. ALOHA requires a length at least 200 times the diameter (the shorter pipeline length is conservative because as the length of the pipeline increases, the release rate of the gas decreases due to friction along the length of the pipeline) (Reference 2.2-43).
- It was conservatively assumed that the pipeline is connected to an infinite tank source. The infinite tank source model assumes that the pipeline is connected to a very large reservoir such that gas is release from the pipeline break until the break is isolated from the reservoir (Reference 2.2-43).
- It was conservatively assumed that the roughness of the pipeline is smooth. The pipeline roughness was used to describe the interior surface of the pipe. Selection of a smooth pipe is a conservative assumption given that increased roughness introduces friction and turbulence to the fluid inside the pipe causing a reduction of the flow rate (Reference 2.2-43).

The results concluded that under this scenario a plausible vapor cloud that could form from a release at either East Tennessee Natural Gas Pipeline 1 or East Tennessee Natural Gas Pipeline 2 will be below the LFL boundary before reaching the CRN Site power block area (Table 2.2-10).

The second delayed ignition event involving the first scenario, an event resulting in the detonation of the vapor cloud was also performed as described in Subsection 2.2.3.1.2 with the ALOHA pipeline inputs from the preceding paragraph because of the possibility that the natural gas vapor cloud may become confined either outside or by migration inside a building. The results of the vapor cloud delayed ignition detonation analysis concluded that the safe distance (the minimum distance required for an explosion to have less than 1 psi peak incident pressure) is less than the separation distances between the CRN Site power block area and a pipeline break at either East Tennessee Natural Gas Pipeline 1 or East Tennessee Natural Gas Pipeline 2 (Table 2.2-10).

As described in Subsection 2.2.3.1.2, an additional scenario was evaluated for postulated release scenarios involving the natural gas pipelines. The second postulated scenario involving a natural gas pipeline considered a release from pipeline whereby an immediate ignition of the released chemical occurs, resulting in a jet fire. As described in Subsection 2.2.3.1.1.3, when a flammable chemical is rapidly released, without entrapment, from an opening in a vessel or pipeline, and immediate ignition occurs, a jet fire will develop. The jet fire stabilizes to a point that is close to the source of the release and continues to burn until the fuel source is stopped. The jet fire scenario is considered for determining safe distances in the vicinity of natural gas pipelines because, in addition to producing thermal radiation, the jet fire causes considerable convective heating in the region beyond the flame tip. The safe distance for a jet fire was measured as the distance from the fire to the point where the thermal heat flux reaches 5.0 kilowatt per square meter (kW/m^2) (the radiant heat exposure endpoint specified by 40 CFR 68.22). For the natural gas pipeline, ALOHA was used to model the worst-case accidental release from a pipeline resulting in a jet fire, including the safe distances and thermal heat flux at the nearest edge of the CRN Site power block area.

The thermal effect of a jet fire strongly depends on atmospheric conditions, and the impact radius for thermal radiation is primarily affected by wind speed, increasing with decreasing wind speed. Thermal radiation is also affected by atmospheric transmissivity. Atmospheric transmissivity is the measure of how much thermal radiation from a fire is absorbed and scattered by water vapor and other components in the atmosphere. Therefore, to model the jet fire scenario in ALOHA, a wind speed of 1 meter per second (m/s) was selected. This wind speed represents the lowest wind speed allowable in ALOHA. Because humidity is used to determine the atmospheric transmissivity in the ALOHA model, the humidity levels were varied to determine the atmospheric worst case in ALOHA for the jet fire scenario (Table 2.2-8). The results of the jet fire analyses concluded that for both East Tennessee Natural Gas Pipelines, the determined safe distances (the distance to 5 kW/m^2) are less than the respective separation distances for each pipeline between the CRN Site power block area and the pipeline break (Table 2.2-10).

Therefore, a jet fire or a flammable vapor cloud ignition or explosion from either a rupture in the East Tennessee Natural Gas Pipeline 1 or East Tennessee Natural Gas Pipeline 2 will not adversely affect the safe operation or shutdown of units within the CRN Site power block area (Table 2.2-10).

2.2.3.1.3 Toxic Chemicals

Accidents involving the release of toxic or asphyxiating chemicals from nearby facilities and nearby transportation sources were considered. Toxic chemicals known to be present within the vicinity of the CRN Site, or to be frequently transported in the vicinity, were evaluated. The materials stored at nearby facilities (Table 2.2-2) and potentially transported along I-40

(Table 2.2-3) and by pipeline (Table 2.2-4) were evaluated to ascertain which chemicals should be analyzed with respect to their potential to form a toxic or asphyxiating vapor cloud following an accidental release.

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. 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, chemicals that lead to concentrations above the Immediately Dangerous to Life and Health (IDLH) limit at the power block area boundary will be identified and evaluated during development of the COLA.

The ALOHA air dispersion model was used to predict the chemical concentrations within a toxic or asphyxiating vapor cloud as it disperses downwind for all facilities and sources. ALOHA is a diffusion model that permits temporal as well as spatial variations. In the case of a toxic vapor cloud, the maximum distance a cloud can travel before it disperses enough to fall below the IDLH or other determined toxicity limit concentration in the vapor cloud is determined using ALOHA. Asphyxiating chemicals were evaluated to determine if their release resulted in the displacement of a significant fraction of the control room air. The Occupational Safety and Health Administration (OSHA) provides guidance on what is considered an oxygen-deficient atmosphere.

The IDLH is defined by the National Institute of Occupational Safety and Health (NIOSH) as a situation that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects, or prevent escape from such an environment. The IDLHs are determined by NIOSH so that workers are able to escape such environments without suffering permanent health damage. Where an IDLH is unavailable for a toxic chemical, the time-weighted average (TWA) or threshold limit value (TLV), promulgated by OSHA or adopted by the American Conference of Governmental Hygienists, is used as the toxicity limit.

Each postulated toxicity/asphyxiation event was evaluated under a spectrum of meteorological conditions, in accordance with RG 1.206, to determine the worst-case meteorological condition. The spectrum of meteorological parameters chosen for the meteorological sensitivity analysis was selected based on the defined Pasquill meteorological stability classes (Table 2.2-8). The meteorological sensitivity analysis included the most stable meteorological class, F, allowable with the ALOHA model. Generally, independent of the chemical release rate, under more stable meteorological classes and lower wind speeds, a formed chemical vapor cloud will disperse less with the air around it. Consequently, the dispersion model will predict higher concentrations in the formed cloud before reaching safety-related structures or the control room (the CRN Site power block area boundary). Additionally, as cited in RG 1.78, the Pasquill Stability Category F represents the worst 5th-percentile meteorology observed at the majority of the nuclear power plant sites.

Other atmospheric inputs/assumptions for the ALOHA model included:

- "Urban or Forest" was selected for the ground roughness. The degree of atmospheric turbulence influences how quickly a pollutant cloud moving downwind will mix with the air around it and will be diluted. Friction between the ground and air passing over it is one cause of atmospheric turbulence. The rougher the ground surface, the greater the turbulence that develops. "Urban or Forest" assumes a chemical cloud is traveling over an area with many friction generating elements, such as trees or small buildings. The release locations for each of the postulated scenarios are at least 1 mi from the CRN Site power block area and require a formed vapor cloud to travel over many friction generating elements.

- For each of the identified chemicals in the liquid state (i.e., under the atmospheric release conditions for that scenario, the physical state of the substance is expected to be a liquid), it was conservatively assumed that the entire contents of the vessel are released. Additionally, for this release, the contents formed an instantaneous 1-cm-thick puddle. This provided a significant surface area from which to maximize evaporation and formation of a vapor cloud.
- For each of the identified chemicals in the gaseous state, or for those chemicals that are normally gases at ambient temperatures (i.e., under the atmospheric release conditions for that scenario, the physical state of the substance was expected to be a gas), it was assumed that the quantity released from the vessel/pipeline is released over a 10-min period into the atmosphere as a continuous direct source (40 CFR 68.25).
- In order to model chromic chloride, the following properties were entered as a new chemical into the ALOHA chemical library:

Chemical Name:	Chromic Chloride
Molecular weight:	158.35 grams/mole (g/mol)

- In order to model sulfur hexafluoride, a chemical with a vapor specific gravity of 5.11, as a heavy gas (the ALOHA model does not have enough properties entered in its chemical library to model sulfur hexafluoride as a heavy gas), the following properties were entered as a new chemical into the ALOHA chemical library:

Chemical Name:	Sulfur hexafluoride-heavy
Molecular Weight:	146.05 g/mol
Normal Boiling Point:	209.3 Kelvin (K)
Normal Freezing Point:	209.26 K@101325 Pascal (Pa)
Critical Temperature:	318.69 K
Critical Pressure:	3760000 Pa
Gas Heat Capacity:	550.02 Joule per kilogram per Kelvin (J/kg-K) (at 230.2 K and 101325 Pa)
Liquid Heat Capacity:	818.18 J/kg-K(at 230.15 K and 101325 Pa)

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 in the COLA in order to provide a detailed control room habitability assessment. The effects of toxic chemical releases from nearby facilities and transportation routes are summarized in Table 2.2-11 and are described in the following subsections relative to the release sources.

