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11 RADIOACTIVE WASTE MANAGEMENT

11.0 Radiological Effluent Release Dose Consequences from Normal Operations

11.1 Introduction

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the information provided in Chapter 11, "Radioactive Waste Management," of the Site Safety Analysis Report (SSAR) contained in Part 2 of the PSEG Site Early Site Permit (ESP) application. The information in Chapter 11 provides the analysis for the liquid and gaseous radioactive effluents to determine whether site characteristics are such that the radiation effluent doses to members of the public would be within regulatory guidelines. The SSAR must comply with the applicable requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) 52.17(a)(1) and 10 CFR 100.21(c)(1).

11.2 Summary of Application

The applicant provided information on the radioactive liquid and gaseous effluents that would be generated as a normal byproduct of nuclear power operations. These radioactive materials will be collected, processed, stored, and discharged in a controlled manner to the local environment. The proposed facility will have the ability to handle these radiological effluents in a manner that minimizes radioactive releases to the environment and maintains exposure to the public during normal plant operation, anticipated operational occurrences (AOO), and maintenance at levels that are as low as is reasonably achievable (ALARA).

11.3 Regulatory Basis

The acceptance criteria for addressing radiological doses to a member of the public from radiological effluents due to postulated normal plant operations are based on meeting the relevant requirements of 10 CFR 52.17, 10 CFR Part 100, 10 CFR Part 20, "Standards for Protection Against Radiation," 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," and 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," 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." The staff considered the following regulations in reviewing the applicant's discussion and analysis of radiological doses to members of the public from radiological effluents due to postulated normal plant operations:

1. 10 CFR Part 20, as it relates to the requirement that annual effluents concentrations would not exceed the radionuclide concentration limits of Appendix B (Table 2, Columns 1 and 2, under the unity rule) for liquid and gaseous discharges into unrestricted areas.
2. 10 CFR Part 50, Appendix I, as it relates to the requirement to provide numerical guidance on design objectives to meet the requirements that radiation doses caused by radioactive materials in effluents released to unrestricted areas be kept ALARA.

3. 10 CFR 52.17(a), as it relates to the requirement that the application contain a description of the anticipated maximum levels of radiological and thermal effluents each proposed facility will produce.
4. 10 CFR 100.21(c), as it relates to the requirement that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that (1) radiological effluent release limits associated with normal operation from the type of facility to be located at the site can be met for any individual located offsite.
5. 40 CFR Part 190, as applicable U.S. Environmental Protection Agency (EPA) environmental radiation standards implemented under 10 CFR 20.1301(e) for all radioactive liquid and gaseous effluents discharged from the proposed facility.

The information assembled in compliance with the above regulatory requirements would be necessary, at the Combined License (COL) or Construction Permit (CP) stage, to assess whether the proposed facility will control, monitor, and maintain radioactive gaseous and liquid effluents from the proposed facility within the regulatory limits (including the environmental radiation standards in 40 CFR Part 190) specified in 10 CFR Part 20, as well as maintain radiological effluents at ALARA levels in accordance with the dose objectives of 10 CFR Part 50, Appendix I. Table 11.3-1 of this report provides a quantitative summary of the standards above.

To the extent applicable for an ESP application under the regulatory requirements cited above, the applicant applied the NRC-endorsed analytical methodologies and parameters found in both Regulatory Guide (RG) 1.109, Revision 1, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," October 1977, and RG 1.111, Revision 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," July 1977. When independently assessing the accuracy of the information the applicant presented in SSAR Chapter 11, the staff confirmed and applied the same analytical methodologies and parameters cited above as those of the applicant's.

Table 11.3-1 Staff Summary of 10 CFR Part 50, Appendix I, Dose Objectives and 40 CFR Part 190, Environmental Standards

| Regulation | Type of Effluent | Pathway | Organ | Dose Limit |
|-------------------------------------|-----------------------------|----------------|-----------------|---|
| 10 CFR Part 50, Appendix I * | Liquid | All | Total Body | 3.0E-2 (3.0E0) mSv/yr/unit (mrem/yr per unit) |
| | | All | Any Organ | 1.0E-1 (1.0E1) mSv/yr/unit (mrem/yr per unit) |
| | Gaseous | All | Total Body | 5E-2 (5E0) mSv/yr/unit (mrem/yr per unit) # |
| | | All | Skin | 1.5E-1 (1.5E1) mSv/yr/unit (mrem/yr per unit) |
| | Radioiodines & Particulates | All | Any Organ | 1.5E-1 (1.5E1) mSv/yr/unit (mrem/yr per unit) |
| | Gaseous | Gamma Air Dose | N/A | 1.0E-1 (1.0E1) mGy/yr/unit (mrad/yr per unit) *** |
| | | Beta Air Dose | N/A | 2.0E-1(2.0E1) mGy/yr/unit (mrad/yr per unit) *** |
| 40 CFR Part 190 ** | All | All | Total Body | 2.5E-1 (2.5E1) mSv/yr/unit (mrem/yr per unit) # |
| | All | All | Thyroid | 7.5E-1 (7.5E1) mSv/yr/unit (mrem/yr per unit) # |
| | All | All | Any Other Organ | 2.5E-1 (2.5E1) mSv/yr/unit (mrem/yr per unit) # |

Notes:

- * 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," defines dose objectives for the maximally exposed individual (MEI).
- ** Dose limits are defined for any real member of the public. Under NRC requirements, this standard is implemented under 10 CFR Part 20.1301(e).
- *** Air doses are expressed in mGy/year (mrad/year) instead of mSv/year (mrem/year).

