3. DESIGN

3.2 Radiological Effluent Release Dose Consequences from Normal Operations

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the information on radiological dose consequences caused by gaseous and liquid effluents that may be released from normal operation of the plant that was provided by reference in Site Safety Analysis Report (SSAR) Section 2.3.5.1 and included in the Environmental Report Section 5.4 and Tables 3.1-9, 5.4-10, and 5.4-11 of the Dominion Nuclear North Anna, LLC (Dominion or the applicant), early site permit (ESP) application to determine whether site characteristics are such that the radiation dose to members of the public would be within regulatory requirements.

3.2.1 Technical Information in the Application

The applicant provided information on the radiological impacts on members of the public from gaseous and liquid effluents that would be generated as a normal byproduct of nuclear power operations. The applicant described the exposure pathways by which radiation and radioactive effluents can be transmitted to members of the public in the vicinity of the site. The estimates on the maximum doses to the public are based on the available data on the reactor designs being considered using the plant parameter envelope (PPE) approach in which the bounding liquid and gaseous radiological effluents were used in the evaluation. The applicant evaluated the impact of these doses by comparing them to regulatory limits.

Using the PPE approach, Dominion provided a list of fission and activation products that may be released as liquid and gaseous effluents from the postulated new units. The applicant evaluated the impacts from releases and direct radiation by considering the probable pathways to individuals, populations, and biota near the proposed new units. The applicant also calculated the highest dose from the major exposure pathways for a given receptor.

If built, the postulated new units at the North Anna ESP site would release liquid effluents into the waste heat treatment facility (WHTF) through the discharge canals used for the operating units. The applicant considered the following liquid pathways–ingestion of aquatic food; ingestion of drinking water; exposure to shoreline sediment; and exposure to water through boating, swimming, and other activities.

Dominion also considered gaseous pathways, including external exposure to the airborne plume, external exposure to contaminated ground, inhalation of airborne activity, and ingestion of contaminated agricultural products, in its application.

The applicant calculated the dose to the maximally exposed individual (MEI) from both the liquid and gaseous effluent release pathways and calculated a collective whole body dose for the population within 50 miles (mi) of the North Anna ESP site.

3.2.2 Regulatory Evaluation

NRC regulations require that applicants for an ESP address the characteristics of the proposed site that could affect the radiation dose to a member of the public from radiological effluents. In SSAR Section 1.8.1, the applicant identified the applicable NRC regulations as Title 10,

Section 52.17(a)(1)(iv), of the *Code of Federal Regulations* (10 CFR 52.17(a)(1)(iv)). Specifically, this regulation states that an ESP application should describe the anticipated maximum levels of radiological effluents that each facility will produce. Furthermore, 10 CFR 100.21(c)(1) requires that radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site be met for any individual located off site. The staff reviewed this portion of the application for conformance with the applicable regulations.

3.2.3 Technical Evaluation

During normal operation, small quantities of radiological materials are expected to be released to the environment through gaseous and liquid effluents from the plant.

3.2.3.1 Gaseous Effluents

The applicant calculated the estimated dose to a hypothetical maximally exposed member of the public from the gaseous effluents using radiological exposure models based on Regulatory Guide (RG) 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," issued March 1976; RG 1.109, Revision 1, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," issued October 1977, and the GASPAR II computer program (NUREG/CR-4653, "GASPAR II—Technical Reference and User Guide," March 1987).

Section 2.3.5 of this safety evaluation report discusses the derivation of the atmospheric dispersion parameters used in the applicant's radiological dose assessment.

Dominion calculated the gaseous pathway doses to the MEI using the GASPAR II program at the nearest site boundary, nearest vegetable garden, nearest residence, and nearest meat cow. The applicant did not calculate doses from the milk pathway because no milk cows or goats are located within a 5-mile radius of the ESP site. Table 5.4-7 of the environmental report includes the gaseous effluent releases used to estimate dose to the MEI. These releases, which were estimated for one unit, considered the advanced boiling-water reactor (ABWR) design to have an output level of 4300 megawatt thermal (MWt), rather than the certified level of 3926 MWt. This difference resulted in a slight increase in release rate for those isotopes for which the ABWR design, as certified, was the bounding condition. Tables 5.4-3 through 5.4-5 of the environmental report include other inputs to the GASPAR II program, including meat and vegetable production rates, atmospheric dispersion factors, ground deposition factors, receptor locations, and consumption factors. Table 5.4-9 of the environmental report presents the gaseous pathway doses to the MEI calculated by the applicant. The staff performed an independent evaluation of gaseous pathway doses with similar results.