2.2.3.1.3.1 Nearby Facilities

ORNL located approximately 3.8 mi (20,200 ft); TVA Kingston Fossil Plant located approximately 7.6 mi (40,100 ft); Oak Ridge WTP located approximately 10.3 mi (54,500 ft); TVA Bull Run Fossil Plant located approximately 15 mi (79,400 ft); and Hallsdale Powell Utility District Melton Hill WTP located approximately 18.2 mi (95,900 ft) from the power block area for the CRN Site were identified as facilities of concern with regard to storage of chemicals with the potential for formation of toxic vapor clouds within the vicinity of the CRN Site as determined in Subsection 2.2.2.2.2.

Each material stored at the identified offsite facilities was evaluated with respect to its potential for formation of a toxic vapor cloud. Each material was then dispositioned based on the identified physical properties of the material and whether a bounding analysis exists. The results of this evaluation are found in Table 2.2-5 (for toxic materials not carried forward for further analysis, footnotes indicating the reason for the disposition are provided in the table). The material stored at ORNL–URS identified for further analysis was nitric acid. The materials stored at ORNL–Battelle identified for further analysis with regard to toxicity potential are: anhydrous ammonia, argon, carbon dioxide, chloroform, chromic chloride, ethanol, gasoline (gasoline blend A and gasoline B), hydrogen fluoride, nitrogen, and sulfur hexafluoride. The material stored at TVA Kingston Fossil Plant and TVA Bull Run Fossil Plant identified for further analysis was anhydrous ammonia. The material stored at the Oak Ridge WTP and the Hallsdale Powell Utility District Melton Hill WTP identified for further analysis was chlorine. (Table 2.2-5)

As described in Subsection 2.2.3.1.3, the identified chemicals were analyzed using the ALOHA dispersion model to determine whether the formed vapor cloud would reach the CRN Site power block area with concentrations greater than the determined toxicity limit.

For those chemicals that are gases under the atmospheric release conditions for the given scenario (anhydrous ammonia, argon, carbon dioxide, chlorine, hydrogen fluoride, nitrogen, and sulfur hexafluoride), the distances to the IDLH/asphyxiating or other determined toxicity limits were calculated following a 10-min release from the largest storage. Except for chromic chloride, for those chemicals that are liquids under the atmospheric release conditions for the given scenario (chloroform, ethanol, gasoline blends A and B, and nitric acid), the release scenario in each of these analyses includes the total loss of the largest vessel, resulting in an unconfined 1-cm thick puddle.

Two chemicals, chromic chloride and sulfur hexafluoride, did not exist in ALOHA's chemical library and are entered as new chemicals as described in Subsection 2.2.3.1.3. Chromic chloride is a liquid compound that when heated to decomposition emits toxic fumes of chlorine (a gas). Therefore, this compound is conservatively analyzed as a direct release over 10 min.

In the case of each of the atmospheric gases analyzed, the distances to the IDLH/asphyxiating or other determined toxicity limit was calculated. The results indicate that any plausible toxic vapor cloud that could form would be below the IDLH or other identified toxicity limit before reaching the CRN Site power block area (Table 2.2-11).

Of the chemicals identified for analysis at ORNL–Battelle, a release of sulfur hexafluoride from ORNL–Battelle results in the longest distance to the toxicity endpoint, 10,560 ft, which is less than the distance of 20,200 ft to the CRN Site power block area (Table 2.2-11).

For the ORNL–URS site, a release of nitric acid was analyzed which results in a distance of 15,312 ft to the toxicity endpoint which is less than the distance of 20,200 ft to the CRN Site power block area (Table 2.2-11).

For both TVA Kingston Fossil and TVA Bull Run Fossil Plants, a release of anhydrous ammonia was analyzed. For TVA Bull Run Fossil Plant, a release of anhydrous ammonia results in the longest distance of 21,648 ft to the toxicity endpoint which is less than the distance of 79,400 ft to the CRN Site power block area. For TVA Kingston Fossil Plant, a release of anhydrous ammonia results in a distance of 6336 ft to the toxicity endpoint which is less than the distance of 40,100 ft to the CRN Site power block area. (Table 2.2-11)

For both the Oak Ridge WTP and the Hallsdale Powell Utility District Melton Hill WTP sites, a release of chlorine was analyzed. For the Hallsdale Powell Utility District Melton Hill WTP site, a release of chlorine results in the longest distance of 20,064 ft to the toxicity endpoint which is less than the distance of 95,900 ft to the CRN Site power block area. For the Oak Ridge WTP site, a release of chlorine results in a distance of 15,312 ft to the toxicity endpoint which is less than the distance of 54,500 ft to the CRN Site power block area. (Table 2.2-11)

Therefore, the formation of a toxic vapor cloud following an accidental release of the analyzed hazardous materials stored on site will not adversely affect the safe operation or shutdown of units within the CRN Site power block area (Table 2.2-11).

2.2.3.1.3.2 Nearby Transportation Routes/Roadways

The nearest approach from I-40 to the CRN Site power block area is approximately 1.1 mi (5800 ft). Table 2.2-3 details the hazardous materials potentially transported on I-40. The materials identified for further analysis with regard to formation of toxic vapor clouds were anhydrous ammonia, chlorine, gasoline, nitric acid, and sulfur hexafluoride (Table 2.2-6). It is conservatively assumed that the maximum quantity of the anhydrous ammonia and butane potentially transported on the roadway is 11,500 gal, which is the maximum transport quantity in an MC-331 high pressure tank truck (49 CFR 173.315 and Reference 2.2-42). For chlorine, a maximum transport quantity of 22 T is assumed (Reference 2.2-18). For nitric acid, it was conservatively assumed that the maximum quantity potentially transported on the roadway is 6000 gal, which is the maximum transport quantity in an MC-312/DOT412 Corrosive Tanker (Reference 2.2-42). For gasoline, it was conservatively assumed that 8500 gal is potentially transported on I-40. For sulfur hexafluoride, it was assumed that the maximum quantity transported is 50,000 lb which is the maximum probable solid cargo highway transport quantity identified in RG 1.91.

An analysis for the identified chemicals was conducted using ALOHA as described in Subsection 2.2.3.1.3. The results indicated that, except for anhydrous ammonia and chlorine, that the distances to the identified toxicity limit for any plausible toxic vapor cloud that could form following an accidental release at the closest approach from the transportation route (I-40) are less than the minimum separation distances from the CRN Site power block area to I-40 (Table 2.2-11).

A release of anhydrous ammonia results in a distance of 13,728 ft to the toxicity endpoint and a release of chlorine results in a distance of 23,760 ft to the toxicity endpoint. Both determined distances to the toxic endpoints are greater than the distance of 5800 ft to the CRN Site power block area. Therefore, a main control room habitability impact analysis will be performed at the COL stage for anhydrous ammonia and chlorine.

2.2.3.1.3.3 Nearby Transportation Routes/Pipelines

There are two natural gas transmission pipelines within the vicinity of the CRN Site. The closest approach from the nearest natural gas transmission pipeline, East Tennessee Natural Gas Pipeline 1 (6-in.), to the edge of the CRN Site power block area is approximately 1.1 mi (5800 ft). The closest approach from the East Tennessee Natural Gas Pipeline 2 (22-in.) to the edge of the power block area is approximately 3 mi (15,800 ft). Natural gas or its main constituent, methane, is not considered toxic and there is no IDLH or other toxicity limit identified. However, natural gas is considered an asphyxiant. Therefore, an analysis was conservatively performed for the identified natural gas transmission pipelines to determine whether an oxygen-deficient environment could exist in the control room from the displacement of air. For this analysis, a determination is made as to whether the distances to the asphyxiating limit are less than the distances from the releases to the CRN Site power block area.

Utilizing the methodology and inputs described in Subsection 2.2.3.1.3, natural gas (as methane) was analyzed using the ALOHA dispersion model to determine whether the formed vapor cloud would reach the CRN Site power block area in concentrations such that methane would displace enough oxygen to create an oxygen-deficient environment. The distances to the asphyxiating limit analyzed for the East Tennessee Natural Gas Pipeline 1 and East Tennessee Natural Gas Pipeline 2, under the determined 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. Therefore, a break in either the East Tennessee Gas Pipeline 1 or East Tennessee Gas Pipeline 2 will not displace enough oxygen for the control room to become an oxygen-deficient atmosphere.

2.2.3.1.4 Fires

The locations and quantities of chemicals that would be stored onsite at the CRN Site have not yet been determined. The effects of fires from onsite chemical storage and brush or forest fires will be evaluated in the COLA.

External accidents were considered in the vicinity of the CRN Site that could lead to high heat fluxes or smoke, and nonflammable gas or chemical-bearing clouds from the release of materials as a consequence of fires. Fires from nearby facilities and fires from transportation accidents and pipelines are evaluated as events that could lead to high heat fluxes or to the formation of such clouds.

Those chemicals stored at nearby facilities and transported by roadway on I-40, are evaluated in Subsection 2.2.3.1.2 for potential effects of accidental releases leading to a delayed ignition of any formed vapor cloud. For each of the stored or transported materials evaluated, the results indicate that any formed vapor cloud will dissipate below the LFL before reaching the CRN Site power block area boundary. Therefore, it is not expected that there would be any hazardous effects to units at the CRN Site from fires or heat fluxes associated with the storage of chemicals at nearby facilities or from the transport of chemicals on I-40.

Furthermore, a heat flux analysis for a pipeline break indicates that there would be no effect on the safe operation or shutdown of units within the CRN Site power block area. ALOHA is used to determine the limiting heat flux from a jet fire due to a natural gas pipeline break. The results of the jet fire analysis conclude that the safe distance (i.e., the distance to 5 kW/m^2) for the 6-in. pipeline (Pipeline 1) of 312 ft is less than the separation distance, 5800 ft, between the CRN Site power block area and the pipeline break. The safe distance for the 22-in. pipeline (Pipeline 2) of 1203 ft is less than the separation distance, 15,800 ft.