See 40 CFR Part 190. Dose limits are for the entire site and apply to all operating units.

11.4 Technical Evaluation

11.4.1 Compliance with 10 CFR Part 20 and 10 CFR Part 50, Appendix I – Liquid Effluents

Liquid Effluent Source Term Analysis

The applicant provided estimates of radiological effects on members of the public from the annual liquid effluents that would be generated as a normal byproduct of nuclear power operations. The estimated bounding annual average quantity of radioactivity projected to be released was indicated in SSAR Table 1.3-8, "Single Unit Composite Average Annual Normal Liquid Release." The highest liquid effluent quantity per year for each of the individual radionuclides represents the highest activity from the four reactor designs presented in SSAR Section 1.3, "Plant Parameters Envelope (PPE)." SSAR Table 1.3-8 would bound the liquid effluent quantity of each radionuclide for any selected reactor design to the highest quantity of liquid effluent expected from any of the four reactor designs. The four reactor designs being considered by the applicant are: (1) Single Unit U.S. EPR; (2) Single Unit Advanced Boiling Water Reactor (ABWR); (3) Single Unit U.S. Advanced Pressurized-Water Reactor (US-APWR); and (4) Dual Unit Advanced Passive 1000 (AP1000). By reviewing the source terms for these four reactor designs, the staff evaluated and confirmed that the bounding annual average liquid effluent source term release values listed in SSAR Table 1.3-8 were consistent.

SSAR Table 11.2-1, "Liquid Release Source Terms," indicates by footnote (a) that the values listed are from SSAR Table 1.3-8. However, the staff noted inconsistencies between the values in these two tables. Therefore, in request for additional information (RAI) 7, Question 11.02-1, the staff requested that the applicant provide information for SSAR Table 1.3-8 indicating the bounding release rate for each radionuclide, in order to rectify the above-mentioned inconsistencies. The staff also noted that the values for four radionuclides (Rh-103m, Rh-106, Ag-110, and Ba-137m) appeared to be missing, without explanation.

In a March 10, 2011, response, to RAI 7, Question 11.02-1, the applicant stated that these are short-lived daughter products of long-lived parents, and that these short-lived daughter products do not have any dose factors in the dose-factor library. The applicant included a footnote at the end of SSAR Table 11.2-1 stating why these radionuclides are not included. Therefore, the staff finds the applicant's response acceptable because the applicant addressed the staff's concern. The staff verified that Revision 2 of the application, dated March 27, 2013, included this information. Accordingly, the staff considers RAI 7, Question 11.02-1, resolved.

10 CFR Part 20 Liquid Compliance

The applicant provided SSAR Table 11.2-2, "Site Concentrations Comparison to 10 CFR 20, Appendix B, Table 2, Column 2, Effluent Concentration Limits (ECLs)," to demonstrate compliance with the annual average liquid release concentrations to meet the 10 CFR Part 20, Column 2, Appendix B, Table 2, "unity rule," concentration limit identified in Note 4 of 10 CFR Part 20, Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage." The applicant's tabulation included site concentrations that encompassed liquid effluent releases from a new dual unit plant as well as the nearby operating Salem Generating

Station (SGS) and Hope Creek Generating Station (HCGS). The staff notes that the liquid effluent site concentrations are below the limits in 10 CFR Part 20, Appendix B, Column 2, Table 2, and the unity calculation described in Note 4.

The staff performed an independent confirmatory assessment of the results presented in SSAR Table 11.2-2 and all associated calculations. The staff finds that, based on the total liquid estimated to be discharged from the site, the concentrations of radioactive materials present in liquid effluents and discharged in unrestricted areas, listed in SSAR Table 11.2-2, comply with the limits specified in 10 CFR Part 20, Appendix B, Table 2, Column 2, and the sum of the ratios meets the 10 CFR Part 20, Appendix B, "unity rule."

10 CFR Part 50, Appendix I Liquid Dose Compliance

The staff identified that sufficient information, input parameters, and resulting doses due to annual liquid effluent releases from the proposed PSEG Site were not included in the ESP application to confirm compliance with 10 CFR Part 50, Appendix I, design objectives.

Therefore, in RAI 23, Question 11.02-3, the staff requested that the applicant provide details of the liquid effluent data and associated effluent dose information, and that supporting details on effluent releases and basis of dose modeling be incorporated into the SSAR. In a June 3, 2011, response to RAI 23, Question 11.02-3, the applicant provided the requested information concerning the liquid effluent data and associated liquid effluent doses. The applicant's response included a description of the required model assumptions and input parameters needed to run LADTAP II computer codes (the NRC technical report designation and contractor report NUREG/CR-4013, "LADTAP II - Technical Reference and User Guide," April 1986), with justification for excluding potential exposure pathways. Using radiological exposure models in RG 1.109, and the LADTAP II computer program, the applicant calculated the estimated public doses to a hypothetical Maximally Exposed Individual (MEI) and to the population within 80 kilometers (km) (50 miles (mi)) from the postulated liquid effluent discharge point.

