11 RADIOACTIVE WASTE MANAGEMENT

This chapter describes the results of the U.S. Nuclear Regulatory Commission (NRC) staff review of the United States - Advanced Pressurized Water Reactor (US-APWR) design-basis and average radioactive source terms, and radioactive waste management systems (RWMS) as described in Chapter 11 of the US-APWR Design Control Document (DCD), Revision 2 submitted by Mitsubishi Heavy Industries, Ltd. (MHI), hereinafter referred to as the applicant, for the design certification (DC) of the US-APWR and the NRC staff referred to as staff.

The RWMS include the liquid waste management system (LWMS), gaseous waste management system (GWMS), solid waste management system (SWMS), and process effluent radiological monitoring and sampling systems (PERMS). The systems include the instrumentation used to monitor and control releases of radioactive effluents and wastes. The systems are designed for normal operations, including refueling outages, containment purging, routine maintenance, and anticipated operational occurrences (AOOs). As operational events, AOOs include unplanned releases of radioactive materials associated with equipment failures, operator errors, and administrative errors, with radiological consequences that are not considered accident conditions.

11.1 Source Terms

11.1.1 Introduction

The operation of the US-APWR will result in the generation of radioactive materials during normal operations, including AOO. Radioactive materials generated during operation include fission, activation, and corrosion products, present in both primary and, to lesser extents, in secondary coolant. The radioactivity thus generated is modeled by two types of radioactive source terms, design-basis and average. The design-basis source term is used to determine and define the capability of the liquid, gaseous, and solid radioactive waste management systems to process associated types and amounts of radioactivity, and for the design of process and effluent radiation monitoring systems in controlling and monitoring releases. This source term serves as the basis for shielding analyses and evaluation of occupational radiation exposures to plant workers. The average source term is used to represent conditions characterizing radionuclide concentrations in primary and secondary coolants under normal operating conditions. The average source term is used in evaluating the impacts of liquid and gaseous effluent releases in the environment and assessing doses to members of the public due to associated effluent releases.

Design basis source terms are analyzed from conservative assumptions on fuel defects and form the basis for radwaste and effluent monitoring system designs, and shielding requirements. The design-basis source term also provides the radionuclide inventory and coolant concentrations for the initial conditions for design-basis accident consequence calculations. Maximum core inventories in the reactor coolant are based on time-dependent fission product core inventories calculated using the ORIGEN code. Source terms for realistic conditions represent average radionuclide concentrations based on industry data from operating nuclear power plants and form the basis for calculating annual releases of radioactivity through liquid and gaseous effluent pathways. Additional sources of radioactivity such as tritium (H-3), C-14, Ar-41, and N-16 are produced by activation of constituents within the reactor coolant. Radioactive material present in the secondary coolant occurs by leakage from the reactor coolant system through steam generator (SG) tube defects governed by the primary-to-secondary leak rate.

11.1.2 Summary of Application

DCD Tier 1: There are no DCD Tier 1 entries for the source term area of review.

DCD Tier 2: The applicant has provided a description of the US-APWR radioactive source terms in DCD Tier 2, Section 11.1 “Source Terms,” summarized here, in part, as follows:

The US-APWR DCD Tier 2, Section 11.1 provides information on the sources of radioactive material generated within the reactor core and coolant systems and transferred to the gaseous and liquid waste management systems for treatment of liquid and gaseous wastes. The applicant provided design-basis and realistic radionuclide activity concentration source terms for the reactor coolant, the steam generator secondary side liquid and the SG secondary side steam.

DCD Tier 2, Section 11.2 explains that the design-basis coolant source terms are conservatively based on bounding design-basis assumptions. The bounding design-basis source term is based on a combination of Technical Specification (TS) limits for halogens and noble gases in the primary coolant. Activation product and tritium concentrations are derived from an industry standard, American National Standards Institute/American Nuclear Society (ANSI/ANS)-18.1-1999, “Radioactive Source Term for Normal Operation of Light Water Reactors.” Since the activated corrosion products are independent of failed fuel fraction, design basis and realistic basis concentrations for corrosion products are assumed to be the same. Design basis values for the remaining fission product radionuclides are calculated based on a 1 percent failed fuel fraction, i.e., it is assumed that 1 percent of the core thermal power is produced by fuel rods containing small cladding defects. Design basis secondary coolant concentrations are based on the TS limit primary to secondary leak rate.

The US-APWR design-basis coolant source terms are listed in DCD Tier 2, Table 11.1-2, “Design Basis Reactor Coolant Activity,” Table 11.1-3, “Tritium Source,” Table 11.1-5, “Design Basis SG Secondary Side Water Activity,” and Table 11.1-6, “Design Basis SG Secondary Side Steam Activity.”

The realistic coolant source terms represent the expected average radionuclide activity concentrations based on industry data from operating pressurized water reactor (PWR) plants. The applicant calculated realistic reactor coolant and secondary coolant source terms based on ANSI/ANS-18.1-1999 and NUREG-0017. The realistic coolant source terms provide the basis for calculating the annual release of radioactive material through liquid and gaseous effluents. The US-APWR realistic coolant source terms are listed in DCD, Tier 2, Table 11.1-9, “Realistic Source Terms.”

The realistic source term is developed using a model based on ANSI/ANS-18.1-1999, in which the reactor coolant radionuclide concentrations are based on observed radionuclide concentrations in currently operating reactors with adjustment for the design parameters of the US-APWR design.

DCD Tier 2, Tables 11.1-1, “Parameters Used to Calculate Design Basis Fission Product Activities,” to 11.1-4, “Parameters Used to Calculate Secondary Coolant Activity,” 11.1-7, “Adjustment Factors (ANSI/ANS-18.1-1999, Table 11),”” and 11.1-8, “Parameters Used to

Describe Realistic Sources," provide parameters used to calculate the primary and secondary source term activity for both bounding and realistic cases. DCD Tier 2, Table 11.1-7 includes a comparison of the US-APWR design with the plant design used in ANSI/ANS-18.1-1999. The resulting reactor coolant and secondary system source terms represent radioactive liquid and gaseous materials that may be transported or released to the environment by radioactive waste systems.

Inspection, Test, Analysis, and Acceptance Criteria (ITAAC): The ITAAC associated with DCD Tier 2, Chapter 11, are given in DCD Tier 1, Section 2.7, "Plant Systems." There are no ITAAC items for the source term area of review.

TS: There are no TS for the source term area of review.

Combined License (COL) information or action items: (See Section 11.1.5 below).

Technical Report(s): There are no technical reports associated with this area of review.

Topical Report(s): There are no topical reports associated with this area of review.

US-APWR Interface Issues Identified in the DCD: There are no US-APWR interface issues associated with this area of review.

Site Interface Requirements Identified in the DCD: There are no site interface requirements associated with this area of review.

Cross-cutting Requirements (Three Mile Island [TMI], Unresolved Safety Issue [USI]/Generic Safety Issue [GSI], Op Ex): There are no cross-cutting issues for this area of review.

Regulatory Treatment of Nonsafety Systems (RTNSS): There are no RTNSS issues for this area of review.

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20, Section 20.1406: There are no issues related to 10 CFR 20.1406 for this area of review.

Conceptual Design Information (CDI): This section of the DCD does not contain CDI that is outside the scope of the US-APWR certification.

11.1.3 Regulatory Basis

The relevant requirements of the Commission's regulations for the source term area of review, and the associated acceptance criteria, are given in Section 11.1 of NUREG-0800 "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants - LWR [light-water reactor] Edition," dated March 2007 (hereafter referred to as NUREG-0800 or the SRP), and are summarized below. Review interfaces with other SRP sections can be found in NUREG-0800, Section 11.1.

1. Title 10 CFR, Part 20, "Standards for Protection Against Radiation,", as it relates to determining the operational source term that is used in calculations associated with potential radioactivity in effluents released to unrestricted areas.

2. 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,” as it relates to determining the operational source term that is used in calculations associated with potential radioactivity in effluents considered in the context of numerical guides for design objectives and limiting conditions for operation to meet the criterion “as low as is reasonably achievable” (ALARA) for radioactive material in light-water cooled reactor (LWR) effluents.

3. 10 CFR Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants,” General Design Criterion (GDC) 60, “Control of Releases of Radioactive Materials to the Environment,” as it relates to determining the operational source term that is used in calculations associated with potential radioactivity in effluents released to unrestricted areas, such that a nuclear power unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents provided during normal reactor operation, including AOOs.

Acceptance criteria adequate to meet the above requirements include:

1. Regulatory Guide (RG) 1.110, “Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors,” dated March 1976, as it relates to the cost-benefit analysis for radioactive waste management systems and equipment.

2. RG 1.112, “Calculation of Releases of Radioactive Materials In Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors,” Revision 1, dated March 2007, as it relates to the method of calculating release of radioactive materials in effluents from nuclear power plants.

3. RG 1.140, “Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants,” Revision 2, June 2001, as it relates to the design, inspection and testing of normal ventilation exhaust system air filtration and adsorption units at nuclear power plants.

4. ANSI/ANS-18.1-1999, “Radioactive Source Term for Normal Operation of Light Water Reactors,” as it relates to the methodology for determining the source term for normal reactor operations including anticipated accidental occurrences.