Therefore, it is not expected that there would be any hazardous effects to units at the CRN Site from fires or heat fluxes associated with the storage of chemicals at nearby facilities, the transport of chemicals on I-40, or from the East Tennessee Natural Gas Pipelines evaluated.

2.2.3.1.5 Collisions with Intake Structure

Because the raw water makeup system intake structure for the CRN Site is not safety-related or anticipated for 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 warranted.

2.2.3.1.6 Liquid Spills

The accidental release of oil or liquids that may be corrosive, cryogenic, or coagulant were considered to determine if the potential exists for such liquids to be drawn into the plant's raw water makeup system's intake structure and circulating water system or otherwise affect the plant's safe operation or shutdown. In the unlikely 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, that is, the intake structure is a non-safety related structure. Therefore, any spill in the Clinch River will not affect the safe operation or shutdown of units at the CRN Site.

2.2.3.2 Effects of Design-Basis Events

Evaluations were performed of potential hazards nearby the CRN Site. These evaluations concluded that potential accidents involving explosions, flammable vapor clouds, collisions with intake structures, and liquid spills do not pose a threat to the CRN Site. The effects of chemical releases from onsite chemical storage will be evaluated in the COLA because plant features such as the control room habitability system design and location of safety-related structures must be considered to determine there is no adverse effect from these hazards.

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Table 2.2-1
Description of Facilities – Products and Materials

Facility	Concise Description	Primary Function	Number of Persons Employed	Major Products
ORNL-Battelle and URS[a]	Federal government science and energy laboratory	Federal sponsored unique research and development	4400	Government research and development laboratory
TVA Kingston Fossil Plant	Coal-fired power plant	Power generation	248	Electrical Power
Oak Ridge WTP[a]	Water treatment plant	Water treatment and distribution	94	Drinking Water Supply
TVA Bull Run Fossil Plant	Coal-fired power plant	Power generation	91	Electrical Power
Hallsdale Powell Utility District Melton Hill WTP[a]	Water treatment plant	Water treatment and distribution	Not Available	Drinking Water Supply

(a) References 2.2-11, 2.2-12, 2.2-14, 2.2-15, 2.2-16, and 2.2-17.

Notes:

U.S. Department of Energy Oak Ridge National Laboratory (ORNL)

UT-Battelle LLC (Battelle)

URS Corporation (URS)

Tennessee Valley Authority (TVA)

Water Treatment Plant (WTP)

Table 2.2-2 (Sheet 1 of 2)
Nearby Facilities Chemical Storage

Chemical	Facility/Location	Capacity (lb)[(a)] (unless otherwise noted)	Toxicity Limit IDLH[(b)]
Tennessee Valley Authority (TVA) Bull Run Fossil Plant			
Anhydrous Ammonia	TVA Bull Run Fossil Plant	60,000 gal	300 ppm
Hydrogen Gas	TVA Bull Run Fossil Plant	95,000	Not available
Tennessee Valley Authority (TVA) Kingston Fossil Plant			
Anhydrous Ammonia	TVA Kingston Fossil Plant	9,999	300 ppm
Bottom Ash	TVA Kingston Fossil Plant	>10,000,000	Not available
Coal	TVA Kingston Fossil Plant	>10,000,000	80 mg/m^3 for coal dust
Fly Ash	TVA Kingston Fossil Plant	>10,000,000	Not available
Fuel Oil	TVA Kingston Fossil Plant	24,999	Not available
Gasoline	TVA Kingston Fossil Plant	4,999	300 ppm TWA[(c)] 750 ppm (as n-Heptane)[(c)]
Gypsum	TVA Kingston Fossil Plant	9,999,999	Not available
Hydrogen Gas	TVA Kingston Fossil Plant	4,999	Not available
Lead	TVA Kingston Fossil Plant	4,999	100 mg/m^3
Limestone	TVA Kingston Fossil Plant	>10,000,000	Not available
Lubricating Oil	TVA Kingston Fossil Plant	9,999	Not available
Mineral Oil	TVA Kingston Fossil Plant	24,999	2,500 mg/m^3
Polychlorinated Biphenyls	TVA Kingston Fossil Plant	9,999	5 mg/m^3
Sulfuric Acid	TVA Kingston Fossil Plant	999	15 mg/m^3
U.S. Department of Energy Oak Ridge National Laboratory – Battelle (ORNL-Battelle)			
Anhydrous Ammonia	ORNL - Battelle	999	300 ppm
Argon	ORNL - Battelle	9,999	Not available
Carbon Dioxide	ORNL - Battelle	4,999	40,000 ppm
Chloroform	ORNL - Battelle	99	500 ppm
Chromic Chloride	ORNL - Battelle	99	25 mg/m^3
Diesel Fuel Oil #2	ORNL - Battelle	24,999	Not available
Ethanol/Gasoline Blend (85:15)	ORNL - Battelle	4,999	3,300 ppm (as ethanol)
Gasoline (unleaded)	ORNL - Battelle	999	300 ppm TWA[(b)] 750 ppm (as n-Heptane)[(b)]
Hydrogen Fluoride	ORNL - Battelle	499	30 ppm
Lead	ORNL - Battelle	9,999	100 mg/m^3
Lithium Hydride	ORNL - Battelle	4,999	0.5 mg/m^3
Mercury	ORNL - Battelle	99	10 mg/m^3
Nitric Acid	ORNL - Battelle	999	25 ppm
Nitrogen	ORNL - Battelle	9,999	Asphyxiant
Oils	ORNL - Battelle	4,999	2,500 mg/m^3
Salt (Sodium Chloride)	ORNL - Battelle	4,999	Not available
Sodium Bisulfite Solution	ORNL - Battelle	9,999	Not available
Sulfuric Acid	ORNL - Battelle	9,999	15 mg/m^3

**Table 2.2-2 (Sheet 2 of 2)
Nearby Facilities Chemical Storage**

Chemical	Facility/Location	Capacity (lb)[(a)] (unless otherwise noted)	Toxicity Limit IDLH[(b)]
Sulfur Hexafluoride	ORNL - Battelle	499,999	1000 ppm as TWA
U.S. Department of Energy Oak Ridge National Laboratory - URS (ORNL – URS)			
Ferri-Floc (Ferric Sulfate)	ORNL - URS	24,999	Not available
Fertilizer (18-24-12)	ORNL - URS	24,999	Not available
Lead	ORNL - URS	499,999	100 mg/m^3
Limestone (AGRI*PEL Pelletized Calcitic)	ORNL - URS	49,999	Not available
Lithium Hydride	ORNL - URS	24,999	0.5 mg/m^3
Nitric Acid	ORNL - URS	499,999	25 ppm
Sodium Hydroxide Solution	ORNL - URS	499,999	10 mg/m^3
Sodium Metal	ORNL - URS	49,999	Not available
Sulfuric Acid	ORNL - URS	24,999	15 mg/m^3
Hallsdale Powell Utility District Melton Hill WTP			
Aluminum Chlorohydrate	Hallsdale Powell Utility District Melton Hill WTP	17,864	Not available
Chlorine	Hallsdale Powell Utility District Melton Hill WTP	24,999	10 ppm
Ferrous Chloride	Hallsdale Powell Utility District Melton Hill WTP	3,580	Not available
Hydrofluorosilicic Acid (Fluoride) 23%	Hallsdale Powell Utility District Melton Hill WTP	11,325	Not available
Sodium Hydroxide Solution	Hallsdale Powell Utility District Melton Hill WTP	700	10 mg/m^3
Sodium Hypochlorite	Hallsdale Powell Utility District Melton Hill WTP	140	10 ppm as Chlorine
Sulfuric Acid	Hallsdale Powell Utility District Melton Hill WTP	7,900	15 mg/m^3
Oak Ridge WTP			
Chlorine	Oak Ridge WTP	10,000	10 ppm

(a) Where a capacity number was obtained from the Superfund Amendments and Reauthorization Act (SARA) Title III, Tier II report, the upper range number is shown and was used in the analysis.
(b) Immediately Dangerous to Life or Health. “Not Available” indicates that there has not been a toxicity limit established for this chemical.
(c) Gasoline does not have an identified IDLH. The Threshold Limit Value–Short Term Exposure Limit TLV–STEL is 500 ppm; the Threshold Limit Value–Time-weighted Average (TLV–TWA) is 300 ppm; and the Protective Action Criteria (PAC) PAC-2 guideline is 1000 ppm for gasoline. For the analyses, n-Heptane is used as a surrogate and has an IDLH of 750 ppm. This selection is conservative given the PAC-2 guideline most closely correlates with the definition of IDLH.