Table 11.4.1-1 below lists the parameters the staff used for the LADTAP II computer code in conducting its independent calculations. The staff considered a direct liquid release to the environment, as the applicant did, into the brackish water of the Delaware River. The drinking water pathway is not considered an exposure pathway due to the brackish water and the Delaware River is not a potable water supply in the vicinity of the site. The staff used a combination of the values listed in SSAR Table 11.2-1 and the applicant's site-specific values in effluent dose estimation. The staff reviewed the calculated doses provided and concluded that the applicant's response to RAI 23, Question 11.02-3, contained the required liquid effluent data and associated dose information. The staff finds this response acceptable and, therefore, considers RAI 23, Question 11.02-3, resolved.

Table 11.4.1-1 Important LADTAP Parameter Values Used by the Staff

| Parameter | NRC Value* | Basis |
|-------------------------------------|---------------------------|---|
| Annual radionuclide release (Ci/yr) | PPE Values from PSEG SSAR | RG 1.112 and RG 1.109 |
| Discharge Flow Rate (cfs) | 4.5E1 | Provided release rate for new unit: SSAR Section 11.2.3.1 |
| Water Type | Salt (Brackish) | Delaware River: |

| | | |
|------------------|-------|--|
| | | ER Section 5.4.1.1 |
| Dilution Factors | 2.0E1 | Ratio of the discharge rates: SSAR Section 11.2.3.1 |

*The staff used the applicant and LADTAP II default values for parameters not listed in the table.

Table 11.4.1-2 below compares the applicant's results to the staff's and the 10 CFR Part 50, Appendix I, liquid dose design objectives. Table 11.4.1-2 below shows that the applicant's results and the staff's confirmatory results are below the 10 CFR Part 50, Appendix I, criteria. The staff performed independent confirmatory assessments and concluded that the applicant demonstrated compliance with the liquid effluent regulatory requirements in 10 CFR Part 20 and 10 CFR Part 50, Appendix I.

Table 11.4.1-2 Comparison of Liquid Maximum Doses, mSv/yr/unit (mrem/yr/unit)

| Organ/Body | Application* | NRC Analysis | 10 CFR Part 50 Appendix I, Section II.A |
|---------------------|----------------------|----------------------|---|
| Total Body | 1.57E-4 (1.57E-2) | 1.57E-4 (1.57E-2) | 3.0E-2 (3.0E0) |
| GI-LLI** (Adult) | 1.77E-3 (1.77E-1) | 1.77E-3 (1.77E-1) | 1.0E-1 (1.0E1) |

*SSAR Table 11.2-6.

**GI-LLI – Gastrointestinal Tract-Lower Large Intestine.

The applicant calculated a collective whole body liquid dose for the population of 8.1 million, within 80 km (50 mi) of the proposed PSEG Site. This included a description of the exposure pathways by which radiation and radioactive effluents could be transmitted to members of the public within the 80 km (50 mi) radius from the site. The applicant used the information for the fish and invertebrate ingestion, shoreline, swimming and boating pathways. The drinking water pathway was not considered since the Delaware River in the site vicinity is composed of brackish water.

Population Dose Evaluation – Liquid Effluents

Table 11.4.1-3 below lists population collective doses that the applicant calculated and compares them to the staff's independently calculated results. Normally, an ESP application does not include the review of the population dose section since a cost benefit analysis is not performed at this stage of the review. However, the staff has verified the population dose values provided by the applicant. The table below shows that the assumptions and parameters the applicant used resulted in approximately the same doses for the total body and thyroid when compared to the staff's bounding independent assessment. The annual population doses listed in SSAR Table 11.2-8, "Collective Annual Doses from a New Unit to Population within 50 Miles, Liquid Pathway," are 4.55E-1 person Sv (4.55E+01 person rem) to the total body, and 6.72E-1 person Sv (6.72E+01 person rem) to the thyroid. The cumulative population exposure is determined for annual liquid effluent releases and then utilized by the applicant during the COL application stage employing RG 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-

Water-Cooled Nuclear Power Reactors,” methodology. This regulatory guidance assesses the potential reductions in the cumulative exposure to the population using augments to the proposed liquid radwaste systems applying a cost-benefit analysis calculation.