5. NUREG-0017 (Revision 1), “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code),” as it relates to (1) the volumes and concentrations of radioactive material given for normal operation and AOOs for each source of liquid and gaseous waste, (2) decontamination factors for in-plant control measures used to reduce liquid effluent releases to the environment, such as filters, demineralizers and evaporators, and (3) building mixing efficiency for containment internal cleanup.

11.1.4 Technical Evaluation

Information needed for the review of radioactive waste management systems includes the type and quantities of radioactivity that are input into these systems for treatment of liquid and gaseous wastes. This includes consideration of parameters used to determine the amount of radioactive material from fission products released to the reactor coolant and the concentrations of all nonfission product radioactive isotopes in the reactor coolant. The source term analysis also determines bounding values of parameters to be used in evaluating radioactive waste system capacities and effluent monitoring systems and in analyzing the consequences of certain postulated accidents. Expected values for source term parameters are also principally determined from industry experience and guidance.

The staff evaluated the information in DCD Tier 2, Section 11.1 against the guidance of SRP Section 11.1. The specific criteria sufficient to meet the relevant requirements of 10 CFR Part 20 and 10 CFR Part 50, Appendix I, for a PWR as taken from SRP Section 11.1 are as follows:

1. All normal and potential sources of radioactive effluent from PWR gaseous wastes and liquid wastes as delineated in SRP Section 11.1 will be considered.

2. For each source of liquid and gaseous waste, the volumes and concentrations of radioactive material given for normal operation and AOOs should be consistent with those given in NUREG-0017 (Revision 1)., “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code).”

3. Decontamination factors for in-plant control measures used to reduce gaseous effluent releases to the environment, such as iodine removal systems and high-efficiency particulate air (HEPA) filters for building ventilation exhaust systems and containment internal cleanup systems should be consistent with those given in RG 1.140. The building mixing efficiency for containment internal cleanup should conform to NUREG-0017.

4. Decontamination factors for in-plant control measures used to reduce liquid effluent releases to the environment, such as filters, demineralizers and evaporators, should be consistent with those given in NUREG-0017.

5. Radwaste augments used in the calculation of effluent releases to the environment are consistent with the findings of a cost-benefit analysis, which may be performed using the guidance of RG 1.110. The provisions that require a cost-benefit analysis are stated in 10 CFR Part 50, Appendix I, Section II.D.

6. Effluent concentration limits at the boundary of the unrestricted area do not exceed the values specified in 10 CFR Part 20, Appendix B, Table 2.

7. The source terms result in meeting the design objectives for doses in unrestricted areas as set forth in 10 CFR Part 50, Appendix I.

8. For evaluating the source terms, the applicant should provide the relevant information in the safety analysis report as required by 10 CFR 50.34, “Contents of applications; technical information,” and 10 CFR 50.34a, “Design objectives for equipment to control releases of radioactive material in effluents - nuclear power reactors.” This technical information should include all the basic data given in to RG 1.112, Appendix B (PWRs) calculate the releases of radioactive material in liquid and gaseous effluents (the source terms). An acceptable method for satisfying the criteria given in RG 1.112, and

Criteria 1 through 5 above consists of using the Gaseous and Liquid Effluent (GALE) computer code and the source term parameters given in NUREG-0017 for PWRs. A complete listing of the GALE computer code for PWRs is given in NUREG-0017.

9. If the applicant's calculation technique or any source term parameter differs from that given in ANSI/ANS-18.1-1999 or NUREG-0017, then each such difference should be described in detail, and the bases for the methods and/or parameters used should be provided.

In reviewing the US-APWR design against the above specific SRP acceptance criteria, the staff determined that some of the above criteria dealt with the source term, which is the subject of this section, while some dealt with the subjects to be discussed in Sections 11.2 through 11.5 of this safety evaluation (SE). The following is the staff's evaluation of the DCD Tier 2, Chapter 11.1 information against the above criteria:

- The staff reviewed DCD Tier 2, Table 11.2-9, "Input Parameters for the PWR-GALE Computer Code," and DCD Tier 2, Sections 11.2 and 11.3, and found that all sources of radioactive effluents delineated in Subsection I of SRP Section 11.1 were considered, and that the sources are consistent with those considered in NUREG-0017. Therefore, the staff finds that SRP Acceptance Criterion 1 above is satisfied.

- DCD Tier 2, Table 11.2-9 addresses the applicant's use of the PWR-GALE code as discussed in Criterion 8. NUREG-0017, which describes the PWR-GALE code, includes nominal system design values pertinent to the calculation of the coolant activity for a reference PWR with a core power of 3,400 MWt, along with a method to adjust the listed values for a plant with a different core power. The staff's review of the values used by the applicant in the PWR-GALE code verified that Criteria 2 through 4 are met by showing that the US-APWR design values are used consistently with the method given in NUREG-0017.

- The decontamination factors used for gaseous effluents and HEPA filter efficiency are consistent with RG 1.140, satisfying Criterion 3.

- DCD Tier 2, Table 11.2-7, "Decontamination Factors," addresses Criterion 4. The staff reviewed this table and confirmed that the decontamination factors (DF) for liquid effluents, such as filters, demineralizers, and evaporators, are consistent with NUREG-0017. Therefore, the staff finds that Criterion 4 is satisfied.

- Criterion 5 with respect to radwaste system augments is addressed in DCD Tier 2, Sections 11.2.1.5 and 11.3.1.5. Radwaste augments are not assumed as part of the licensing basis. The radwaste system cost-benefit analysis is addressed in DCD Tier 2 Sections 11.2.4, "Liquid Waste Management System cost-Benefit Analysis," and 11.3.4, "Gaseous Waste Management systems Cost-Benefit Analysis," Sections 11.2 and 11.3 of this SE. Discuss the staff's review of the cost-benefit analyses for the LWMS and the GWMS.

- DCD Tier 2, Table 11.2-12, "Comparison of Annual Average Liquid Release Concentrations with 10CFR20 (Expected Releases)," DCD Tier 2, Table 11.2-13, "Comparison of Annual Average Liquid Release Concentrations with 10 CFR 20 (Maximum Releases)," DCD Tier 2, Table 11.3-6, "Comparison of Calculated Offsite

Airborne Concentrations with 10 CFR 20 Limits (Expected Releases)," and DCD Tier 2, Table 11.3-7, "Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Maximum Releases)," address Criterion 6. Based on the evaluation in Sections 11.2 and 11.3 of this SE, the staff finds the release concentrations acceptable.

- DCD Tier 2, Table 11.1-1, "Parameters Used to Calculate Design Basis Fission Product Activities," DCD Tier 2, Table 11.1-4, "Parameters Used to Calculate Secondary Coolant Activity," DCD Tier 2, Table 11.1-8, "Parameters Used to Describe Realistic Sources," and DCD Tier 2, Section 11.1.1 address Criterion 8. The staff reviewed the parameters in these tables and confirmed that they are consistent with those given in ANSI/ANS-18.1-1999 and NUREG-0017. The staff also finds that the methods used by the applicant to calculate the design basis and realistic coolant source terms do not differ from the methods given in ANSI/ANS-18.1-1999 and NUREG-0017. Therefore, the staff finds Criterion 8 to be satisfied.

- The applicant used a proprietary version of the PWR-GALE code with an updated ANSI/ANS-18.1-1999 source term specification and input design values specific to the US-APWR. Based on the evaluation in Sections 11.2 and 11.3 of this SE, the staff finds Criterion 9 to be is satisfied.

Sections 11.2 and 11.3 of this SE document the staff's evaluation of the potential radioactive wastes and the capability of the LWMS and GWMS to keep radioactive effluents in unrestricted areas ALARA, in accordance with the requirements of 10 CFR Part 50, Appendix I. In addition, Sections 11.2 and 11.3 of this SE documents the staff's evaluation in compliance with 10 CFR 20.1302, which defines the criteria for radionuclide concentration limits in liquid and gaseous effluents released into unrestricted areas. Sections 11.2 through 11.5 of this SE discusses compliance with 10 CFR Part 50, Appendix A, GDC 60, as it relates to the design of the radioactive waste management systems to control releases of radioactive materials and to conform to the guidance in RG 1.110 and RG 1.140. As discussed above, an applicant conforms to the guidance in RG 1.112 by meeting Criterion 9.

DCD Tier 2, Section 11.1 describes the sources of radioactivity that are generated within the core and have the potential of leaking to the reactor coolant system (RCS) during normal plant operation, including AOOs, by way of defects in the fuel cladding. Two source terms are presented for the primary and secondary coolant. The first is the design-basis source term, which assumes a design basis fuel defect level of 1 percent. Reactor coolant activity is determined based on time-dependent fission product core inventories that are calculated by the ORIGEN 2.2 code. The first source term serves as a basis for RWMS design and shielding requirements, and is listed in DCD Tier 2, Tables 11.1-2, 11.1-3, 11.1-5, and 11.1-6. The second source term is a realistic model which represents the expected average concentrations of radionuclides in the primary and the secondary coolant. These values are determined using the methodology in ANSI/ANS-18.1-1999 and the PWR-GALE code (NUREG-0017). The realistic source term provides the bases for estimating typical concentrations of the principal radionuclides, and is listed in DCD Tier 2, Table 11.1-9, "Realistic Source Terms (Sheets 1 and 2)." This source term model reflects the industry experience at a large number of operating PWR plants.