In Table 1.3-8 of the SSAR, the applicant estimated the radiological dose consequences caused by gaseous effluents that may be released from normal operation of the plant. The applicant determined the gaseous radioactive effluent concentrations based on a composite of the highest activity content of the individual isotopes it anticipated would be released from the alternative reactor designs under consideration.

The applicant also provided a bounding gaseous effluent source term to support its compliance with the gaseous effluent release concentration limits in Table 2 of Appendix B, "Annual Limits on Intakes (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage," to 10 CFR Part 20, "Standards for Protection Against Radiation."

3.2.3.2 Liquid Effluents

The applicant calculated the estimated dose to a hypothetical maximally exposed member of the public from the liquid effluents using radiological exposure models based on RG 1.109 and the LADTAP II computer program (NUREG/CR-4013, "LADTAP II—Technical Reference and User Guide," April 1986).

Dominion calculated liquid pathway doses using the LADTAP II program for various activities, including eating fish and invertebrates caught near the discharge point; drinking water from Lake Anna; and boating, swimming, and using the shoreline for recreational purposes. Table 5.4-6 of the environmental report includes the liquid effluent releases for one new unit used in the estimate of dose to the MEI. These releases considered the ABWR design to have an output level of 4300 MWt, rather than the certified level of 3926 MWt. This difference resulted in a slight increase in release rate for those isotopes for which the ABWR design was the bounding condition. Tables 5.4-1 and 5.4-2 of the environmental report include other parameters used as input to the LADTAP II program, including effluent discharge rate, dilution factor for discharge, transit time to receptor, and impoundment concentration.

The applicant calculated liquid pathway doses to the MEI, including a maximum annual dose to the total body of 0.013 milliSievert (mSv) (1.3 millirem (mrem)) for the adult. Dominion calculated the maximum annual dose to the thyroid as 0.013 mSv (1.3 mrem) for the infant and the maximum annual dose to the liver as 0.017 mSv (1.7 mrem) for the child. The staff performed an independent evaluation of liquid pathway doses with similar results. The staff concludes that the applicant has provided a bounding assessment to demonstrate its capability to comply with the regulatory requirements in 10 CFR Part 20 and Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

3.2.4 Conclusions

The applicant provided adequate information to provide reasonable assurance that it will control, monitor, and maintain radioactive gaseous and liquid effluents from the ESP site within the regulatory limits described in 10 CFR Part 20, as well as maintain them at as low as is reasonably achievable (ALARA) levels, in accordance with the effluent design objectives contained in Appendix I to 10 CFR Part 50.

As set forth above, the staff has independently verified the adequacy of the applicant's dose consequence calculations from normal operations. A combined license (COL) or construction permit (CP) applicant that references an ESP for the North Anna site should verify that the calculated radiological doses to members of the public from radioactive gaseous and liquid

effluents for any facility to be built on the North Anna site are bounded by the radiological doses included in the ESP application and reviewed by the NRC staff as described above. This includes any changes made to the input parameters used to calculate the radiological doses (i.e., meteorological data, distance to receptors, and land use data). In addition, detailed information on the solid waste management system used to process the radioactive gaseous and liquid effluents will be required. This is **COL Action Item 3.2-1.**

Based upon these considerations, the staff concludes that radiological doses to members of the public from radioactive gaseous and liquid effluents resulting from the normal operation of one or more new nuclear power plants that might be constructed on the proposed ESP site do not present an undue risk to the health and safety of the public. Therefore, the staff concludes, with respect to radiological effluent release dose consequences from normal operations, that the proposed site is acceptable for constructing a plant falling within the applicant's PPE, and that the site meets the relevant requirements of 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," and 10 CFR Part 100, "Reactor Site Criteria."