Table 11.4.1-3 Comparison of Liquid Population Doses Person Sv/yr (person rem/yr)

| Organ/Body | Application* | NRC Analysis |
|------------|--------------------|--------------------|
| Total Body | 4.55E-1 (4.55E+01) | 4.56E-1 (4.56E+01) |
| Thyroid | 6.72E-1 (6.72E+01) | 6.73E-1 (6.73E+01) |

*SSAR Table 11.2-8

11.4.2 Compliance with 10 CFR Part 20 and 10 CFR Part 50, Appendix I – Gaseous Effluents

Gaseous Effluent Source Term Analysis

The applicant provided estimates of radiological impacts on members of the public from the annual gaseous effluent that would be generated as a normal byproduct of nuclear power operations. The estimated bounding annual average quantity of radioactivity projected to be released was given in SSAR Table 1.3-7, “Single Unit Composite Average Annual Normal Gaseous Release.” The gaseous effluent quantity represents the highest activity of the individual radionuclides from the four reactor designs, namely, U.S. EPR, ABWR, US-APWR, and dual unit AP1000, presented in SSAR Section 1.3, “Plant Parameters Envelope (PPE),” and would bound the gaseous effluent quantity of each radionuclide for any selected reactor design to the highest quantity of gaseous effluent expected from any of these four reactor designs.

In addition to the information provided in SSAR Chapter 11, it is necessary to use those results found in SSAR Chapter 2, Section 2.3.5, “Long-Term (Routine) Diffusion Estimates,” for the proposed site’s long-term (routine) atmospheric diffusion parameters. Through review of SSAR Section 2.3.5, the staff finds that the parameters necessary for input into the GASPARD II computer code are acceptable. The staff’s review of the proposed site’s long-term (routine) atmospheric diffusion parameters is found in Section 2.3.5 of this report.

By reviewing the referenced source terms for the four reactor designs, the staff evaluated and confirmed that the bounding annual average gaseous effluent source term releases listed in SSAR Table 1.3-7 were consistent. The staff determined that SSAR Table 1.3-7, indicating the bounding release rate for each radionuclide, was not consistent with SSAR Table 11.3-5, “Gaseous Release Source Terms,” that stated in footnote (a) that the values listed are from SSAR Table 1.3-7. The values for five radionuclides (Kr-90, Rh-103m, Rh-106, Ba-137m, and Xe-139) appeared to be missing without explanation. Therefore, in RAI 6, Question 11.03-1, the staff requested that the applicant clarify this apparent inconsistency. In a March 3, 2011, response to RAI 6, Question 11.03-1, the applicant stated that these are short-lived daughter products of long-lived parents which also do not have any dose factors in the dose-factor library. The applicant provided footnotes at the end of SSAR Table 11.3-5 explaining why these five radionuclides are not included. The staff verified that Revision 2 of the application, dated March 27, 2013, included this information. The staff finds this response acceptable and, therefore, considers RAI 6, Question 11.03-1, resolved.

10 CFR Part 20, Gaseous Compliance

The applicant initially provided SSAR Table 11.3-6, "Site Concentrations Comparison to 10 CFR Part 20, Appendix B, Table 2, Column 1 Effluent Concentration Limits (ECLs)," to demonstrate compliance with the annual average gaseous release concentrations identified in Note 4 of 10 CFR Part 20, Appendix B, Table 2, Column 1, "unity rule" concentration limit. The applicant's tabulation included site concentrations that encompassed gaseous effluent releases from the operating SGS, HCGS, and a potential new dual unit plant at the proposed PSEG Site. The gaseous effluent site concentrations in SSAR Table 11.3-6 indicated that the values are below the limits in 10 CFR Part 20, Appendix B, Column 1, Table 2, and the unity calculation in Note 4.

The staff reviewed the initial results in SSAR Table 11.3-6, and the associated calculations, and verified that these initial values indicated that the gaseous effluent site concentrations were below the 10 CFR Part 20, Appendix B, Column 1, Table 2 limits, and the unity calculation in Note 4. However, the staff issued RAI 18, Question 11.03-3, because the methodology utilized by the applicant to determine the MEI doses in SSAR Table 11.3-8, "Comparison of Maximally Exposed Individual Doses with 10 CFR 50, Appendix I Criteria," and the 10 CFR Part 50, Appendix I, gaseous effluent doses, also affected the gaseous effluent source term. Since the gaseous effluent source term was impacted, the 10 CFR Part 20, Appendix B, Column 1, Table 2, and the unity calculation in Note 4, and the effluent doses calculated in accordance with 10 CFR Part 50 Appendix I were affected. Therefore, any table in the SSAR relating to the gaseous effluent source term must be re-evaluated. In an April 12, 2011, response to RAI 18 Question 11.03-3, the applicant updated the gaseous effluent source term in SSAR Table 1.3-7, "Single Unit Composite Average Annual Normal Gaseous Release." (Additional discussion of RAI 18 is in the section titled, "10 CFR Part 50, Appendix I, Gaseous Dose Compliance" below.)

In the April 12, 2011, response to RAI 18, Question 11.03-3, the applicant also revised SSAR Table 11.3-5 and SSAR Table 11.3-7, which had initially been verified to comply with 10 CFR Part 20, Appendix B, Column 1, Table 2, and the unity calculation in Note 4. In RAI 37, Question 11.03-7, the staff requested that the applicant use the information submitted to the staff in the April 12, 2011, response to RAI 18, Question 11.03-3 to re-evaluate the concentrations of all radionuclides in SSAR Table 11.3-6, and to determine if the recalculated gaseous concentrations are within the limits specified in 10 CFR Part 20, Appendix B, Column 1, Table 2, and the unity calculation in Note 4.