The staff found that the assumption of a 1 percent fuel defect level used for the US-APWR design-basis source term conforms to the standard fuel defect assumption of 1 percent given as guidance in SRP Sections 11.2 and 11.3 for the LWMS and the GWMS, respectively.

The staff performed confirmatory calculations with the ORIGEN-ARP isotope generation and depletion computer code to verify the applicant's core fission product isotopic inventory and ultimately to verify the applicant's design basis coolant source terms assuming 1 percent cladding defect. ORIGEN-ARP is a newer revision of the ORIGEN 2.2 code than the applicant used. The core fission product isotopic inventory is discussed in DCD Tier 2, Section 15.A.1.1, "Source Terms," and the inventory is listed in DCD Tier 2, Table 15A-10, "Reactor Fission Product Nuclide Inventory and Related Parameters (Sheets 1 to 4)." In Request for Additional Information **(RAI) 38-412, Question 15.0.03-20**, the staff asked the applicant to justify the use of the ORIGEN 2.2 code, which is no longer maintained by the author, Oak Ridge National Laboratory. In **RAI 38-412, Question 15.0.03-21**, the staff asked the applicant to verify that the cross-section libraries used in the calculation of the core fission product inventory were applicable to the assumed maximum fuel burnup of 55 gigawatt-days per metric ton uranium.

By letter dated October 20, 2008, the applicant responded to the above RAIs. The staff found the applicant's responses acceptable, as discussed in Section 15.0.3.1 of this SE. Based on the above, the staff finds that the applicant has used an appropriate isotope generation and depletion code and has used appropriate input values to the code with reference to the US-APWR fuel design with regard to the operating cycle length, burnup, and uranium enrichment in calculating the core isotopic inventory. The staff's calculations using the ORIGEN-ARP code and the applicant's design values for operating cycle length, burnup and uranium enrichment confirmed the applicant's core fission product isotopic inventory as listed in DCD Tier 2, Table 15A-10. **RAI 38-412, Questions 15.0.03-20 and 15.0.03-21** are closed. Further discussion of the staff's review of the core inventory can be found Chapter 15 of this SE.

The applicant then applied a set of standard differential equations that accounts for the introduction to the reactor coolant of fission products from the cladding defect, radioactive decay, fission product escape, dilution, letdown, primary-to-secondary leakage and decontamination to calculate the reactor coolant fission product source term and secondary coolant and steam fission product source terms.

The activities of corrosion products are independent of fuel defect and are based on existing plant data. The corrosion product inventory is given in DCD Tier 2, Table 11.1-2, "Design Basis Reactor Coolant Activity." DCD Tier 2, Table 11.1-3, "Tritium Source," gives the design basis tritium source based on both fission and activation, while DCD Tier 2, Table 11.1-9 gives the typical tritium activity the reactor and secondary coolants. The applicant also determined the amount of activation products in the coolant. The applicant determined the production of C-14, Ar-41, and N-16 through activation of the coolant, using standard assumptions consistent with NUREG-0017 and engineering practice at current operating reactors. The staff verified that these values are consistent with operating plant data and are bounded by the methodology in NUREG-0017.

DCD Tier 2, Tables 11.1-1 and 11.1-4, "Parameters Used to Calculate Secondary Coolant Activity," give the parameters used to calculate the design basis fission product activities in the reactor coolant and the secondary coolant. In DCD Tier 2, Table 11.1-4, the applicant listed the total primary-to-secondary leakage as 150 gallons per day (gpd), which equals the TS 3.4.13 limit for one SG. The total primary-to-secondary leakage should account for leakage through all four of the SGs in the US-APWR design, which would be 600 gpd if all SGs were leaking at their maximum allowable rate. In **RAI 9-411, Question 11.01-1**, the staff requested the applicant to provide the basis for using 150 gpd for the primary-to-secondary leakage assumption. By letter dated July 18, 2008, the applicant responded that the total primary-to-secondary leakage of 150 gpd in the coolant source term analysis is used to avoid an overly conservative shielding design by modeling leaks in multiple SGs. The DCD, Tier 2, Chapter 15, "Transient and Accident Analyses," design basis accident radiological consequences analyses that include releases from the SGs do assume that all SGs have primary-to-secondary leakage at the TS limit, for a total primary-to-secondary leakage of 600 gpd, in accordance with the guidance in RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors." For comparison purposes, ANSI/ANS-18.1-1999 nominal concentrations are based on a total primary-to-secondary leakage rate of 75 lb/day as the average for the current operating PWRs with u-tube SGs like those in the US-APWR. The 75 pounds (lb)/day would approximately equal to 9 gpd at standard temperature and pressure, which is the basis for the TS leakage rate value. Based on the discussion above, the staff has found the applicant's response acceptable, and finds that the applicant has used inputs that are consistent with the guidance in RG 1.112 and NUREG-0017; therefore, the design basis reactor coolant and secondary coolant source terms are acceptable. **RAI 9-411, Question 11.01-1** is closed.

DCD Tier 2, Section 11.1.3, "Realistic Reactor Coolant and Secondary Coolant Activity," and Tables 11.1-7, "Adjustment Factors (ANSI/ANS 18.1-1999 Table 11)," and 11.1-8, "Parameters Used to Describe Realistic Sources," give input design parameters used by the applicant to calculate the realistic source terms given in DCD Tier 2, Table 11.1-9 (Sheets 1 and 2). The applicant used the model and procedures in ANSI/ANS-18.1-1999 and NUREG-0017, in accordance with the guidance in SRP, Section 11.1.

From review of DCD Tier 2, Tables 11.1-2 and 11.1-9, the staff determined that Tc-99 concentrations were not identified in the primary and secondary coolant. As a result, in **RAI 29-595, Question 11.01-2**, the staff requested that the applicant identify the Tc-99 concentrations in the primary and secondary coolant under design basis and realistic conditions, or justify its exclusion from the tables. By letter dated August 6, 2008, the applicant responded to the above RAI. Tc-99 concentration is only important for evaluation of doses due to liquid releases to the environment. Because this question is related to the radioactive source terms only used in the liquid tank failure analysis, the staff's evaluation of the applicant's response to **RAI 29-595, Question 11.01-2** is discussed in Section 11.2.4.8 of this SE.

11.1.5 Combined License Information Items

The staff did not identify any COL information items specifically related to radioactive source terms to be included in DCD Tier 2, Table 1.8-2, "Compilation of All Combined License Applicant Items for Chapters 1-19."

11.1.6 Conclusions

Based on the above evaluation, the staff determined that the source terms described in DCD Tier 2, Section 11.1 is acceptable. The staff determined the acceptability of the applicant's proposed source terms based on the applicant's conformance with the guidance given in SRP Section 11.1 and ANSI/ANS-18.1-1999. The staff further determined that use of these source terms in calculating liquid and gaseous effluents, and as design parameters for the LWMS and GWMS discussed in Sections 11.2 and 11.3 of this SE, respectively, will meet the regulatory requirements of 10 CFR Part 20 and 10 CFR Part 50, with respect to offsite radiation dose limits and effluent concentration limits.

11.2 Liquid Waste Management System

11.2.1 Introduction

The LWMS is designed to ensure that process fluid streams and liquid wastes produced during normal operation including AOOs, are handled, processed, stored, and released or routed to their final destination in accordance with applicable regulatory guidance and relevant NRC regulations. Liquid wastes typically generated by PWRs consist of primary coolant processed to control boron concentration levels, leakage collected from equipment and floor drains in buildings housing equipment and components that contain radioactive fluids, SG blowdowns, demineralizer effluents, regenerant solutions, contaminated liquids from anticipated plant operations (such as resin sluices, filter backwashes, decontamination solutions, and sample station drains), and detergent wastes. Wastes associated with the treatment of liquid process streams include sludge, spent resins, spent filters, and concentrated wastes, among others. Such wastes are handled by the solid waste management system (SWMS) evaluated in Section 11.4 of this SE.

11.2.2 Summary of Application

DCD Tier 1: The applicant provided a system description in DCD Tier 1, Section 2.7.4.1, “Liquid Waste Management System,” summarized here, in part, as follows:

The LWMS located in the containment, auxiliary building (A/B), and reactor building (R/B) is a non safety-related system with non-seismic components. However, the reactor coolant drain tank and the containment vessel sump include a safety-related containment isolation qualified for harsh environments that is designed and constructed to meet seismic Category I and American Society of Mechanical Engineers (ASME) code, Section III requirements.

The LWMS provides the capability to segregate, collect, treat, store, sample, and analyze treated liquid for safe control and disposal. Four interconnected subsystems are designed in the LWMS with redundancy to segregate and process liquid wastes, which includes the equipment and floor drain processing subsystem, the detergent drain subsystem, the chemical drain subsystem, and the reactor coolant drain subsystem. Tanks and equipment used for storing and processing liquid waste are located in controlled areas and are shielded. Processed waste is temporarily stored in monitor tanks and sampled prior to recycle or discharge. Connections are provided to forward liquid waste to contracted mobile systems or temporary equipment. The LWMS is designed in accordance with ALARA, and to provide containment isolation of the LWMS lines penetrating containment. Detailed descriptions regarding the LWMS design and operation features are provided in DCD Tier 2, Section 11.2, “Liquid Waste Management System.”