Notes:

URS Corporation (URS)

Parts per million (ppm)

Milligram per cubic meter (mg/m^3)

Immediately Dangerous to Life or Health (IDLH)

Water Treatment Plant (WTP)

Time-weighted Average (TWA)

Sources: References 2.2-4, 2.2-11 and 2.2-13

Table 2.2-3
Hazardous Materials Potentially Transported Along I-40 in the CRN Site Vicinity

Chemical	Quantity	Toxicity Limit IDLH[(a)]
Anhydrous Ammonia	11,500 gal[(h)]	300 ppm
Argon	50,000 lb[(e)]	Asphyxiant
Butane	11,500 gal[(h)]	Asphyxiant
Carbon Dioxide	50,000 lb[(e)]	40,000 ppm
Chlorine	44,000 lb[(f)]	10 ppm
Chloroform	50,000 lb[(e)]	500 ppm
Chromic Chloride	50,000 lb[(e)]	25 mg/m^3
Ethanol	50,000 lb[(e)]	3,300 ppm
Gasoline	8,500 gal[(i)]	300 ppm TWA[(b)] 750 ppm (as n-Heptane)[(b)]
Hydrogen Gas	15,032.84 ft^3/tube[(g)]	Not available[(c)]
Hydrogen Fluoride	50,000 lb[(e)]	30 ppm
Nitric Acid	6,000 gal[(j)]	25 ppm
Nitrogen	50,000 lb[(e)]	Asphyxiant
Sodium Hypochlorite	50,000 lb[(e)]	10 ppm as Chlorine
Sulfur Hexafluoride	50,000 lb[(e)]	1,000 ppm[(d)]

(a) IDLH. “Not Available” indicates that there has not been a toxicity limit established for this chemical.
(b) Gasoline does not have an identified IDLH. The Threshold Limit Value–Short Term Exposure Limit (TLV–STEL) is 500 ppm; the Threshold Limit Value–Time-weighted Average (TLV–TWA) is 300 ppm; and the Protective Action Criteria (PAC) PAC-2 guideline is 1000 ppm for gasoline. For the analyses, n-Heptane is used as a surrogate and has an IDLH of 750 ppm. This selection is conservative given the PAC-2 guideline most closely correlates with the definition of IDLH.
(c) This analysis is bounding for ALOHA vapor cloud dispersion modeling of gaseous hydrogen due to the extreme buoyancy of hydrogen. That is, hydrogen gas would rise extremely rapidly and not cause a travelling vapor cloud.
(d) No IDLH is established for sulfur hexafluoride; therefore, the TWA is used as a toxic limit.
(e) Per RG 1.91, the maximum probable cargo for a single highway truck is 50,000 lb and used for the quantity transported unless a more appropriate value could be determined.
(f) Chlorine gas quantity determined from The Chlorine Institute Bulk Storage of Liquid Chlorine (Reference 2.2-18).
(g) Hydrogen gas quantity determined from Weldship Corporation super jumbo tube product specifications (the largest size tube available) (Reference 2.2-29).
(h) The maximum capacity of MC-331 high pressure tank truck is 11,500 gal per 49 CFR 173.315.
(i) The maximum highway cargo capacity, 50,000 lb provided in RG 1.91 was converted to gal for gasoline.
(j) The maximum capacity of MC-312/DOT412 corrosive tanker is 6000 gal.

Notes:

Parts per million (ppm)

Immediately Dangerous to Life or Health (IDLH)

Time-weighted Average (TWA)

Sources: References 2.2-4, 2.2-13, 2.2-18 and 2.2-29

Table 2.2-4
Pipeline Information Summary

Operator	Pipeline Age	Product	Pipeline Diameter	Operating Pressure	Depth of Burial	Distance Between Isolation Valves
East Tennessee Natural Gas Company[(a)]	1957	Natural Gas Transmission	6-in.	720 psig	Minimum of 3 ft	Unknown
East Tennessee Natural Gas Company[(a)]	1950	Natural Gas Transmission	22-in.	720 psig	Minimum of 3 ft	Unknown

(a) Spectra Energy is the parent company of East Tennessee Natural Gas Company

Source: Reference 2.2-5

Table 2.2-5 (Sheet 1 of 4)
Offsite Chemical Storage – Disposition

Material	Toxicity Limit (IDLH)	Flammability	Explosion Hazard	Vapor Pressure	Disposition
Tennessee Valley Authority (TVA) Bull Run Fossil Plant					
Anhydrous Ammonia	300 ppm	16–25%	Vapor may explode[q]	400 mmHg @ -49.72°F	Toxicity Analysis[o] Flammability Analysis Explosion Analysis
Hydrogen Gas	Not available	4%–75%	Vapor may explode	1.231 psi @ -434°F	No further analysis required[n]
Tennessee Valley Authority (TVA) Kingston Fossil Plant					
Anhydrous Ammonia	300 ppm	16–25%	Vapor may explode[q]	400 mmHg @ -49.72°F	Toxicity Analysis[o] Flammability Analysis Explosion Analysis
Bottom Ash	Not available	Not flammable	None listed	Not available	No further analysis required[b]
Coal	80 mg/m^3 for coal dust	Yes, flammable	None listed	Not available	No further analysis required[e,n]
Fly Ash	Not available	Not flammable	None listed	Not available	No further analysis required[d]
Fuel Oil	Not available	0.7–5%	Vapor may explode	5 mmHg @ 100°F	No further analysis required[a]
Gasoline	300 as TWA[r] 750 ppm (as n-Heptane)[r]	1.4–7.6%	Vapor may explode	382.58 mmHg	No further analysis required[n]
Gypsum	Not available	Not flammable	None listed	0 mmHg	No further analysis required[g]
Hydrogen Gas	Not available	4%–75%	Vapor may explode	1.231 psi @ -434°F	No further analysis required[n]
Lead	100 mg/m^3	Not flammable	None listed	1.77 mmHg	No further analysis required[i]
Limestone	Not available	Not flammable	None listed	0 mmHg	No further analysis required[j]
Lubricating Oil	Not available	Combustible; no flammability limits	None listed	2.17 mmHg @ 70°F 0.042 psi	No further analysis required[a]
Mineral Oil	2500 mg/m^3	Combustible; no flammability limits	None listed	2.17 mmHg @ 70°F 0.042 psi	No further analysis required[a]
Polychlorinated Biphenyls	5 mg/m^3	Not flammable	None listed	6E-05 mmHg	No further analysis required[a]
Sulfuric Acid	15 mg/m^3	Not flammable	None listed	1 mmHg @ 294.8°F	No further analysis required[a]
U.S. Department of Energy Oak Ridge National Laboratory – Battelle (ORNL-Battelle)					
Anhydrous Ammonia	300 ppm	16–25%	Vapor may explode[q]	400 mmHg @ -49.72°F	Toxicity Analysis[o] Flammability Analysis Explosion Analysis
Argon	Not available	Not flammable	None listed	1,044,630 Pa @ 117.3K	Toxicity Analysis (Asphyxiation)
Carbon Dioxide	40,000 ppm	Not flammable	None listed	56.5 atm @ 68°F	Toxicity Analysis
Chloroform	500 ppm	Not flammable	None listed	160 mmHg	Toxicity Analysis

Table 2.2-5 (Sheet 2 of 4)
Offsite Chemical Storage – Disposition

Material	Toxicity Limit (IDLH)	Flammability	Explosion Hazard	Vapor Pressure	Disposition
Chromic Chloride	25 mg/m^3	Not flammable	None listed	Not available	Toxicity Analysis
Diesel Fuel Oil #2	Not available	1.3–6%	Vapor may explode	2.17 mmHg @ 70°F	No further analysis required[a]
Ethanol/Gasoline Blend	3300 ppm (as ethanol)	3.3–9% 1.4%–7.6%	Vapor may explode	40 mmHg @ 66°F	Toxicity Analysis Flammability Analysis Explosion Analysis
Gasoline (unleaded)	300 as TWA[r] 750 ppm (as n-Heptane)[r]	1.4–7.6%	Vapor may explode	382.58 mmHg	Toxicity Analysis Flammability Analysis Explosion Analysis
Hydrogen Fluoride	30 ppm	Not flammable	None listed	783 mmHg	Toxicity Analysis
Lead	100 mg/m^3	Not flammable	None listed	1.77 mmHg	No further analysis required[i]
Lithium Hydride	0.5 mg/m^3	Yes, flammable	None listed	0 mmHg	No further analysis required[a]
Mercury	10 mg/m^3	Not flammable	None listed	0.0012 mmHg	No further analysis required[a]
Nitric Acid	25 ppm	Not flammable	None listed	48 mmHg	No further analysis required[n]
Nitrogen	Asphyxiant	Not flammable	None listed	1.931 psi @ -344°F	Toxicity Analysis (Asphyxiation)
Oils	2500 mg/m^3	Combustible; no flammability limits	None listed	2.17 mmHg @ 70°F 0.042 psi	No further analysis required[a]
Salt (Sodium Chloride)	Not available	Not flammable	None listed	1 mmHg	No further analysis required[a]
Sodium Bisulfite Solution	Not available	Not flammable	None listed	Solid – in solution	No further analysis required[m]
Sulfuric Acid	15 mg/m^3	Not flammable	None listed	1 mmHg @ 294.8°F	No further analysis required[a]
Sulfur Hexafluoride	1000 ppm as TWA	Not flammable	None listed	21.5 atm	Toxicity Analysis
U.S. Department of Energy Oak Ridge National Laboratory - URS (ORNL - URS)					
Ferri-Floc (Ferric Sulfate)	Not available	Not flammable	None listed	Not available	No further analysis required[k]
Fertilizer (18-24-12)	Not available	Not flammable	None listed	Not available	No further analysis required[l]
Lead	100 mg/m^3	Not flammable	None listed	1.77 mmHg	No further analysis required[i]
Limestone (AGRI*PEL Pellitized Calcitic)	Not available	Not flammable	None listed	0 mmHg	No further analysis required[j]
Lithium Hydride	0.5 mg/m^3	Yes, flammable	None listed	0 mmHg	No further analysis required[a]
Nitric Acid	25 ppm	Not flammable	None listed	48 mmHg	Toxicity Analysis
Sodium Hydroxide Solution	10 mg/m^3	Not flammable	None listed	Solid – in solution	No further analysis required[h]
Sodium Metal	Not available	Yes, flammable	Vapor may explode	Not available	No further analysis required[p]
Sulfuric Acid	15 mg/m^3	Not flammable	None listed	1 mmHg @ 294.8°F	No further analysis required[a]