In a September 19, 2011, response to RAI 37, Question 11.03-7, the applicant re-evaluated the gaseous concentrations of all radionuclides in SSAR Table 11.3-6. The applicant determined that the modified gaseous effluent site concentrations in SSAR Table 11.3-6 indicated that the values are below the limits in 10 CFR Part 20, Appendix B, Column 1, Table 2, and the unity calculation in Note 4.

The staff reviewed the modified results in SSAR Table 11.3-6 and the associated revised calculations. The staff verified that the SSAR Table 11.3-6 values for the gaseous effluent site concentrations are below the 10 CFR Part 20, Appendix B, Column 1, Table 2 limits, and the unity calculation in Note 4 and, therefore, are acceptable. The staff verified that Revision 2 of the application, dated March 27, 2013, included this information. Accordingly, the staff considers RAI 37, Question 11.03-7, resolved.

10 CFR Part 50, Appendix I, Gaseous Dose Compliance

The staff identified that sufficient information, including input parameters to be used along with the derivation of the atmospheric dispersion parameters in Section 2.3.5 of the SSAR to calculate the resulting doses due to annual gaseous effluent releases, was not included in the ESP application to confirm compliance with 10 CFR Part 50, Appendix I, design objectives. Therefore, in RAI 24, Question 11.03-4, the staff requested that the applicant provide details of the gaseous effluent data, the associated effluent dose information, and then incorporate the effluent information into the SSAR. In a June 3, 2011, response to RAI 24, Question 11.03-4, the applicant provided the requested information concerning the gaseous effluent data and associated gaseous effluent doses. The applicant's response to RAI 24, Question 11.03-4, included a description of the required model assumptions and input parameters needed to run the GASPARD II computer codes along with the justifications for potential exposure pathways. Using radiological exposure models in RG 1.109 and the GASPARD II computer program (NUREG/CR-4653, "GASPARD II - Technical Reference and User Guide"), the applicant calculated the estimated public doses to a hypothetical MEI and to the population within 80 km (50 mi) from postulated gaseous effluents discharge point. The staff reviewed the additional information and finds it acceptable for evaluation of the gaseous effluent doses for proposed PSEG site.

However, the staff determined that a disagreement existed between the information provided in the June 3, 2011, response to RAI 24, Question 11.03-4, and the data the applicant used in the GASPARD II calculations for population doses. "Table RAI 24-1" in the RAI response contained transposed sector and distance population distributions when compared to the data used in the GASPARD II calculation model. Therefore, in follow-up RAI 36, Question 11.03-6, the staff requested that the applicant clarify the information provided. In a September 19, 2011, response to RAI 36, Question 11.03-6, the applicant confirmed that the "Table RAI 24-1" provided in the response to RAI 24, Question 11.03-4, is correct and the error in transposed population distributions is a result of using a feature of GASPARD II to start inputting data from south instead of north. The staff finds the applicant's response acceptable. The response to RAI 36, Question 11.03-6, did not result in a revision to the SSAR. Accordingly, the staff considers RAI 36, Question 11.03-6, resolved.

In RAI 18, Question 11.03-3, the staff requested that the applicant justify the use of a partial occupancy factor from the site Offsite Dose Calculations Manual (ODCM) of 2000 hr/year to calculate the gaseous effluent dose in SSAR Section 11.3.3.2 to comply with 10 CFR Part 50, Appendix I. SSAR Table 11.3-8 used the assumption that a member of the public will work onsite for 2000 hr/yr as a basis for a 10 CFR Part 50, Appendix I dose to an MEI. In an April 12, 2011, response to RAI 18, Question 11.03-3, the applicant removed the use of 2000 hr/yr for the member of the public at the nearest site boundary to calculate the 10 CFR Part 50, Appendix I, gaseous effluent dose. The applicant provided a calculation of effluent MEI gaseous doses for the 10 CFR Part 50, Appendix I criteria based on a member of the public being located at the nearest site boundary for the full duration of the year. The staff reviewed the changes and verified that all gaseous effluent releases and dose calculations provided by the applicant meet NRC design criteria. The staff verified that Revision 2 of the application, dated March 27, 2013, included this information. Accordingly, the staff considers RAI 18, Question 11.03-3, resolved.

In RAI 46, Question 11.03-8, the staff requested that the applicant confirm its intention to use the Bell Bend Nuclear Power Plant (BBNPP) effluent release rate, given that BBNPP has sought a departure from the U.S. EPR Design Certification Document (DCD) source terms, and that the

BBNPP COL application is not the reference COL application for this reactor design. The staff also stated in this question that there were standing RAIs to the BBNPP applicant to justify the approach to use their developed source terms.