DCD Tier 2: The applicant provided a system description in DCD Tier 2, Section 11.2, “Liquid Waste Management System,” summarized here, in part, as follows:

DCD Tier 2, Section 11.2 describes the design of the LWMS and its functions in controlling, collecting, processing, storing, and disposing of liquid radioactive waste generated as a result of normal operation including AOOs. The LWMS, located in containment, A/B, and R/B is a non safety-related system. Failure of the LWMS does not adversely affect any safety-related system or component and performs no function related to the safe shutdown of the plant. However, the reactor coolant drain tank and the containment vessel sump include a safety-related containment isolation qualified for harsh environments that is designed and constructed to meet seismic Category I and ASME Code Section III requirements evaluated in Section 6.2 of this SE. DCD Tier 2, Section 3.2, “Classification of Structures, Systems, and Components,” describes the seismic and quality group classification and corresponding codes and standards that apply to the design of the LWMS components and piping and structures housing the system. The LWMS is designed to the seismic criteria of RG 1.143 (Revision 2), "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants." Principle LWMS equipment is housed in portions of the A/B designed to contain the liquid inventory in the event of an operating-basis earthquake. The quality assurance (QA) program assures LWMS equipment and installation is performed in accordance with the codes and standards of RG 1.143 listed in DCD Tier 2, Table 11.2-1, "Equipment Codes (Extracted from Table 1, RG 1.143)" for structures, systems, and components (SSCs) in radioactive waste facilities. The QA program is developed in accordance with ANSI/ANS-55.6-1993 (R1999), "Liquid Radioactive Waste Processing for Light Water Reactor Plants." The LWMS does not normally process non-radioactive secondary system effluent. The US-APWR is designed with no interconnections and/or sharing between systems or between units to prevent contamination due to potential radioactivity or due to backflow making water unfit for human consumption (DCD Tier 2, Section 9.2.4, "Potable and Sanitary Water Systems").

DCD Tier 2, Figure 11.2-1, "Liquid Waste Processing System Process Flow Diagram (Sheet 1 of 3)," depicts the boundary of the liquid waste processing system, which starts at the interface valves for each of the input waste streams that contain potential radioactive material from other plant systems. For many of the waste streams, the boundary of the LWMS starts at the respective building sump tank discharge line. The boundary of the liquid waste processing system ends at the isolation valve of the discharge lines to a liquid containing tank or the discharge header.

The LWMS is comprised of four subsystems to treat the major and minor liquid waste streams:

- Equipment and floor drain processing subsystem (major contributor to waste stream)
- Detergent drain subsystem (minor contributor to waste stream)
- Chemical drain subsystem (minor contributor to waste stream)
- Reactor coolant drain subsystem

The liquid waste processing system, equipment drainage and floor drainage processing subsystem consists of four waste holdup tanks (WHT) divided into two sets (each with two WHT) designed to collect high-quality liquid from equipment drainage and the other set to collect liquid from floor drainage, two WHT pumps, two liquid filters, an activated carbon filter, four ion exchange columns, two waste monitor tanks, and two waste monitor tank pumps to collect treated liquid for analysis.

The process flow diagram is depicted in DCD Tier 2, Figure 11.2-1, "Liquid Waste Processing System Process Flow Diagram (Sheet 1 of 3)." The WHT and waste monitor tanks and their associated pumps are located in the A/B. Filters and ion exchange columns are located at an elevation of 3 feet (')-7 inches (") in the A/B as shown in DCD Tier 2, Figure 11.5-2a, "Location of Radiation Monitors at Plant (Power Block at Elevation -26'-4")," through Figure 11.5-2k, "Location of Radiation Monitors at Plant (Power Block Section A-A)." Process flow diagrams with process equipment, flow data, tank batch capabilities, and key control instrumentation are provided in DCD Tier 2, Figures 11.2-1 through 11.2-3 to indicate process design, method of operation, and release monitoring. The COL applicant is required to provide the piping and instrumentation diagrams (P&IDs) in COL Information Item 11.2(6).

The liquid waste processing system is designed with redundancy and interchangeability. Although a common header with an isolation valve is provided to segregate the collection from equipment drainage and floor drainage, the WHT can be used interchangeably in the event that excess equipment drainage and/or floor drainage waste is generated. Two cartridge filters with one filter in use, the other is on standby or being maintained, is connected in parallel to provide redundancy. The activated carbon filter used to remove organics that could foul the ion exchange columns is sized to handle the entire liquid effluent inventory, and is designed to operate occasionally and only when there is a high level of organic contaminants. The four ion exchange columns (demineralizers) used to remove radionuclide impurities in the liquid stream operate in separate trains: two ion exchange columns in series each with mixed resins for optimum performance. Four ion exchange columns consisting of anion and cation resins are provided to operate in separate trains with two ion exchange columns in series each with mixed resins for optimum performance. Only one of the two trains of ion exchange columns is required to operate during normal operation including AOOs while the other train is on standby. The four ion exchange columns can be arranged upon detection of high radionuclide concentration such as in a design basis failed fuel event to operate in series so that the treated liquid meets recycle and/or release specifications. Two waste monitor tanks are provided with one in the receiving mode, the other in standby, sampling and analysis, or in transferring release mode. Two WHT pumps and two waste monitor tank pumps are provided for processing and transfer operations of which normally only one of each is required for recirculation, processing, and transferring of liquid.

The LWMS design provided in DCD Tier 2, Table 11.2-3, "Component Data - Tanks (Sheets 1 and 2)," includes nominal tank and sump volumes (batch volumes are about 80 percent full capacity):

- Four 30,000 gallon (gal) WHT
- One 2,500 gal detergent drain tank
- One 2,500 gal detergent drain monitor tank
- One 1,000 gal chemical drain tank
- Two 30,000 gal waste monitor tanks
- One 60 ft^3 containment vessel (C/V) reactor coolant drain tank (RCDT)
- One 1,200 gal A/B sump tank
- One 1,200 gal A/B equipment drain sump tank
- Two 1,200 gal R/B sump tanks
- One 1,200 gal C/V RCDT sump

DCD Tier 2, Table 11.2-19, "Expected Inputs to the LWMS, Processing Time and Days of Holdup," indicates the liquid waste processing system is designed with sufficient capacity to temporarily store the expected maximum volume per event for a day of operation during AOOs assuming 80 percent full tank capacity of 90,000 gal for the equipment and floor drainage subsystem, 1,000 gal for the chemical drain subsystem, and 1,000 gal for the detergent subsystem based on nominal volume processing rates of 90 gallons per minute (gpm), 20 gpm, and 20 gpm, respectively, which is selected from sampling and processing of one tank volume in one shift of operation, assuming a 40-hour work week.

Laboratory wastes and decontamination solutions are collected for treatment in the chemical drain subsystem and disposed of in appropriate portable containers. Decontamination solutions and process liquids are inherently free of hazardous materials and toxic to the greatest extent practicable to minimize generation of mixed waste. Chemical wastes are pH adjusted, and neutralized prior to being pumped to WHT for further processing or transferred to a container for disposal. The chemical drain tank and chemical drain tank pump are located at an elevation of -26 ’-4” in the A/B.

Detergent waste does not typically contain any significant levels of radioactive contaminants consists primarily of material from sinks, showers, emergency showers is collected in the detergent drain tank, filtered, and released through the discharge header. The detergent drain tank, detergent drain tank pump, filter, detergent drain monitor tank, and detergent drain monitor tank pump are located at an elevation of -26’-4” in the A/B.

Small quantities of reactor-grade water are collected during normal operations including AOOs in the C/V RCDT and the C/V reactor coolant pump (suction side) located inside containment. A nitrogen cover gas is maintained over the liquid in the C/V RCDT to preserve the quality of the water and to minimize the potential for the formation of a flammable mixture. The water temperature (up to 200 °F) is monitored in the C/V RCDT and is decreased (below 200 °F) by the addition of primary makeup water. The C/V RCDT is maintained at a near constant level to minimize both the amount of gas sent to the GWMS and the nitrogen cover gas.

During refueling, the C/V reactor coolant drain pumps are used to drain water from the reactor cavity and the fuel transfer canal to the refueling water storage auxiliary tank (RWSAT), located outside of containment, without entering the C/V RCDT. During maintenance or outages, any remaining gas is purged from the system to the GWMS using nitrogen.

Operation and monitoring of the LWMS is performed from the radwaste control room with provisions for local monitors. The LWMS operates on a batch basis with manual start and automatic stops. Parameters such as tank levels, processing flow rates, differential pressures across filters, ion exchange columns, etc., are indicated and/or alarmed to provide information on operational and equipment performance. High-level alarms associated with the liquid tanks are activated in the main control room (MCR). A summary of indications, level annunciations, and overflows for the LWMS are shown in DCD Tier 2, Table 11.2-8, “Parameters Used to Describe Realistic Sources.” A liquid radwaste discharge radiation detector and dual isolation valves are installed on the sole discharge line from the LWMS to monitor and control liquid effluent discharges to the environment.

The LWMS is designed with permanently installed equipment such as tanks, filters, activated carbon filter, ion exchange columns, and pumps, and does not include the use of mobile or temporary equipment which is the responsibility of the COL applicant. However, space is provided inside the A/B to accommodate future mobile or temporary equipment where treated liquid can be returned to the WHT for sampling, recycling, and/or release.