Table 2.2-5 (Sheet 3 of 4)
Offsite Chemical Storage – Disposition

Material	Toxicity Limit (IDLH)	Flammability	Explosion Hazard	Vapor Pressure	Disposition
Hallsdale Powell Utility District Melton Hill WTP					
Aluminum Chlorohydrate	Not available	Not flammable	None listed	Solid – in a solution	No further analysis required[f]
Chlorine	10 ppm	Not flammable	None listed	7600 mmHg @ 86°F (6.8 atm)	Toxicity Analysis[o]
Ferrous Chloride	Not available	Not flammable	None listed	Solid – in a solution	No further analysis required[c]
Hydrofluorosilicic Acid (Fluoride) 23%	Not available	Not flammable	None listed	Solid – in a solution	No further analysis required[a]
Sodium Hydroxide Solution	10 mg/m^3	Not flammable	None listed	Solid – in a solution	No further analysis required[h]
Sodium Hypochlorite	10 ppm as Chlorine	Not flammable	None listed	12.1 mmHg @ 68°F	No further analysis required[n]
Sulfuric Acid	15 mg/m^3	Not flammable	None listed	1 mmHg @ 294.8°F	No further analysis required[a]
Oak Ridge WTP					
Chlorine	10 ppm	Not flammable	None listed	7600 mmHg @ 86°F (6.8 atm)	Toxicity Analysis[o]

(a) According to Regulatory Guide 1.78, if a substance's vapor pressure is below 10 torr (approximately 10 mmHg); the vapor pressure is sufficiently low such that the formation of a vapor cloud is not a likely event. Therefore, an air dispersion hazard is not a likely exposure route.
(b) Bottom Ash is a noncombustible solid and the vapor pressure is not applicable. It is stable under most conditions, thus, an air dispersion hazard is not a likely route of exposure.
(c) Ferrous Chloride is a noncombustible solid in solution and does not burn. No IDLH is established and the TWA is 1 mg/m^3. Therefore, an air dispersion hazard is not a likely exposure route.
(d) Fly Ash is a noncombustible solid and the vapor pressure is not applicable. It is stable under most conditions, thus, an air dispersion hazard is not a likely route of exposure.
(e) Coal is a highly flammable/combustible solid that may be ignited by friction, heat, sparks or flames. Coal dust is explosive when exposed to heat or flame and freshly prepared material can heat and spontaneously ignite in air. Some coal material may burn rapidly with flare burning effect. Coal powder, dusts, shavings, borings, turnings or cuttings may explode or burn with explosive violence.
(f) Aluminum Chlorohydrate is a colorless to light yellow, noncombustible solid in solution. No toxicity limit is established for this chemical and an air dispersion hazard is not a likely exposure route.
(g) Gypsum is a noncombustible white or nearly white, odorless, crystalline solid with a very low vapor pressure. No toxicity limit is established for this chemical. An air dispersion hazard is not a likely exposure route.
(h) Sodium hydroxide solution is a dark, thick liquid that is a severe irritant and is toxic and corrosive. It will not burn under typical fire conditions and is normally stable but is unstable at elevated temperatures and pressures.
(i) Lead, in its pure form, is a noncombustible solid and, therefore, has a very low vapor pressure. No toxicity limit in air is established for this chemical. Therefore, an air dispersion hazard is not a likely route of exposure.
(j) Limestone is a noncombustible solid and has a very low vapor pressure. No toxicity limit is established for this chemical; therefore, an air dispersion hazard is not a likely route of exposure.
(k) Ferri-Floc is a noncombustible solid and has a very low vapor pressure. No toxicity limit is established for this chemical; therefore, an air dispersion hazard is not a likely route of exposure.
(l) 18-24-12 Fertilizer is a noncombustible solid and has a very low vapor pressure. No toxicity limit is established for this chemical; therefore, an air dispersion hazard is not a likely route of exposure.
(m) Sodium Bisulfite Solution is a pale yellow, noncombustible solid in solution. No toxicity limit is established for this chemical and an air dispersion hazard is not a likely exposure route.

Table 2.2-5 (Sheet 4 of 4)
Offsite Chemical Storage – Disposition

(n) No further analysis is required because either a bounding analysis is provided (e.g., chemical is analyzed in greater quantity) or according to Regulatory Guide 1.78, chemicals stored or situated at distances greater than 5 mi from the plant need not be considered because atmospheric dispersion will dilute and disperse the incoming plume such that toxic limits will never be reached.
(o) Per 40 CFR 68.130, chemicals such as ammonia and chlorine have been identified as very hazardous substances and require an offsite consequence analysis for Risk Management Programs required under the Clean Air Act consisting of a worst-case release scenario and/or alternative release scenarios with a toxic endpoint evaluated at facilities greater than 5 mi from the CRN Site (as defined in 40 CFR 68.25).
(p) Sodium metal is extremely toxic; however as a solid it is not capable of forming a vapor cloud, therefore an air dispersion hazard is not a likely route of exposure.
(q) Studies have shown that an ammonia-air mixture does not ignite at less than 1562°F. Conditions favorable for ignition are seldom encountered during normal operations due to this high ignition temperature required.
(r) Gasoline does not have an identified IDLH. The Threshold Limit Values–Short Term Exposure Limit (TLV–STEL) is 500 ppm; the TLV–TWA is 300 ppm; and the Protective Action Criteria (PAC) PAC-2 guideline is 1000 ppm for gasoline. For the analyses, n-Heptane is used as a surrogate and has an IDLH of 750 ppm. This selection is conservative given the PAC-2 guideline most closely correlates with the definition of IDLH.

Notes:

Immediately Dangerous to Life or Health (IDLH)

Parts per million (ppm)

Millimeters of mercury (mmHg)

Time-weighted Average (TWA)

Pascal (Pa)

Kelvin (K)

Atmosphere (atm)

Water Treatment Plant (WTP)

Sources: References 2.2-4, 2.2-11, 2.2-13, 2.2-18, and 2.2-29

Table 2.2-6 (Sheet 1 of 2)
Disposition of Hazardous Materials Potentially Transported on Interstate 40 (I-40)

Material	Toxicity Limit (IDLH)	Flammability	Explosion Hazard	Vapor Pressure	Disposition
Anhydrous Ammonia	300 ppm	16–25%	Vapor may explode[g]	400 mmHg @ -49.72°F	Toxicity Analysis[a]
Argon	Not available	Not flammable	None listed	1,044,630 Pa @ 117.3K	No further analysis required[b]
Butane	Asphyxiant	1.6–8.4%	Vapor may explode	760 mmHg @ 31.1°F	Flammability Analysis Explosion Analysis
Carbon Dioxide	40,000 ppm	Not flammable	None listed	56.5 atm @ 68°F	No further analysis required[b]
Chlorine	10 ppm	Not flammable	None listed	7600 mmHg @ 86°F (6.8 atm)	Toxicity Analysis[d]
Chloroform	500 ppm	Not flammable	None listed	160 mmHg	No further analysis required[b]
Chromic Chloride	25 mg/m^3	Not flammable	None listed	Not available	No further analysis required[b]
Ethanol	3300 ppm 10% LEL	3.3–19%	Vapor may explode	40 mmHg @ 66°F	No further analysis required[c]
Gasoline	300 as TWA[h] 750 ppm (as n-Heptane)[h]	1.4–7.6%	Vapor may explode	382.58 mmHg	Toxicity Analysis Flammability Analysis Explosion Analysis
Hydrogen Gas	Not available	4–75%	Vapor may explode	1.231 psi @ -434°F	Explosion Analysis [f]
Hydrogen Fluoride	30 ppm	Not flammable	None listed	783 mmHg	No further analysis required[b]
Nitric Acid	25 ppm	Not flammable	None listed	48 mmHg	Toxicity Analysis[a]
Nitrogen	Asphyxiant	Not flammable	None listed	1.931 psi @ -344°F	No further analysis required[b]
Sodium Hypochlorite	10 ppm as Chlorine	Not flammable	None listed	12.1 mmHg @ 68°F	No further analysis required[e]
Sulfur Hexafluoride	1000 ppm as TWA	Not flammable	None listed	21.5 atm	Toxicity Analysis[a]

(a) Single or multiple storage locations; maximum evaluated quantity greater than 50,000 lbs; maximum evaluated safe distance is greater than 1 mi for toxicity and less than 1 mi for flammable/explosive evaluations.
(b) Single storage location (assume transport quantity is equivalent to maximum storage quantity); maximum evaluated safe distance is less than 1 mi for each accident category evaluated.
(c) Screened based on bounding heat of combustion evaluation (butane for hydrocarbons); no toxicity limit or toxicity limit based on 10% LEL.
(d) Multiple storage location; maximum evaluated quantity is less than 50,000 lbs; and maximum evaluated safe distance is greater than 1 mi.
(e) Screened based on bounding toxicity evaluation for chlorine.
(f) Due to the buoyant nature of gaseous hydrogen such as in tube trailers, gaseous hydrogen is not considered to present an outdoor vapor cloud explosion potential or toxic threat to the control room.
(g) Studies have shown that an ammonia-air mixture does not ignite at less than 1562°F. Conditions favorable for ignition are seldom encountered during normal operations due to high ignition temperature required.
(h) Gasoline does not have an identified IDLH. The Threshold Limit Value–Short Term Exposure Limit (TLV–STEL) is 500 ppm; the Threshold Limit Value (TLV–TWA) is 300 ppm; and the Protective Action Criteria (PAC) PAC-2 guideline is 1000 ppm for gasoline. For the analyses, n-Heptane is used as a surrogate and has an IDLH of 750 ppm. This selection is conservative given the PAC-2 guideline most closely correlates with the definition of IDLH.