In a February 3, 2012, response to RAI 46, Question 11.03-8, the applicant declined to provide the requested reference information concerning the liquid and gaseous effluent data in the SSAR. In review of other previous RAI responses from the applicant, the staff found the similar referenced information, as requested in RAI 46, Question 11.03-8, provided in response to RAI 13, Question 02.04.13-2. In a February 23, 2012, teleconference, the staff requested that the applicant provide the gaseous effluent reference data information in the same format as RAI 13, Question 02.04.13-2. In a March 29, 2012, supplemental response to RAI 46, the applicant included revised footnotes to SSAR Table 1.3-7 to describe the origin of the various gaseous source terms provided in the PPE approach used in the ESP application. The staff determined that the markup notes were not acceptable because the applicant's response did not include what was requested. On October 24, 2012, the staff held a public teleconference meeting with the applicant to resolve the issue described above. In a January 11, 2013, supplemental response, the applicant included references for the source terms in SSAR Tables 1.3-7 and 1.3-8 used in the PPE determination. The staff confirmed that these references are consistent with those for SSAR Table 1.3-9 that were submitted with the original ESP application. The staff verified that Revision 2 of the application, dated March 27, 2013, included this information. The staff reviewed the changes to the SSAR tables and finds them acceptable and, therefore, considers RAI 46, Question 11.03-8, resolved.

In the June 3, 2011, response to RAI 24, Question 11.03-4, the applicant provided a description of the required model assumptions and input parameters needed to run the GASPARI computer codes and justifications for potential exposure pathways using radiological exposure models in RG 1.109 and the GASPARI computer program (NUREG/CR-4653, "GASPARI - Technical Reference and User Guide"). In the response, the applicant calculated the estimated public doses to a hypothetical MEI and to the population within 80 km (50 mi) from postulated gaseous effluents discharges. Table 11.4.2-1 below lists the parameters used by staff for the GASPARI computer code in conducting its verification calculations.

Table 11.4.2-1 Important GASPARI Parameter Values Used by the Staff

| Parameter | NRC Value* | Basis |
|--|---|---|
| Annual Radionuclide Release (Ci/yr) | PPE Values from PSEG SSAR | RG 1.112, and RG 1.109 SSAR Table 11.3-5 |
| Annual Average X/Q (with no decay) | 1.00E-5 sec/m ³ | SSAR Section 2.3.5.2 |
| Production Rate | Population data multiplied by consumption rates | Population Data from SSAR Table 2.1-2 Consumptions provided in NUREG/CR-4653, also provided in SSAR Table 11.3-3 |

*The staff used the applicant and GASPAR II default values for parameters not listed in the table.

The applicant also provided justification for all potential gaseous effluent exposure pathways. The pathways that the applicant analyzed were based on information provided in the SSAR. In accordance with NRC guidelines, the staff evaluated the information provided by the applicant and independently verified the parameters used in gaseous effluent dose calculations and resulting doses. The staff verified that Revision 2 of the application, dated March 27, 2013, included this information. The staff finds the applicant's response adequate and acceptable and, therefore, considers RAI 24, Question 11.03-4, resolved.

The staff's independent gaseous effluent dose calculations were performed in accordance with the NRC guidance using the applicant's site-specific values and SSAR Table 11.3-5 source term. Annual gamma air doses at the site boundary were determined to be 0.061 mGy (6.1 millirad (mrad)), and the beta annual air dose is estimated to be 0.11 mGy (11.0 mrad). The annual total body and skin doses, at the location of highest offsite exposure (evaluated at a location that is anticipated to be occupied during the lifetime of the plant or evaluated with respect to such potential land and water usage and food pathways), were estimated to be 0.046 mSv (4.6 mrem) and 0.122 mSv (12.2 mrem), respectively. The maximum annual organ dose (thyroid) to the nearest child was estimated to be 0.0722 mSv (7.22 mrem). The Total Body dose of 0.046 mSv (4.6 mrem) compared to the limit of 0.05 mSv is very close to the limit for two reasons: (1) The Total Body Dose is for the MEI, the nearest resident for the application data; the applicant chose to use the value for the Site Boundary to demonstrate compliance, which shows that at a closer distance to the plant it still meets the dose objectives of 10 CFR Part 50, Appendix I, and (2) in the GASPAR computer code, when the Undecayed, Undepleted and Decayed, Undepleted X/Q values are equal, the equation GASPAR II uses to solve for decay time sets time equal to zero. Without a decay time, the short-lived gaseous radionuclides increase the total dose. The staff's independent verification of the calculated gaseous effluent doses indicates that the applicant's results are acceptable and comply with 10 CFR Part 50, Appendix I design objectives. Therefore, the staff finds that SSAR effluent doses adequately address the design criteria in 10 CFR Part 50, Appendix I (see Table 11.4.2-2 of this report), and are acceptable.

Table 11.4.2-2 below, is a comparison of the applicant's results to the staff's verification calculations, specifically comparing those results to 10 CFR Part 50, Appendix I, objectives.

Table 11.4.2-2 Comparison of Gaseous Maximum Individual Doses, mSv/yr/unit (mrem/yr/per unit)

| Description | Applicant Results | NRC Results | 10 CFR Part 50, Appendix I, Section II.B and Section II.C Limits |
|---|-------------------|------------------|--|
| Noble Gases | | | |
| Gamma Dose Site Boundary | 6.1E-2 (6.1E0) * | 6.1E-2 (6.1E0) * | 1.0E-1 (1.0E1) * |
| Beta Dose Site Boundary | 1.1E-1 (1.1E1) * | 1.1E-1 (1.1E1) * | 2.0E-1 (2.0E1) * |
| Total Body At MEI | 4.6E-2 (4.6E0) | 4.6E-2 (4.6E0) | 5.0E-2 (5.0E0) |
| Skin At MEI | 1.22E-1 (1.22E1) | 1.22E-1 (1.22E1) | 1.5E-1 (1.5E1) |
| Radioiodines and Particulates Maximum Organ Thyroid At MEI (Child)** | 7.22E-2 (7.22E0) | 7.23E-2 (7.23E0) | 1.5E-1 (1.5E1) |

* Units of mGy/yr (mrad/yr).