The SG blowdown radiation monitor measures the radiation level in the SG blowdown water after it is treated and before it is returned to the condensate storage tank. A sample from the SG blowdown mixed bed demineralizers is monitored for radiation. In the event of primary-to-secondary system leakage due to an SG tube leak with radiation monitored above a predetermined setpoint, an alarm is automatically initiated for operator actions in the MCR, and a valve is automatically turned off through which treated liquid is sent to the discharge header.

Design features are provided in the LWMS to control and collect radioactive material spills from liquid tanks and equipment. Component connections are butt-welded to minimize leakage. High-level alarms are installed on the tanks to shut off feed pumps or to alert operators to re-direct the flow to other storage tanks to minimize overflow. The total tank capacity is adequately sized to accommodate the expected volumes of generated waste from input streams for processing. The tanks are equipped with overflows (at least as large as the largest inlet) into sumps. Cells/cubicles that contain significant quantities of radioactivity are lined with an impermeable epoxy coating applied up to the cubicle wall height equivalent to the full tank volume to facilitate eventual decontamination in the event of tank leakage or failure. The LWMS is designed with redundancy, leak detection, liquid level detection, drainage, and transfer capabilities to minimize contamination to the facility and the environment. All LWMS tanks are vented to the ventilation system with the exception of the C/V RCDT which is routed to the GWMS and monitored for radioactivity through the plant vent stack.

Design features are also provided in the LWMS to control and maintain personnel doses ALARA. Filters such as the activated carbon filter and ion exchange columns are remotely handled to eliminate direct contact and reduce potential exposures. Components that require inspections such as tanks are located in cubicles with access doors to allow quick ingress and egress. Components that require maintenance, such as pumps, are located in low radiation corridors outside the equipment cubicles. Tanks, equipment, and pumps used for storing and processing radwaste are located in controlled areas and shielded based on design basis source term inventories.

The LWMS will be subjected to preoperational inspections and testing by the COL licensee to ensure that all subsystems are operationally ready, meet their design basis and performance specifications, and that all automatic control functions are fully operational, including the automatic termination and isolation of radioactive releases upon the detection of a high radiation signal from the liquid effluent radiation monitor. The COL licensee will develop administrative procedures governing the operation of all subsystems, control the treatment of various process and waste streams, and prevent accidental discharges into the environment.

Process equipment for the LWMS includes cartridge filtration systems to remove suspended solids and radioactive particulates, activated charcoal to remove organic contaminants, and ion exchange resin to remove dissolved solids and nuclides that are commonly used and proven in other nuclear power plants. After the waste has been processed and treated, it is temporarily stored in monitor tanks and sampled. Waste monitor tanks are designed with sample ports and mixing nozzles to allow thorough mixing of representative samples. Depending on the sampling results, the waste may be returned to the WHT for further processing, reused for resin sluicing application or flushing lines, or released when determined to be compliant with the NRC regulations and site-specific permit requirements. Sump tanks are designed with oil separator baffles to isolate contaminated oil and sludge which is transferred into a drum minimizing damage of downstream ion exchange columns and extend the lifespan of the activated carbon filter. Spent cartridge filter media is transferred as slurry with PMW to the SWMS for further processing and packaging.

In assessing the radiological impacts from radioactive liquid effluent releases, DCD Tier 2, Tables 11.2-7, “Decontamination Factors,” and 11.2-9, “Input Parameters for the PWR-GALE Code (Sheets 1 of 2),” through 11.2-17, “Calculation Results of Effluent Concentrations due to Liquid Containing Tank Failures,” present information supporting the development of the liquid source term, and compliance with the effluent concentration limits (ECLs) of 10 CFR Part 20, Appendix B, Table 2, Column 2; and 10 CFR 20.1301(e) insofar as it required meeting the U.S. Environmental Protection Agency (EPA) environmental radiation protection standards of 40 CFR Part 190, “Environmental Radiation Protection Standards for Nuclear Power Operations”, and the numerical design objectives of 10 CFR Part 50, Appendix I. The results show that expected annual liquid effluents released during normal operation including AOOs in unrestricted areas and doses to members of the public comply with the NRC regulations and conform to the NRC guidance. As discussed in Section 11.2 of this SE, the results also demonstrate compliance with the ALARA requirements of 10 CFR Part 50, Appendix I, and SRP acceptance criteria for the postulated failure of a liquid tank containing radioactivity.

ITAAC: The ITAAC associated with DCD Tier 2, Section 11.2, “Liquid Waste Management System,” are given in DCD Tier 1, Section 2.7.4.1, ”Liquid Waste Management System (LWMS),” and Table 2.7.4.1-1, “Liquid Waste Management System Inspections, Tests, Analyses, and Acceptance Criteria.” The ITAAC associated with the LWMS equipment, components, and piping and that comprise a portion of the containment isolation system are described in Table 2.11.2-2, “Containment Isolation System Inspections, Tests, Analyses, and Acceptance Criteria (Sheets 1 to 8).” DCD Tier 2, Section 14.3.4.7, “ITAAC for Plant Systems,” summarizes how ITAAC were developed for DCD Tier 1, Section 2.7.4.1.

TS: There is information pertinent to TS associated with the LWMS in DCD Tier 2, Sections 11.2.3.2, “Radioactive Effluent Releases due to Liquid Containing Tank Failures,” and 11.2.3.3, “Offsite Dose Calculation Manual,” and DCD Tier 2, Chapter 16, TS 5.5.1, “Offsite Dose Calculation Manual (ODCM),” TS 3.4.16 and TS B 3.4.16, “RCS Specific Activity,” and TS 5.5.12, “Explosive Gas and Storage Tank Radioactivity Monitoring Program,” and Section 3.3.3, “Post Accident Monitoring (PAM) Instrumentation.”

10 CFR 20.1406: There is information pertinent to 10 CFR 20.1406 in DCD Tier 2, Sections11.2.1.2, “Design Criteria,” 11.2.1.4, “Method of Treatment,” and 11.2.1.6, ”Mobile or Temporary Equipment.”

COL information or action items: See Section 11.2.5 below

Technical Report(s): There is a technical report associated with this area of review described in “Calculation Methodology for Radiological Consequences in Normal Operation and Tank Failure Analysis,” Technical Report MUAP-10019 [Proprietary]P (R0), Technical Report MUAP-10019 [Non-Proprietary]NP (R0), MHI, September 2010.

Topical Report(s): There are no topical reports associated with this area of review.

US-APWR Interface Issues Identified in the DCD: There are no US-APWR interface issues associated with this area of review.

Site Interface Requirements Identified in the DCD: There are no site interface requirements associated with this area of review.

Cross-cutting Requirements (Three Mile Island [TMI], Unresolved Safety Issue [USI]/Generic Safety Issue [GSI], Op Ex): There are no cross-cutting issues for this area of review.

RTNSS: There are no RTNSS issues for this area of review.

CDI: This section of the DCD does not contain CDI that is outside the scope of the US-APWR certification.

11.2.3 Regulatory Basis

The relevant requirements of the NRC regulations for the LWMS and the associated acceptance criteria are given in SRP Section 11.2 of NUREG-0800 and are summarized below. Review interfaces with other SRP sections can be found in NUREG-0800, Section 11.2. The following acceptance criteria are applicable:

1. 10 CFR 20.1301, "Dose limits for individual members of the public" as it relates to dose limits for individual members of the public.

2. 10 CFR 20.1302, "Compliance with dose limits for individual members of the public," as it relates to limits on doses to members of the public and liquid effluent concentrations and doses in unrestricted areas.

3. 10 CFR 20.1406, "Minimization of contamination," as it relates to facility design and operational procedures for minimizing facility contamination and the generation of radioactive waste.

4. 10 CFR 50.34a, "Design objectives for equipment to control releases of radioactive material in effluents-nuclear power reactors," as it relates to the inclusion of sufficient design information in demonstrating compliance with the design objectives for equipment necessary to control releases of radioactive effluents to the environment.

5. 10 CFR 50.36a, "Technical specifications on effluents from nuclear power reactors," as it relates to TS requiring that operating procedures be developed for radiological monitoring and sampling equipment as part of the administrative controls and surveillance on effluent controls in meeting the ALARA criterion and 10 CFR 20.1301 dose limits.

6. 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," Sections II.A and II.D as they relate to numerical guidelines and design objectives and limiting conditions for operation in meeting dose criteria and the criterion of "as low as is reasonably achievable" of Appendix I.

7. 10 CFR Part 50, Appendix A, GDC 60, "Control of Releases of Radioactive Materials to the Environment," as it relates to the design of LWMS to control releases of liquid radioactive effluents.

8. 10 CFR Part 50, Appendix A, GDC 64, "Monitoring Radioactivity Releases," as it relates to the design of LWMS to monitor for radioactivity that may be released from normal operations including AOOs and from postulated accidents.

9. 10 CFR Part 50, Appendix A, GDC 61, "Fuel Storage and Handling and Radioactivity Control," as it relates to the design of the LWMS in ensuring adequate safety under normal operations and postulated accident conditions.

10. 40 CFR Part 190 (the EPA generally applicable environmental radiation standards), as implemented under 10 CFR 20.1301(e), as it relates to controlling doses within EPA generally applicable environmental radiation standards.

11. 10 CFR 52.47(b)(1), “Contents of applications; technical information,” which requires that applications for DCs contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the DC is built, will operate in accordance with the DC and provisions of the Atomic Energy Act and the NRC regulations.