3.5.1.6 Aircraft Hazards

For an early site permit (ESP) application, the NRC staff reviews the applicant's assessment of aircraft hazards to ensure that the risks associated with aircraft hazards are sufficiently low.

3.5.1.6.1 Technical Information in the Application

In Section 2.2.2.6 of the SSAR, the applicant presented information concerning airports and airways in the site vicinity that could affect a nuclear power plant or plants that might be constructed on the proposed ESP site. The applicant evaluated this information in SSAR Section 2.2.3.2.1.

The applicant stated that three airports exist within 15 miles of the proposed ESP site. Two of the airports are paved civil fields at which one or more aircraft are based, and the other is an unpaved private field at which no aircraft are based. None of the airports has commercial operations.

The closest airport is the Lake Anna Airport, about 7 miles south-southeast of the proposed ESP site. According to the applicant, approximately 3640 operations occurred at the field in 2002. The field is occasionally used for practice takeoffs and landings. The other paved field is the Louisa County Airport, which is about 11 miles west-southwest of the proposed ESP site. Approximately 6240 operations occurred at the field in 2002. The third airport is Cub Field, which is about 10 miles south-southwest of the proposed ESP site, and has a few operations per year.

The applicant stated that none of these airports has a sufficient number of flight operations per year to rise above the threshold set forth in Section 3.5.1.6 of Review Standard (RS)-002, "Processing Applications for Early Site Permits," which would trigger a detailed evaluation of potential hazards associated with airport flight operations. Therefore, the applicant did not include a detailed evaluation of potential hazards associated with airport flight operations.

The applicant stated that one civil airway and three military training routes pass near the proposed ESP site. The centerline of the civil airway (V223) is about 5.5 miles west of the site, and the edge of the airway is about 1.5 miles from the site. No traffic data are kept for this airway. However, the applicant stated that the Federal Aviation Administration (FAA) characterizes the airway as "not heavily used" and estimates the traffic to be less than 200 aircraft per day.

The centerlines of the military training routes, which are 10 miles wide, are less than 1 mile south of the proposed ESP site. The applicant stated that the Oceana Naval Air Station in Virginia Beach controls these routes. The applicant added that, according to a knowledgeable representative of the Navy whom it had contacted, pilots using these routes are instructed to fly near the edge of the route to avoid the North Anna Power Station (NAPS) and to generally remain 3 to 4 miles from NAPS. Flights along the routes typically involve one or two aircraft, and rarely four aircraft. The applicant stated that the number of flights per year on the military routes has remained approximately constant, as evidenced by the documented total traffic for these three routes over a 3-year period. Specifically, the annual number of flights for these three routes was 2582, 2348, and 2623 for the years 1991, 1992, and 1993, respectively.

The airways are sufficiently close to the proposed site to warrant detailed evaluations of the associated potential hazards. In the SSAR, the applicant included detailed evaluations it performed following the guidance in RS-002, Section 3.5.1.6. The applicant's analysis concluded that the probability of an aircraft crash on the proposed ESP site from flights along the V223 airway is 3.45×10^{-8} per year. Similarly, the applicant's analysis concluded that the probability of an aircraft crash on the proposed ESP site from flights along the military training routes is 1.56×10^{-8} per year.

3.5.1.6.2 Regulatory Evaluation

In SSAR Section 1.8, the applicant identified the applicable NRC regulations and guidance related to the identification and evaluation of hazards associated with aircraft hazards as Title 10, Part 100, "Reactor Site Criteria," of the *Code of Federal Regulations* (10 CFR Part 100), Subpart B; Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," issued February 1972; and RS-002, Section 3.5.1.6. Section 2.2.3.2 of the SSAR refers to NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants"; however, RS-002 includes the portion of NUREG-0800 that is referenced. The staff agrees that the foregoing regulations and guidance apply to this portion of the review. The staff considered the regulatory requirement in 10 CFR Part 100, Subpart B, in reviewing aircraft hazards.

According to Section 3.5.1.6 of RS-002, the requirement in 10 CFR 100.20, "Factors to be Considered When Evaluating Sites," that individual and societal risks of potential plant accidents be low is met if the probability of aircraft accidents having the potential for radiological consequences greater than the 10 CFR 50.34(a)(1) exposure guidelines is less than about 10^{-7} per year. The probability is considered to be less than about 10^{-7} per year by inspection if the distances from the site meet all of the following criteria:

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

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

If the above proximity criteria are not met, or if sufficiently hazardous military activities are identified, a detailed review of aircraft hazards should be performed. Section 3.5.1.6 of RS-002 provides guidance on performing such a review.