** The MEI here was calculated using the highest of each category, which included using the Goat Milk value for an infant and child for every other pathway.

Population Dose Evaluation—Gaseous Effluents

Table 11.4.2-3 of this report lists the population doses that the applicant calculated as compared to the staff's verification of the applicant's results. Normally, an ESP does not include the review of the population dose section since a related cost benefit analysis is not performed at this stage of the review. However, the staff has verified the population dose values that the applicant provided. The applicant's calculated gaseous annual population doses from the proposed unit(s) are 0.204 person Sv (20.4 person rem) to the total body and 0.91 person Sv (91 person rem) to the thyroid. Table 11.4.2-3 below shows the assumptions and parameters used by the applicant that resulted in the same dose for the total body and a slightly lower dose for the thyroid when compared to the staff's bounding independent assessment.

Table 11.4.2-3 Comparison of Gaseous Population Doses, Person Sv/yr (person rem/yr)*

| Organ/Body | Application** | NRC Analysis ** |
|-------------------|--------------------|--------------------|
| Total Body | 2.04E-1 (2.04E+01) | 2.04E-1 (2.04E+01) |
| Thyroid | 9.10E-1 (9.10E+01) | 9.12E-1 (9.12E+01) |

* SSAR Table 11.3-10, "Collective Annual Doses from a New Unit to Population within 50 miles, by Pathway."

** Population doses are per reactor.

10 CFR 20.1301(e), (40 CFR Part 190) Liquid and Gaseous Effluent Dose Compliance

10 CFR 20.1301(e) requires that NRC-licensed facilities comply with "the provisions of EPA's generally applicable environmental radiation standards in 40 CFR Part 190" for all facilities that are part of the fuel cycle. The EPA annual dose limits are 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid, and 0.25 mSv (25 mrem) to any other organ. Compliance with 10 CFR 20.1301(e) requires the consideration of all potential sources of external radiation and radioactivity, including liquid and gaseous effluents and external radiation exposures from buildings, storage tanks, radioactive waste storage areas, and radioactive Nitrogen-16 (N-16) sky shine (reflected radiation from a Boiling Water Reactor (BWR) site back to the ground) from BWR turbine buildings. The EPA standards apply to the entire site or facility, whether it has a single unit or multiple units.

The staff reviewed SSAR Chapter 11 for compliance with 10 CFR 20.1301(e) and EPA general radiation protection standard, 40 CFR Part 190.

The staff determined that the effluent dose information in SSAR Table 11.3-9, "Comparison of Maximally Exposed Individual Doses with 40 CFR Part 190 Criteria," was not transferred correctly from SSAR Table 11.2-7, "Liquid Contributions to Maximally Exposed Individual Doses with Regards to 40 CFR 190 Criteria," SSAR Table 11.3-7, "Doses to Maximally Exposed Individual from Gaseous Effluent Releases," and SSAR Table 11.3-8, "Comparison of Maximally Exposed Individual Doses with 10 CFR Part 50, Appendix I Criteria."

In RAI 11, Question 11.03-2, the staff requested that the applicant provide the required dose information in accordance with 10 CFR 20.1301(e). In a March 10, 2011, response to RAI 11, Question 11.03-2, the applicant provided information concerning calculated liquid and gaseous effluent doses from anticipated planned discharges of radioactive materials to be transferred to SSAR Table 11.3-9 to indicate compliance with 40 CFR Part 190. The staff reviewed the response and determined that it was not consistent with the dose totals shown in SSAR Table 11.3-9.

Therefore, in follow-up RAI 28, Question 11.03-5, the staff requested that the applicant provide a consistent presentation of tabulated doses results. In a June 3, 2011, response to follow-up RAI 28, Question 11.03-5, the applicant supplied additional effluent data and doses in applicable SSAR tables. The staff performed a final review of the information in SSAR Table 11.3-9 and determined that direct doses from all fuel cycle facilities were not included in the applicant's response.