The following RGs contain the regulatory positions and guidance for meeting the relevant requirements of the regulations identified above:

1. RG 1.109, “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,” as it relates to demonstrating compliance with the numerical guidelines for dose design objectives and the ALARA criterion of 10 CFR Part 50, Appendix I.

2. RG 1.110, “Cost Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors,” as it relates to performing a cost-benefit analysis for reducing cumulative doses to populations by using available technology.

3. RG 1.112, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors,” as it relates to the acceptable methods for calculating annual average releases of radioactivity in effluents.

4. RG 1.113, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I,” dated April 1977, as it relates to the use of acceptable methods for estimating aquatic dispersion and transport of liquid effluents in demonstrating compliance with 10 CFR Part 50, Appendix I dose objectives.

5. RG 1.143, “Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants,” as it relates to the seismic design and quality group classification of components used in the LWMS and the structures housing this system, as well as provisions used to control leakage.

6. RG 1.206, “Combined License Applications for Nuclear Power Plants,” as it relates to the minimum information requirements specified in 10 CFR 52.79, “Contents of applications; technical information in Final Safety Analysis Report,” to be submitted in a COL application.

7. RG 1.33, “Quality Assurance Program Requirements (Operation),” Revision 2, dated February 1978, as it relates to QA for the operation of the LWMS provisions for the sampling and monitoring of radioactive materials in process and effluent streams and control of radioactive effluent releases to the environment.

8. RG 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning,” dated June 2008, as it relates to minimizing the contamination of equipment, plant facilities, and environment, and minimizing the generation of radioactive waste during plant operation.

9. Branch Technical Position (BTP) 11-6, “Postulated Radioactive Releases Due to Liquid-Containing Tank Failures,” as it relates to the assessment of radiological impacts associated with the assumed failure of an LWMS tank.

10. NUREG-0017 (Revision 1), “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs) (PWR-GALE Code),” as it relates to the methodology to calculate gaseous and liquid effluent releases.

11. NUREG-1301, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors,” dated April 1991, as it relates to ODCM guidance for PWR plants.

12. NUREG-0133, “Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants,” dated October 1978, as it relates to the methodology for the assessment of the liquid tank failure using the RATAF code.

13. NUREG/CR-4013, “LADTAP II − Technical Reference and User Guide,” as it relates to the methodology to calculate liquid effluent doses.

14. GL 89-01, “Implementation of Programmatic and Procedural Controls for Radiological Effluent Technical Specifications,” Supplement No. 1, dated November 14, 1990, as it relates to an operational program which addresses the development of a site-specific radiological environmental monitoring program.

15. IE Bulletin 80-10, “Contamination of Nonradioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment,” dated May 6, 1980, as it relates to methods and procedures used in avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled releases of radioactivity.

16. ANSI/ANS-18.1-1999, “Radioactive Source Term for Normal Operation of Light Water Reactors," as it relates to the methodology for determining the source term for normal reactor operations including anticipated accidental occurrences.

11.2.4 Technical Evaluation

GDC 60 requires that the nuclear power unit design include provisions to handle radioactive wastes produced during normal reactor operation including AOOs. GDC 61 requires that the fuel storage and handling, radioactive waste, and other systems which may contain radioactivity be designed to assure adequate safety under normal and postulated accident conditions. GDC 64 requires that the LWMS is designed to monitor radiation levels and radioactivity in effluents, as well as radioactive leakages and spills, during routine operation including AOOs.

The relevant requirements of GDC 60 and GDC 61 are met by using the Regulatory Positions contained within RG 1.143 as they relate to the seismic design, quality group classification of components used in the LWMS and structures housing the systems, provisions used to control leakage, and definitions of discharge paths beginning with interfaces with plant primary systems and terminating at the point of controlled discharges. Other relevant aspects of RG 1.143 address design and construction methods, materials specifications, welding, and inspection and testing standards for LWMS components and piping. The COL applicant is responsible for testing all liquid waste processing subsystems installed in the plant as described in DCD Tier 2, Chapter 14, "Verification Programs." Section 20.1406 of 10 CFR Part 20 requires applicants for standard DC to describe how the facility design will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

The staff reviewed the system construction standards, system process flow outlines and descriptions, sources of waste gases, sampling collection points, flow paths of liquids through subsystems including potential bypasses, and provisions for monitoring radioactivity levels or concentrations in process streams and before being released to the environment. The review addressed system construction standards, seismic design, and quality group classification of components.

The evaluation of the LWMS includes reviews of the design basis, design objectives, design criteria, methods of treatment, including system P&IDs and process flow diagrams showing methods of operation and factors that may influence waste treatment (e.g., system interfaces and potential bypass routes to nonradioactive systems). The evaluation addresses expected releases of radioactivity and associated concentrations and doses to members of the public; and methods, assumptions, and principal parameters used in calculating effluent source terms, releases of radioactive materials in liquid effluents, and associated doses to members of the public. The review considers methods and programs used to control and monitor releases of liquid effluents into the environment, such as radiation monitoring methods and use of filtration, adsorption media, and storage.

The radiological impacts associated with radioactive liquid effluent releases associated with the LWMS are described in DCD Tier 2, Tables 11.2-10, "Liquid Releases Calculated by the PWR-GALE Code (Ci/yr) (Sheets 1 of 2)," through 11.2-13, "Comparison of Annual Average Liquid Release Concentrations with 10 CFR 20 (Maximum Releases) (Sheets 2 of 2), 11.2-15, "Individual Dose from Liquid Effluents," and 11.2-17, "Calculation Results of Effluent Concentrations due to Liquid Containing Tank Failures." The information describes the liquid effluent source term and doses to demonstrate compliance with 10 CFR 20.1301; 10 CFR 20.1302; 10 CFR 10 CFR Part 20, Appendix B, Table 2, Column 2 and 10 CFR Part 50, Appendix I.

DCD Tier 2, Section 11.5.2.9 includes COL Information Items 11.5(2) and 11.5(3) requiring the COL applicant to prepare the ODCM and develop the Radiological Environmental Monitoring Program (REMP), respectively, using Nuclear Energy Institute (NEI) ODCM Template 07-09A (Revision 0, dated March 2009). The use of an ODCM is described in DCD Tier 2, Section 13.4, "Operational Program Implementation." The operational program addresses the development of a site-specific REMP meeting the provisions of GL 89-01, "Implementation of Programmatic and Procedural Controls for Radiological Effluent Technical Specifications," Supplement No. 1, dated November 14, 1990; Radiological Assessment Branch Technical Position (Revision 1, dated November 1979) included in Appendix A to NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," dated April 1991, as ODCM guidance for PWR plants; and the guidance in NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," dated October 1978. Alternatively, a COL applicant may use NEI 07-09A to meet this regulatory milestone until a plant and site-specific ODCM is prepared, before fuel load, under the requirements of a license condition described in the Final Safety Analysis Report (FSAR), Section 13.4 of a COL application. The staff has reviewed NEI 07-09A and determined it to be acceptable (ML091050234). COL Information Items 11.5(2) and 11.5(3) are evaluated by the staff in Section 11.5 of this SE.

11.2.4.1 Design Considerations

The LWMS comprises liquid waste processing system and the reactor coolant drainage system. The liquid waste processing system includes the equipment and floor drainage processing subsystem, the detergent drainage subsystem, and the chemical drainage subsystem.

The equipment and floor drainage processing subsystem, depicted in DCD Tier 2, Figure 11.2-1, “Liquid Waste Processing System Process Flow Diagram (Sheet 1 of 3),” is made up of four WHT, two WHT pumps, two filters, an activated carbon filter, four ion exchange columns, a strainer, two waste monitor tanks, and two waste monitor tank pumps. The WHT are divided into two sets: one set collects high-quality liquid from equipment drainage, and the other set collects liquid from floor drainage. Normally, waste collected in the WHT is processed by one filter, one set of ion exchange columns and is sent to one of two waste monitor tanks where the processed effluent is then sampled. Based on the results of the sampling, the effluent is sent to the WHT for additional processing, used for sluicing or flushing, or discharged to the environment by way of the monitored discharge header.

The detergent drainage subsystem, shown on DCD Tier 2, Figure 11.2-1, “Liquid Waste Processing System Process Flow Diagram (Sheet 2 of 3),” collects wastes from sinks, showers, and emergency showers which are not expected to be highly contaminated, and it sends them to the detergent drain tank. Wastes are then processed through a filtration system and sent to the detergent drain monitor tank where the waste is sampled. The processed waste is then sent to the discharge header if discharge standards are met, or transferred to the WHT for further processing.