3.5.1.6.3 Technical Evaluation

The applicant identified three airfields near the proposed ESP site. Two of the three airfields are described as public fields, and the third is identified as a private field. As noted in Section 3.5.1.6.1 of this safety evaluation report (SER), the applicant concluded that none of the fields has a sufficiently large number of flight operations to warrant a detailed analysis of the risk to a plant constructed at the proposed ESP site.

The staff notes, however, that a landing approach holding pattern for the Louisa County Airport is relatively close to the ESP site. Depending on the speed of an aircraft on an approach to the airport, this holding pattern can be less than 2 statute miles from the ESP site. As such, it would not meet the third criterion described in Section 3.5.1.6.2 of this SER. Failure to meet this criterion would, under the guidance in RS-002, necessitate a detailed aircraft hazards review. After consulting with the FAA, the staff has determined that only about 1 percent of all landing approaches to the Louisa County Airport involve the use of this particular holding pattern. Hence, the staff has made an estimate of this hazard by taking into account the above holding pattern usage fraction, the number of annual airport operations (6240 operations per year), the effective target area (0.013 square miles (mi^2)), and the crash frequency for general aviation as given in NUREG-0800, Section 3.5.1.6. On this basis, the estimated crash frequency is about 9.7×10^{-9} crashes per year.

The staff has confirmed that the applicant identified the public airfields closest to the proposed ESP site. The next closest public airfield is in Spotsylvania County, more than 20 miles from the site. The staff did not identify any additional private airfields within 10 miles of the site. Given the typical number of flight operations per year from private airfields and the size and type of aircraft that generally use private fields, the staff concludes that a detailed analysis of risk to a plant at the proposed ESP site from operations at private fields is not necessary.

The applicant identified one airway and three military training routes that pass near or over the proposed ESP and, using procedures described in RS-002, Section 3.5.1.6, separately estimated the probability of an aircraft crashing into a plant constructed at the proposed site from aircraft using the airway or military training routes. The staff has reviewed the applicant's calculations and finds them to be consistent with the procedures detailed in RS-002.

In calculating the crash probabilities, the applicant used an effective area of 0.013 mi^2 for safety-related structures that might be damaged by a crash sufficient to cause the potential for radiological consequences in excess of the 10 CFR 50.34(a)(1) criteria. The applicant used drawings included in the SSAR to estimate this area. The area is somewhat smaller than that listed for the power block (0.018 $mi^{2)}$ in the plant parameter envelope (PPE). The staff considers the area the applicant used in its calculation to be reasonable. Use of either figure for the effective area would result in a crash frequency (for all four routes) of less than 10^{-7} per year.

Appropriately, the applicant used the crash rates per mile of flight included in NUREG-0800 for the calculations. The staff concludes that the probability of an accident having the potential for radiological consequences in excess of the exposure criteria found in 10 CFR 50.34(a)(1) is less than about 10^{-7} per year.

3.5.1.6.4 Conclusions

The staff has reviewed the applicant's aircraft hazard analysis using the procedures set forth in RS-002, Section 3.5.1.6. As set forth above, the staff has independently verified the applicant's assessment of aircraft hazards at the site and concluded that the probability of an accident having the potential for radiological consequences in excess of the exposure criteria found in 10 CFR 50.34(a)(1) is less than about 10^{-7} per year. In addition, equivalent aircraft traffic in equal or closer proximity to plant sites reviewed in past NRC licensing actions was, after careful examination, found to present no undue risk to the safe operation of those plants. Based upon these considerations, the staff concludes that aircraft hazards do not present an undue risk to the health and safety of the public from potential construction and operation of one or more new nuclear plants on the proposed ESP site. Therefore, the staff concludes, with respect to aircraft hazards, that the proposed site is acceptable for constructing a plant falling within the applicant's PPE, and that the site meets the relevant requirements of 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," and 10 CFR Part 100.

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