Therefore, in RAI 62, Question 11.03-9, the staff requested that the applicant account for the location and direct dose to the general environment from uranium fuel cycle operations and to consider radiation from these operations from all fuel cycle facilities in SSAR Table 11.3-9 to demonstrate compliance with 40 CFR Part 190 and 10 CFR 20.1301(e). In an August 7, 2012, response to RAI 62, 11.03-9, the applicant revised SSAR Table 11.3-9. The applicant's response included the sum of the actual current liquid and gaseous effluent doses from the three operating units at the site, plus the conservative direct dose from one new unit, considered an ABWR, from the PPE designs considered, and the liquid and gaseous effluent doses projected from a maximum of two potential new units. The bounding direct radiation dose at the

proposed site is for the design that is based on a single ABWR unit. The direct dose based on a new single ABWR unit is more conservative and bounding than the direct dose based on any new dual unit designs. The staff concluded that all doses from all fuel cycle facilities were being accounted for in SSAR Table 11.3-9. For the total site dose, the applicant's results are less than the maximum doses specified in 40 CFR Part 190.10(a) of 25 mrem/yr whole body, 75 mrem/yr thyroid, and 25 mrem/yr any other organ. The staff finds that the information submitted in the August 7, 2012, response to RAI 62, Question 11.03-9, meets the requirements of 40 CFR Part 190 and 10 CFR 20.1301(e), and is acceptable. The staff verified that Revision 2 of the application, dated March 27, 2013, included this information. Accordingly, the staff considers RAI 11, Question 11.03-2, RAI 28, Question 11.03-5, and RAI 62, Question 11.03-9, resolved.

Table 11.4.2-4 below compares the staff's independent calculations to those results obtained by the applicant. This table accounts for Liquid and Gaseous Effluent dose and Direct dose contributions.

Table 11.4.2-4 Comparison of Maximum Individual Doses to 10 CFR 20.1301(e)/40 CFR Part 190 mSv/yr (mrem/yr)

| Dose Type | Gaseous Dual Unit | Liquid Dual Unit | Existing Units | Direct Radiation Dual Units | Total | 10 CFR 20.1301 and 40 CFR Part 190, Limits |
|------------------------------|----------------------|----------------------|----------------------|-----------------------------|---------------------|--|
| Total Body Applicant* | 4.00E-3 (4.00E-1) | 3.14E-4 (3.14E-2) | 5.36E-5 (5.36E-3) | 2.50E-2 (2.50E0)** | 2.94E-2 (2.94E0) | 2.5E-1 (2.5E1) |
| Organ/Body Applicant* | 1.1E-2 (1.1E0) | 3.54E-3 (3.54E-1) | 2.04E-4 (2.04E-2) | 2.50E-2 (2.50E0)** | 3.97E-2 (3.97E0) | 2.5E-1 (2.5E1) |
| Thyroid Applicant* | 4.26E-2 (4.26E0) | 8.30E-4 (8.30E-2) | 2.04E-4 (2.04E-2) | 2.50E-2 (2.50E0)** | 6.86E-2 (6.86E0) | 7.5E-1 (7.5E1) |
| Total Body NRC | 4.00E-3 (4.00E-1) | 3.14E-4 (3.14E-2) | 5.36E-5 (5.36E-3) | 2.50E-2 (2.50E0)** | 2.94E-2 (2.94E0) | 2.5E-1 (2.5E1) |
| Organ/Body NRC | 1.1E-2 (1.1E0) | 3.54E-3 (3.54E-1) | 2.04E-4 (2.04E-2) | 2.50E-2 (2.50E0)** | 3.97E-2 (3.97E0) | 2.5E-1 (2.5E1) |
| Thyroid NRC | 4.26E-2 (4.26E0) | 8.30E-4 (8.30E-2) | 2.04E-4 (2.04E-2) | 2.50E-2 (2.50E0)** | 6.86E-2 (6.86E0) | 7.5E-1 (7.5E1) |

* Source: SSAR Table 11.3-9.

** The 2.5E-2 mSv (2.5 mrem) values used here are the direct dose contributions from one ABWR unit

The staff independently confirmed the adequacy of the applicant's dose consequence calculations from normal operations. The staff determined that since specific details on how the new facility will control, monitor, and maintain radioactive gaseous and liquid effluents are not known at the ESP stage, a COL applicant that references this ESP for the proposed PSEG Site will need to verify that the calculated radiological doses to members of the public from

radioactive gaseous and liquid effluents for one or more new units which may be built at the PSEG Site are bounded by the radiological doses included in the ESP application and reviewed by the staff, as described above, and address with justification any discrepancies. This includes any changes made to address differences in reactor design used to calculate radiological doses (e.g., basis of the liquid and gaseous radiological source terms, and liquid effluent discharge flow rates and site-specific dilution flow rates). In addition, detailed information on the solid waste management system used to process radioactive gaseous and liquid effluents will be necessary to reflect plant and site-specific COL design considerations. The staff identified these items collectively as **COL Action Item 11-1**.

11.5 Conclusion

As set forth above, the applicant provided information adequate 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, Appendix B, Table 2, as well as maintain them at levels that are in accordance with the effluent design objectives contained in 10 CFR Part 50, Appendix I, Sections II.A, II.B, and II.C. Under the requirements of 10 CFR 20.1301 (e), the applicant also demonstrated compliance with the environmental radiation standards of the EPA under 40 CFR Part 190.

Based upon the above findings and considerations including COL Action Item 11-1, 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 two new nuclear power plants that might be constructed on the proposed site do not present an undue risk to the health and safety of the public. Therefore, with respect to radiological effluent releases and dose consequences from normal operations, the staff concludes that appropriate long-term atmospheric dispersion coefficients have been established for the proposed site, and are acceptable for constructing one or two units falling within the applicant's bounding site-specific PPE, and that the proposed 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."