Table 2.2-6 (Sheet 2 of 2)
Disposition of Hazardous Materials Potentially Transported on Interstate 40 (I-40)

Notes:
Immediately Dangerous to Life or Health (IDLH)
Millimeters of mercury (mmHg)
Pascal (Pa)
Kelvin (K)
Atmosphere (atm)
Lower Explosive Limit (LEL)
Time-weighted Average (TWA)

Sources: References 2.2-4, 2.2-13, 2.2-18, and 2.2-29

Table 2.2-7
Aircraft Operations—Significant Factors

Airport	Projected Number of Operations per Year[a]	Distance from Plant, D (statute mile (mi))	Significance Factor[b]
Big T (80TN)	<10[c]	5[d]	12,500
Wolf Creek (2TN7)	<10[e]	5[d]	12,500
Cox Farm (TN71)	<10[f]	5[d]	12,500
Will A Hildreth Farm (TN74)	<10[g]	5[d]	12,500
Riley Creek (12TN)	11,000[h]	5[d]	12,500
Oliver Springs (TN08)	9000[i]	10[j]	100,000
Fergusons Flying Circus (TN09)	<10[k]	10[j]	100,000
Knoxville McGhee Tyson Airport (TYS)	193,735	22.3	497,290
Knoxville Downtown Island Airport (DKX)	108,099	28.8	829,440
Chattanooga Lovell Airport (CHA)	103,611	74.9	5,610,010
Lexington Blue Grass Airport (LEX)	145,040	136.0	18,496,000
Louisville International Standiford Field Airport (SDF)	268,817	178.0	31,684,000
Charlotte Douglas International Airport (CLT)	1,014,103	199.1	39,649,969
Hartsfield-Jackson Atlanta International Airport (ATL)	1,432,594	212.0	44,944,000

(a) The values for airports with available Federal Aviation Administration (FAA) Terminal Area Forecast (TAF) data operations are projected 2040 APO values (where the projected number of operations is not derived from FAA TAF data, the data is noted).
(b) $500D^2$ movements per year for sites within 5 to 10 statute mi and $1000D^2$ movements per year for sites outside 10 statute mi where D is the distance from the Clinch River Nuclear (CRN) Site to the airport.
(c) Private airport with one single engine plane based. Permission is required to land; no operations reported for 12 months ending 5/29/2005 (References 2.2-7 and 2.2-8).
(d) Conservatively, for airports located between 5 and 10 statute mi of the CRN Site the significance factor is based on a distance of 5 mi.
(e) Private airport with 2 single engine planes based. No operations reported for 12 months ending March 19, 2003. (References 2.2-7 and 2.2-8)
(f) Private airport with 2 single engine planes based. Permission is required to land; no operations reported (References 2.2-7 and 2.2-8).
(g) Private airport with 4 single engine planes based. Permission is required to land; no operations reported (References 2.2-7 and 2.2-8).
(h) Private airport with 31 single engine planes and 3 multi-engine planes based. 11,000 operations reported for 12 months ending February 9, 2000. (References 2.2-7 and 2.2-8)
(i) Private airport with 22 single engine planes based. 7000 general aviation and 2000 general aviation itinerant operations reported (References 2.2-7 and 2.2-8).
(j) Conservatively, for airports located between 10 and 15 mi of the CRN Site the significance factor is based on a distance of 10 mi.
(k) Private airport with 9 single engine planes based. No operations reported (References 2.2-7 and 2.2-8).

Table 2.2-8
ALOHA Meteorological Sensitivity Analysis Inputs

Stability Class	Surface Wind Speed (m/s)		Cloud Cover (percent)	Date/ Time
ALOHA Vapor Cloud Analyses (Toxic, Flammable and Explosion [Delayed Ignition])[(a)]				
A	1.5		0	June 21, 2014 / 12 noon
B	1.5		50	June 21, 2014 / 12 noon
C	3		50	June 21, 2014 / 12 noon
C	5.5		0	June 21, 2014 / 12 noon
D	3		50	June 21, 2014 / 5 AM
D	5.5		50	June 21, 2014 / 12 noon
E	1		50	June 21, 2014 / 5 AM
E	2		50	June 21, 2014 / 5 AM
F	1		0	June 21, 2014 / 5 AM
F	2		0	June 21, 2014 / 5 AM
F	3		0	June 21, 2014 / 5 AM
ALOHA Jet Fire Analysis				
Stability Class	**Surface Wind Speed (m/s)**	**Cloud Cover (percent)**	**Humidity (percent)**	**Date/ Time**
F	1	0	0	June 21, 2014 / 5 AM
F	1	0	25	June 21, 2014 / 5 AM
F	1	0	50	June 21, 2014 / 5 AM
F	1	0	75	June 21, 2014 / 5 AM
F	1	0	100	June 21, 2014 / 5 AM

(a) A day time temperature of 95.7 degrees Fahrenheit (° F) is used for the day time meteorological sets (12 noon). This is the highest mean of the extreme maximum temperatures for Oak Ridge, Tennessee (KOQT) (Reference 2.2-48). A night time temperature of 68.8°F is used for the night time meteorological sets (5 AM). This is the highest mean daily minimum temperature for Oak Ridge, Tennessee (KOQT) (Reference 2.2-48). The position of the sun for the date and time is used to determine the solar radiation. The date, June 21, 2014, was selected because it coincides with the summer solstice.

Notes:

Ante Meridiem (AM)

Post Meridiem (PM)

Table 2.2-9
Design-Basis Events – Explosions

Source	Chemical Evaluated	Quantity Analyzed	Heat of Combustion (Btu/lb)	Distance to CRN Site Power Block Area (ft)	Safe Distance for Explosion to have less than 1 psi of Peak Incident Pressure (ft)
Nearby Offsite Facilities					
TVA Bull Run Fossil Plant	Anhydrous Ammonia	30,000 gal	7,992	79,400	270.9
TVA Kingston Fossil Plant	Anhydrous Ammonia	9,999 lb	7,992	40,100	105.3
ORNL-Battelle	Anhydrous Ammonia	999 lb	7,992	20,200	47.8
	Ethanol (85%)	4,249 lb	11,570		103.3
	Gasoline Blend A (as n-Heptane)	750 lb	18,720		63.4
	Gasoline B (as n-Heptane)	999 lb	18,720		75.4
Nearby Transport Routes/Roadways					
I-40	Butane	11,500 gal	19,512	5,800	3,708
	Gasoline	8,500 gal	18,720		273
	Hydrogen	15,032 ft^3[(a)]	50,080		520
Nearby Transport Routes/Pipelines					
East Tennessee Natural Pipeline 1 (6-in)	Natural Gas (as methane)	1,960 lb[(b)]	21,517	5,800	1,250
East Tennessee Natural Pipeline 2 (22-in)	Natural Gas (as methane)	26,400 lb[(b)]	21,517	15,800	2,970

(a) Transport quantity for a super jumbo tube (Reference 2.2-29).
(b) Quantity of natural gas released over 5 seconds after a postulated pipeline rupture.

Notes:

British Thermal Unit (Btu)

Tennessee Valley Authority (TVA)

U.S. Department of Energy Oak Ridge National Laboratory–Battelle (ORNL–Battelle)

Table 2.2-10 (Sheet 1 of 2)
Design-Basis Events –Flammable Vapor Clouds (Delayed Ignition) Deflagration and Detonation and Jet Fire

Source	Chemical Evaluated	Quantity Analyzed[h]	Distance to CRN Site Power Block Area (ft)	Distance to LFL (ft)	Safe Distance for Vapor Cloud Explosions to have less than 1 psi of Peak Incident Pressure (ft)	Jet Fire—Distance to 5 kW/m^2 (ft)
Nearby Offsite Facilities						
TVA Bull Run Fossil Plant	Anhydrous Ammonia	30,000 gal	79,400	924[a]	2,601[b]	
TVA Kingston Fossil Plant	Anhydrous Ammonia	9,999 lb	40,100	345[b]	918[b]	
ORNL-Battelle	Anhydrous Ammonia	999 lb	20,200	126[b]	342[b]	
	Ethanol (85%)	4,249 lb		<33	No Detonation[c]	
	Gasoline Blend A (as n-Heptane)	750 lb		<33	75[d]	
	Gasoline B (as n-Heptane)	999 lb		<33	81[d]	
Nearby Transport Routes/Roadways						
I-40	Butane	11,500 gal	5,800	1,827[b]	3,864[b]	
	Gasoline	8,500 gal		132[b]	618[d]	
Nearby Transport Routes/Pipelines						
East Tennessee Natural Gas Pipeline 1 (6-in)	Natural Gas (as methane)	666,312 lb[f] 683,023 lb[g]	5,800	477[e]	1,575[b]	312[b]
East Tennessee Natural Gas Pipeline 2 (22-in)		9,624,751 lb[f] 9,866,045 lb[g]	15,800	1,401[e]	4,572[b]	1,203[b]