SRP Section 11.2, Acceptance Criteria 5 states, “System designs should describe features that will minimize, to the extent practicable, contamination of the facility and environment.” From review of DCD Tier 2, Sections 11.2.2.1, “Liquid Waste Processing System Operation,” and 11.2.2.2.8, “Detergent Drain Subsystem,” and Table 11.2-18, “Equipment Malfunction Analysis (Sheets 2 of 2), " the staff requested the applicant in **RAI 189-2009, Question 11.02-13** to provide a description in the DCD of any automatic actuations based on detection of radioactivity levels in the liquid waste discharge stream or failure of the liquid radwaste discharge radiation monitor, and confirm that the discharge of the detergent drain subsystem is upstream of the liquid radwaste discharge radiation monitor in the discharge header. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 189-2009, Question 11.02-13**, the applicant described the liquid radwaste discharge radiation monitor in DCD Section 11.5.2.5.1, “Liquid Radwaste Discharge Radiation Monitor (RMS-RE-035),” which measures the total radioactive content in the liquid waste discharge stream before reaching the discharge header to prevent the release of radionuclide concentrations that exceed 10 CFR Part 20 limits. The applicant stated the discharge isolation valve is under supervisory control. Supervisory approval is required to open this valve to discharge liquid effluent into the environment. If radioactivity levels in the liquid discharge stream are detected above the predetermined setpoint, the monitor pump is automatically shut off, the discharge isolation valve is automatically closed, and an alarm is annunciated in the MCR. The applicant added to DCD Tier 2, Section 11.2.2.2.8, “Detergent Drain Subsystem,” a statement to identify the detergent drain system in DCD Tier 2, Figure 11.2-1, “Liquid Waste Processing System Process Flow Diagram (Sheet 2 of 3),” and depict the transfer of the discharge stream from the detergent drain monitor tank via the detergent drain monitor tank pump routed to upstream of the liquid radwaste discharge radiation monitor. The staff confirmed that Revision 2 to DCD Tier 2, Section 11.2.2.2.8 included this information.

The staff reviewed the applicant's response and, in **RAI 462-3752, Question 11.02-22**, requested that the applicant provide an explanation of why the automatic shut off for the monitor pump is not discussed in DCD Tier 2, Section 11.5.2.5.1, as it relates to radioactivity levels in the liquid discharge stream exceeding the predetermined ODCM setpoint, and verify in the DCD that both discharge isolation valves automatically close when radioactivity in the liquid discharge stream is detected to be above the predetermined setpoint, and provide a description in the DCD of any actuations or interlocks in the event the liquid radwaste discharge radiation monitor fails. By letter dated November 17, 2009, the applicant responded to the above RAI.

In response to **RAI 462-3752, Question 11.02-22**, the applicant commits to revise DCD Tier 2, Section 11.5.2.5.1 to include information on the automatic shut off feature of the monitor pump; discharge isolation valves which are designed to open only by the liquid radwaste discharge radiation monitor for an acceptable discharge range; and closure with all other conditions including high radiation level, lack of signal such as loss of power supply, and liquid radwaste discharge radiation monitor failure.

The staff reviewed the applicant's response and finds it acceptable because the applicant commits to include this information in the next revision of the DCD. These design features used in controlling liquid effluent discharges comply with the requirements of GDC 60, as they relate to provisions for controlling releases of radioactive materials in liquid effluents to the environment during normal operation including AOOs. **RAI 189-2009, Question 11.02-13** is closed, but **RAI 462-3752, Question 11.02-22** is being tracked as **Confirmatory Item 11.02-3.**

The chemical drainage subsystem, shown on DCD Tier 2, Figure 11.2-1 (Sheet 2 of 3), sends laboratory wastes and decontamination solutions to the chemical drain tank. Wastes are then neutralized and sent to the WHT or disposed of in portable containers evaluated in Section 11.4 of this SE.

The reactor coolant drainage subsystem, shown as DCD Tier 2, Figure 11.2-1, "Reactor Coolant Drainage System Process Flow Diagram (Sheet 3 of 3)," contains a C/V reactor coolant drain tank (CVDT) and two C/V reactor coolant drain pumps. During normal operation, the CVDT located inside containment receives reactor grade water from various sources inside containment. This water is normally transferred to the holdup tank (HT) in the chemical and volume control system (CVCS) by one of two C/V reactor coolant drain pumps. The liquid is sent to the WHT for processing if the liquid collected in the CVDT is oxygenated or above the specified radiation limits.

With the exception of the CVDT, the LWMS tanks include a vent path to the heating, ventilation, and air conditioning (HVAC) system. Because the CVDT includes a vent path to the GWMS, the staff finds that provisions to adequately handle gaseous effluents have been provided in the LWMS design, and this design feature meets the requirements of GDC 60, as it relates to provisions to control releases of radioactive material in gaseous effluents to the environment during normal operation including AOOs.

Compliance with the requirements of 10 CFR 50.34a and GDC 60 is based, in part, on adherence to RG 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants." The staff reviewed the LWMS for conformance to RG 1.143, as it relates to the definition of the LWMS boundary. In **RAI 186-2009, Question 11.02-16**, the staff requested the applicant to define the LWMS boundary. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 186-2009, Question 11.02-16**, the applicant described the LWMS boundary in the process flow diagrams depicting system interfaces and boundaries by the associated P&IDs. The applicant revised DCD Tier 2, Section 11.2.2, "System Description," to define the LWMS boundary as interface valves for each of the input streams potentially containing radioactive material from other plant systems as indicated in DCD Tier 2, Figure 11.2-1. The applicant also defined the liquid waste processing system as ending at the isolation valve of the discharge lines to a tank or the discharge header. The applicant clarified in DCD Tier 2, Section 11.2.2.1.2.3, "Maintenance/Refueling Operations," that liquid is transferred via one of two reactor coolant drainage system pumps to the CVCS HT as indicated in DCD Tier 2, Figure 11.2-1 (Sheet 3 of 3). The applicant also confirmed that there are no vacuum conditions in the LWMS as stated in DCD Tier 2, Section 11.2.2 because the LWMS operates at ambient temperature with no fans or heating devices and tanks have vents and overflow lines that are open to the cubicle environment.

The staff reviewed the applicant's descriptions expanding the LWMS boundary definition to include interface valves for each of the input streams potentially containing radioactive material, as it relates to conformance to RG 1.143, Section B, "Discussion;" clarification of the CVCS HT; and design provisions to preclude placing components and structures of the system under adverse vacuum conditions, and found them to be acceptable. The staff also confirmed that Revision 2 to the DCD included this information. **RAI 189-2009, Question 11.02-16** is closed.

The system process flow diagrams were reviewed to determine all sources and volumes of liquid process and effluent streams and points of collection of liquid waste. The figures were also reviewed for flow paths of liquids through the system (including all bypasses), and points of release of liquid effluents to the environment. These design criteria and design provisions were compared with the guidance of RG 1.143, based on the information provided by the applicant related to liquid wastes produced during normal operation including AOOs.

From a review of DCD Tier 2, Figure 11.2-1 (Sheet 1 of 3), the staff identified multiple items related to inconsistencies in process flow diagrams described below. In **RAI 186-2009, Questions 11.02-8 through 11.02-10**, the staff requested the applicant to clarify the capabilities of the LWMS to meet the anticipated processing requirements of the plant. By letter dated March 10, 2009, the applicant responded to the above RAI.

In responses to **RAI 186-2009, Questions 11.02-8 through 11.02-10**, the applicant proposed several changes to show only normal operating conditions and not design conditions in DCD Tier 2, Figure 11.2-1 (Sheets 1 to 3), replace "activated charcoal filter" with "activated carbon filter" in DCD Tier 2, Sections 11.2.1.4 and 11.2.1.6, and add a connection from the activated carbon filter to remove the spent filter media as slurry in DCD Tier 2, Figure 11.2-1 (Sheet 1 of 3) (**RAI 186-2009, Question 11.02-8**); correct the detergent drain filter design flow rate to 20 gpm in DCD Tier 2, Table 11.2-5, "Component Data - (Filters)," and add the elevation information (-26'-4" in the A/B) of the detergent drainage and monitor tanks and associated pumps in DCD Tier 2, Section 11.2.2 (**RAI 186-2009, Question 11.02-9**); revise DCD Tier 2, Section 11.2.2.1.2.1 to include information on some drains sent to the suction of the C/V reactor coolant drain located inside containment, replace "CVDT pump" to "C/V reactor coolant drain tank pump" in DCD Tier 2, Figure 11.2-1 (Sheet 3 of 3), and replace "CVDT pump" with "C/V reactor coolant drain tank pump" in DCD Tier 2, Table 11.2-4 **(RAI 186-2009, Question 11.02-10)**. The staff reviewed the additional information and presents the following evaluation.

In **RAI 186-2009, Question 11.02-8**, the staff requested the applicant to address design flow rate and temperature inconsistencies in DCD Tier 2, Figure 11.2-1 (Sheet 1 of 3). The applicant stated the tables in DCD Tier 2, Figure 11.2-1 (Sheets 1 to 3) indicate design conditions and proposed to revise this figure to show only normal operating conditions. The staff found this response unacceptable since the design conditions are being removed from the DCD. As a result, in follow-up **RAI 462-3752, Question 11.02-23**, the staff requested that the applicant provide in the DCD both the design and normal operating conditions to demonstrate the LWMS is capable to meet the anticipated processing requirements of the plant. By letter dated November 17, 2009, the applicant responded to **RAI 462-3752, Question 11.02-23**. The applicant commits to revise DCD Tier 2, Figure 11.2-1 (Sheets 1 to 3) to include both the design and normal operating conditions. The staff finds this acceptable as the previously removed information has been replaced.

In **RAI 186-2009, Question 11.02-8**, the staff also requested that applicant explain why different LWMS component nomenclature is used in DCD Tier 2, Section 11.2.2 and Figure 11.2-1 (Sheet 1 of 3). By letter dated March 10, 2009 the applicant corrected the naming inconsistency and missing information between DCD Tier 2, Section 11.2 and Figure 11.2-1 (Sheet 1 of 3). The staff confirmed that Revision 2 to the DCD included this information.