Table 2.2-10 (Sheet 2 of 2)
Design-Basis Events –Flammable Vapor Clouds (Delayed Ignition) Deflagration and Detonation and Jet Fire

(a) Worst-case scenario meteorological condition is F stability class at two meters per second (m/s).
(b) Worst-case scenario meteorological condition is F stability class at one m/s.
(c) "No Detonation" is listed when ALOHA reports that there is no detonation of the formed vapor cloud, i.e., no part of the vapor cloud is above the lower explosive limit (LEL) at any time.
(d) Worst-case scenario meteorological condition is B stability class at 1.5 m/s.
(e) Worst-case scenario meteorological condition is D stability class at 5.5 m/s.
(f) Quantity of natural gas (as methane) released from a break in the natural gas pipeline under worst case meteorological condition for deflagration scenario; assumed pipeline length of 200 times the diameter; pressure 734.7 pounds per square inch atmosphere (psia); complete break; and connected to infinite source (Subsection 2.2.3.1.2.3).
(g) Quantity of natural gas (as methane) released from a break in the natural gas pipeline under worst case meteorological condition for detonation scenario; assumed pipeline length of 200 times the diameter; pressure 734.7 psia; complete break; and connected to infinite source. (Subsection 2.2.3.1.2.3)
(h) Where a capacity number was obtained from the Superfund Amendments and Reauthorization Act (SARA) Title III, Tier II report, the upper range number is shown and was used in the analysis.

Notes:

Tennessee Valley Authority (TVA)

U.S. Department of Energy Oak Ridge National Laboratory–Battelle (ORNL–Battelle)

Table 2.2-11 (Sheet 1 of 2)
Design-Basis Events –Toxic Vapor Clouds

Source	Chemical Evaluated	Quantity Analyzed[n]	IDLH Limit	Distance to CRN Site Power Block Area (ft)	Distance to IDLH (ft)
Nearby Offsite Facilities					
TVA Bull Run Fossil Plant	Anhydrous Ammonia	30,000 gal	300 ppm	79,400	21,648[a]
TVA Kingston Fossil Plant	Anhydrous Ammonia	9,999 lb	300 ppm	40,100	6,336[a]
ORNL–Battelle	Anhydrous Ammonia	999 lb	300 ppm	20,200	2,190[a]
	Argon	9,999 lb	71,400 ppm[b]		180[a]
	Carbon Dioxide	4,999 lb	40,000 ppm		360[a]
	Chloroform	99 lb	500 ppm		60[d]
	Chromic Chloride	99 lb	25 mg/m^3		2,871[a]
	Ethanol (85%)	4,249 lb	3,300 ppm		87[a]
	Gasoline Blend A (as n-Heptane)	750 lb	750 ppm[e]		75[a][f]
	Gasoline Blend B (as n-Heptane)	999 lb	750 ppm[e]		90[a][g]
	Hydrogen Fluoride	499 lb	30 ppm		4,848[c]
	Nitrogen	9,999 lb	71,400 ppm[b]		489[a]
	Sulfur Hexafluoride	499,999 lb	1,000 ppm[i]		10,560[a]
ORNL–URS	Nitric Acid	499,999 lb	25 ppm	20,200	15,312[h]
Hallsdale Powell Utility District Melton Hill WTP	Chlorine	24,999 lb	10 ppm	95,900	20,064[c]
Oak Ridge WTP	Chlorine	10,000 lb	10 ppm	54,500	15,312[c]
Nearby Transport Routes/Roadways					
I-40	Anhydrous Ammonia	11,500 gal	300 ppm	5,800	13,728[j][a]
	Butane	11,500 gal	71,400 ppm[b]		849[a]
	Chlorine	22 T	10 ppm		23,760[c][k]
	Gasoline	8,500 gal	750 ppm[e]		687[a][l]
	Nitric Acid	6,000 gal	25 ppm		5,280[c]
	Sulfur Hexafluoride	50,000 lb	1,000 ppm[i]		3,705[a]

Table 2.2-11 (Sheet 2 of 2)
Design-Basis Events –Toxic Vapor Clouds

Source	Chemical Evaluated	Quantity Analyzed[n]	IDLH Limit	Distance to CRN Site Power Block Area (ft)	Distance to IDLH (ft)
Nearby Transport Routes/Pipelines					
East Tennessee Pipeline 1 (6-in)	Natural Gas (as methane)	666,312 lb[m]	71,400 ppm[b]	5,800	282[h]
East Tennessee Pipeline 2 (22-in)		9,624,751 lb[m]		15,800	846[h]

(a) Worst-case scenario meteorological condition is F stability class at one meter per second (m/s).
(b) Asphyxiation Limit.
(c) Worst-case scenario meteorological condition is F stability class at three m/s.
(d) Worst-case scenario meteorological condition is F stability class at two m/s.
(e) Gasoline does not have an identified IDLH. The Threshold Limit Value–Short Term Exposure Limit (TLV–STEL) is 500 ppm; the Threshold Limit Value–Time-weighted Average (TLV–TWA) is 300 ppm; and the Protective Action Criteria (PAC) PAC-2 guideline is 1000 ppm for gasoline. For the analyses, n-Heptane is used as a surrogate and has an IDLH of 750 ppm. This selection is conservative given the PAC-2 guideline most closely correlates with the definition of IDLH.
(f) The distance to the TLV–STEL is 99 ft, and the distance to the TLV–TWA is 132 ft.
(g) The distance to the TLV–STEL is 111 ft, and the distance to the TLV–TWA is 150 ft.
(h) Worst-case scenario meteorological condition is D stability class at 5.5 m/s.
(i) TLV–TWA Limit.
(j) The toxicity limit at the CRN Site power block area is exceeded. A main control room habitability impact analysis will be performed at the COL stage for this chemical. (Subsection 2.2.3.1.3.2).
(k) The toxicity limit at the CRN Site power block area is exceeded. A main control room habitability impact analysis will be performed at the COL stage for this chemical.
(l) The distance to the TLV–STEL is 843 ft and the distance to the TLV–TWA is 1089 ft.
(m) Quantity of natural gas (as methane) released from a break in the natural gas pipeline under worst case meteorological condition for the toxic vapor cloud scenario; assumed pipeline length of 200 times the diameter; pressure 734.7 pounds per square inch atmosphere (psia); complete break; and connected to infinite source. (Subsection 2.2.3.1.2.3)
(n) Where a capacity number was obtained from the Superfund Amendments and Reauthorization Act (SARA) Title III, Tier II report, the upper range number is shown and was used in the analysis.

Notes:

Immediately Dangerous to Life and Health (IDLH)

Parts per million (ppm)

Ton (T)

Tennessee Valley Authority (TVA)

Waste Treatment Plant (WTP)

U.S. Department of Energy Oak Ridge National Laboratory–Battelle (ORNL–Battelle)

U.S. Department of Energy Oak Ridge National Laboratory–URS (ORNL–URS)

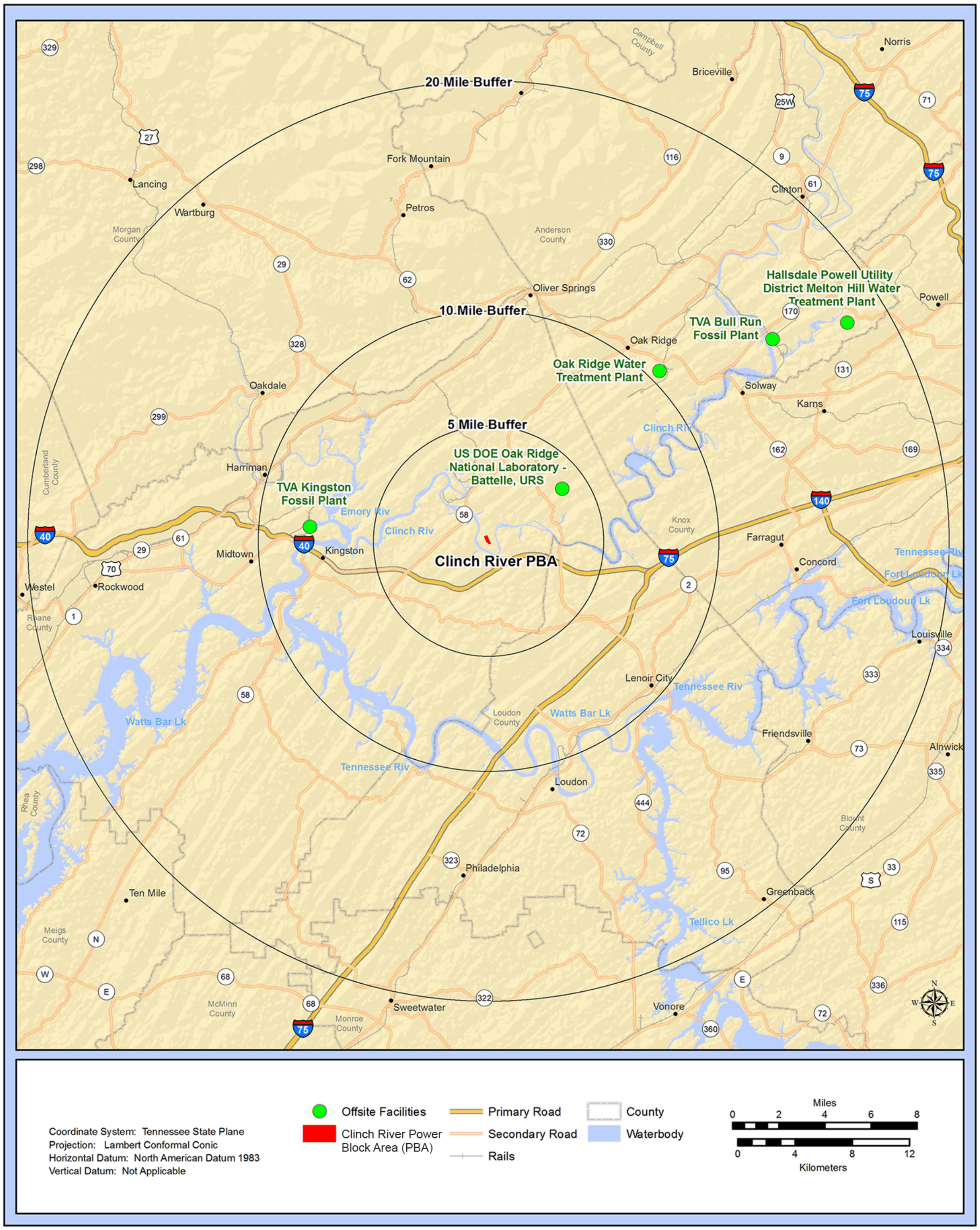

Figure 2.2-1. Identified Industrial Facilities Nearby the Clinch River Nuclear Site

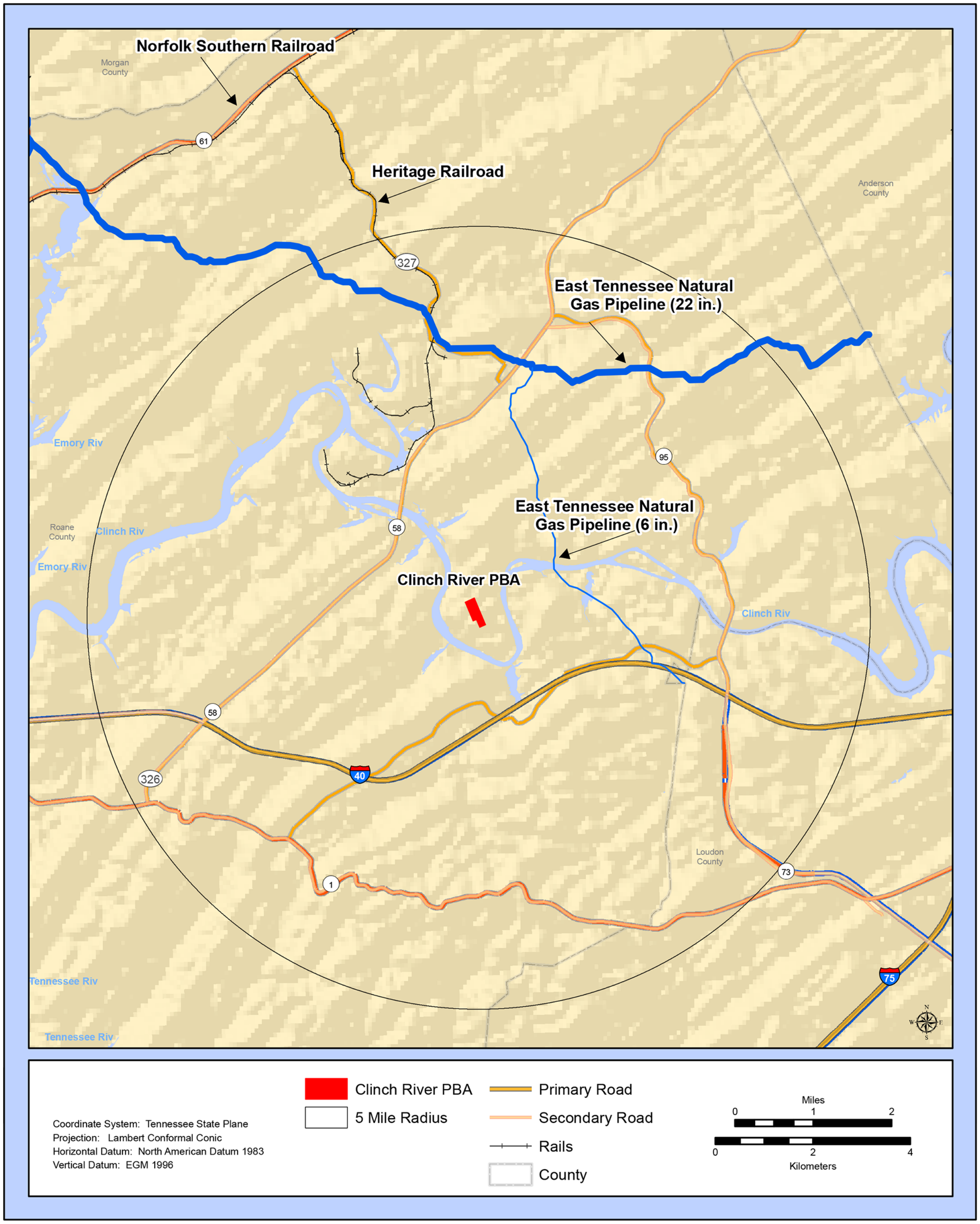

Figure 2.2-2. Transportation Routes and Pipelines Within the Clinch River Nuclear Site Vicinity

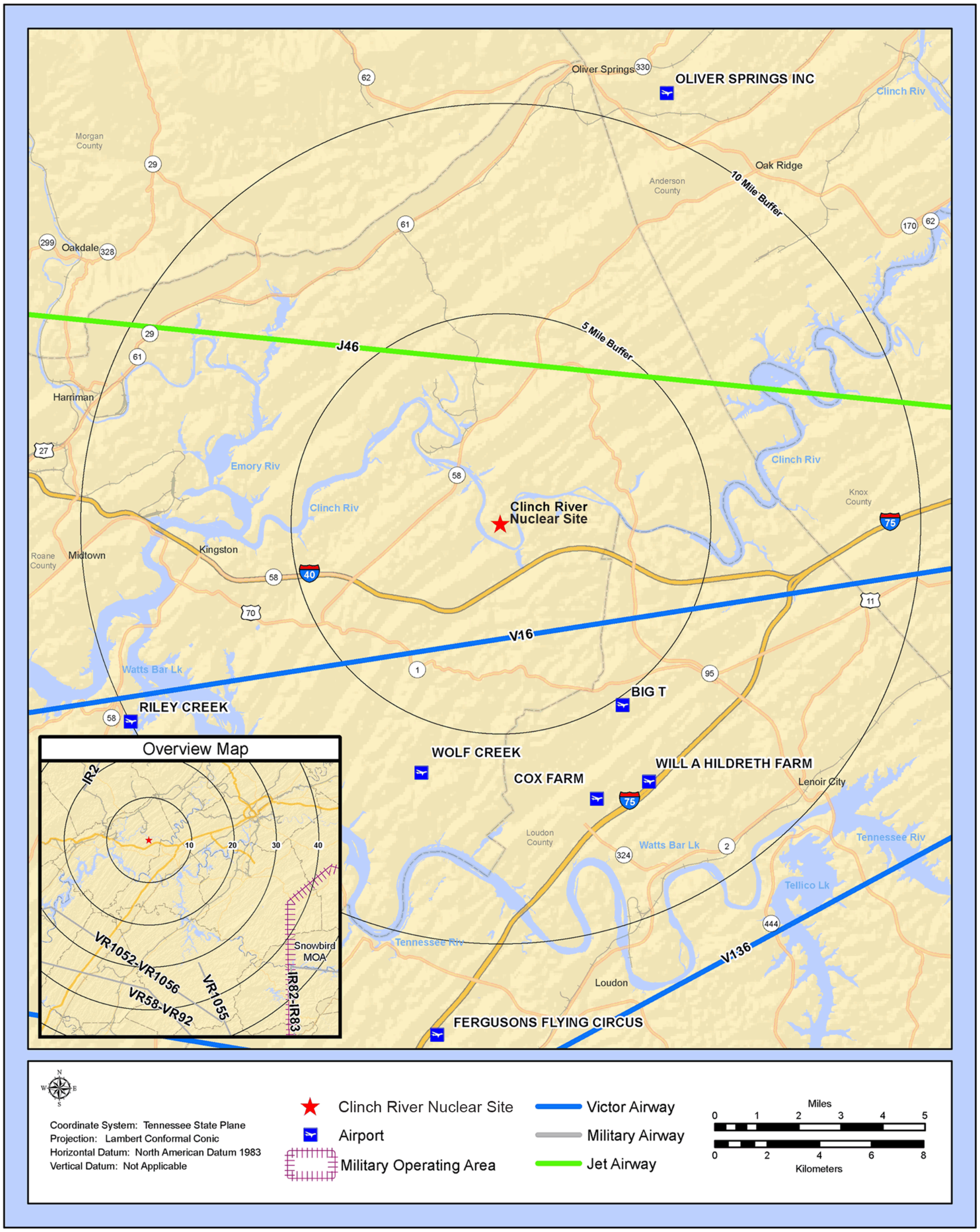

Figure 2.2-3. Location of Airports and Airways