Lastly, in **RAI 186-2009, Question 11.02-8**, the staff requested the applicant to justify why the spent filter media transfer is not shown in DCD Tier 2, Figure 11.2-1 (Sheet 1 of 3) for conformance to SRP Section 11.2, Acceptance Criteria 5. Because the applicant revised DCD Tier 2, Figure 11.2-1 (Sheet 1 of 3) in response to this RAI to add a connection from the activated carbon filter to remove the spent filter media as slurry, the staff finds the applicant's response acceptable. The staff confirmed that Revision 2 to the DCD included this information. Therefore, **RAI 186-2009, Question 11.02-8,** and **RAI 462-3752, Question 11.02-23** are closed.

In **RAI 186-2009, Question 11.02-9**, the staff requested the applicant to explain how the detergent drain filter can have a lower design flow rate than the upstream detergent drain tank pump for conformance to SRP Section 11.2, Acceptance Criteria 5. By letter dated March 10, 2009, the applicant proposed to revise the detergent drain filter design flow rate to 20 gpm in DCD Tier 2, Table 11.2-5. The staff found this to be acceptable because the upstream detergent drain tank pump and the detergent drain filter flow rates will be consistent.

In **RAI 186-2009, Question 11.02-9**, the staff also requested that the applicant explain why the neutralizing agent measuring tank is not included in DCD Tier 2, Table 11.2-3. By letter dated March 10, 2009, the applicant stated the information on the neutralizing agent measuring tank is unavailable because it is part of a vendor purchased package to neutralize the chemical drain tank. Because the applicant stated that the vendor would provide this information but did not provide any other acceptable design parameters for such a tank, the staff requested this information in **RAI 462-3752, Question 11.02-24**. By letter dated November 17, 2009, the applicant commits to add neutralizing agent measuring tank component data in DCD Tier 2, Table 11.2-3. The staff reviewed the applicant's response and found it to be acceptable. **RAI 462-3752, Question 11.02-24** is being tracked as **Confirmatory Item 11.02-4.**

In **RAI 186-2009, Question 11.02-9**, the staff also requested the applicant explain why the two waste effluent strainers, the detergent drain strainers, and the neutralizing agent measuring tank are not discussed in DCD Tier 2, Section 11.2.2 or was not included in any of the tables. By letter dated March 10, 2009, the applicant described the two waste effluent and the detergent drain stainless steel strainers as in-line installed piping items of a basket-type with 25 micron to 550 micron mesh openings. Because the waste effluent strainers are installed downstream of the ion exchange columns to remove any resin fines that may be carried over from the columns, and the detergent drain strainer is installed upstream of the detergent drain tank to remove any materials that may be carried over from the waste streams, the staff found the applicant's response acceptable. However, because the applicant did not commit to include this information in the next revision of the DCD, in **RAI 462-3752, Question 11.02-25**, the staff requested the applicant to include this information in the DCD. By letter dated November 17, 2009, the applicant replied to the above RAI and agreed to include this information in the next revision of the DCD. The staff reviewed this information and found it to be acceptable. **RAI 462-3752, Question 11.02-25** is being tracked as **Confirmatory Item 11.02-5.**

Finally, in **RAI 86-2009, Question 11.02-9**, the staff requested the applicant to explain why different component nomenclature is used in DCD Tier 2, Section 11.2.2 and Figure 11.2-1 (Sheet 2 of 3). By letter dated March 10, 2009, the applicant corrected the naming inconsistency and missing information between DCD Tier 2, Section 11.2.2 and Figure 11.2-1 (Sheet 2 of 3). The staff reviewed the applicant's response and found it to be acceptable. The staff confirmed that Revision 2 to the DCD included this information. **RAI 186-2009, Question 11.02-9** is closed.

DCD Tier 2, Tables 11.2-19, "Expected Inputs to the LWMS, Processing Time and Days of Holdup," and 11.2-2, "Waste Liquid Inflow into the LWMS," shows the maximum, shutdown, and normal inputs to the equipment and floor drainage subsystem. However, these expected inputs, processing time, and holdup capacity for the reactor coolant drainage subsystem are not discussed in the same detail as the equipment and floor drainage, detergent, and chemical drain subsystems. In **RAI 186-2009, Question 11.02-11**, the staff requested that the applicant provide additional system details and justification on how the reactor coolant drainage subsystem meets the SRP acceptance criteria that assumes processing equipment is unavailable for two consecutive days per week. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 186-2009, Question 11.02-11** the applicant stated if the reactor coolant drain tank subsystem is unavailable, the tank content can be drained to the C/V sump for forwarding to the LWMS, and there is no direct release from the CVCS system. The staff reviewed the response and, to verify that the LWMS is capable of processing this additional liquid during a period of maximum expected input to the LWMS in **RAI 462-3752, Question 11.02-26**, requested that the applicant provide assurance that the LWMS is capable of processing the additional liquid from the CVDT in the event the CVDT is unavailable during a period of maximum expected inputs to the LWMS. By letter dated November 17, 2009 the applicant responded to the above RAI.

In response to **RAI 462-3752, Question 11.02-26**, the applicant verified that the LWMS is capable of processing the additional liquid from the CVDT. The staff finds the response acceptable because the applicant demonstrated that the LWMS is adequately sized and designed to process this potential input. DCD Tier 2, Tables 11.2-2 and 11.2-3 present information on the liquid waste inflow into the LWMS and LWMS component data, respectively. The specifications and processing rates indicate that the LWMS subsystems are sized to store a volume of waste water equivalent to the normal quantity of liquid waste produced in one week or more. In the equipment and floor drainage subsystem, the tanks can store more than 53 days of expected normal volumes, 20 days of expected shutdown volumes, and 1.07 days of expected maximum volumes. In the detergent subsystem, the tanks can store 10 days of expected normal volumes and 1.05 days of expected shutdown volumes. The chemical drain subsystem can store 16 days of expected normal volumes and 0.8 days of expected maximum volumes. In addition, the radioactive waste processing building has space and provisions for connection to site-specific mobile processing equipment. **RAI 186-2009, Question 11.02-11 and RAI 462-3752, Question 11.02-26** are closed.

The liquid waste processing system has the capacity to process the normal or shutdown weekly discharge quantities of liquid waste in less than one day. Therefore, the LWMS can be unavailable for more than six days per week and still process the expected influent. The liquid waste processing system does not have the capacity to store two consecutive days of expected maximum influent with the primary means for processing liquid waste unavailable if the equipment and floor drainage subsystem, detergent subsystem, and chemical drain subsystem can only store the expected maximum influent for 1.07 days, 1.05 days, and 0.8 days, respectively. Consequently, the staff requested the applicant in **RAI 186-2009, Question 11.02-12** to clarify how the equipment and floor drainage, chemical drain, and detergent subsystems meet the SRP acceptance criteria for storage requirements given that processing equipment should be assumed to be unavailable for two consecutive days per week. By letter dated March 15, 2009, the applicant responded to the above RAI.

In response to **RAI 186-2009, Question 11.02-12**, the applicant stated the combined tank capacity of the floor drain and equipment drains subsystem is 96,000 gal and the maximum input to the subsystem is 90,000 gal per event. Table 7, "PWR Liquid Radioactive Waste Processing System Design Inputs," to ANSI/ANS-55.6-1993 (R2007), "Liquid Radioactive Waste Processing System for Light Water Reactor Plants," lists the maximum generation input rate for the "equipment and area decontamination" waste as 3,000 gpd during shutdown operations. Similarly, ANSI/ANS-55.6-1993 (R2007) indicates the maximum generation input rate for the "hot shower" and "hand wash" waste as 400 gpd and 1,500 gpd, respectively. The applicant also stated the detergent drains can be temporarily directed to the A/B floor drain sump if the detergent drain tank is not available. If the chemical drain tank is unavailable, the chemical drains can be collected in drums until the tank is available. The staff finds the applicant's response acceptable because the equipment and floor drainage subsystem has enough capacity to contain the expected maximum inputs of both the detergent and the equipment and floor drainage subsystems during a 2 day period of excessive waste generation or when major processing equipment is unavailable. The staff also determined that the design meets the provisions to meet the anticipated processing requirements when major processing equipment may be down for maintenance or during periods of excessive waste generation. **RAI 186-2009, Question 11.02-12** is closed.

Design provisions have been incorporated to prevent or collect material spills from LWMS tanks. Specifically, tanks where radioactive liquid is stored are curbed and lined up to a wall height equivalent to the tank's full volume. Overflow from the tanks are directed to a sump that automatically activates on high liquid levels. From a review of DCD Tier 2, Sections 11.2.1.2, 11.2.1.4, and 11.2.2.2.2, the staff requested the applicant in **RAI 186-2009, Question 11.02-17** to clarify whether the waste collection tanks are the same tanks shown as the WHT in DCD Tier 2, Figure 11.2-1 (Sheet 1 of 3), and if the component connections that are butt welded to minimize leakage, also apply to connections for all LWMS components and piping joints. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 186-2009, Question 11.02-17**, the applicant stated that all waste collection and monitor tanks in the LWMS including those collecting radioactive, chemical, and detergent wastes are provided with an overflow connection at least as large as the inlet, to minimize tank over pressurization conditions. The staff finds the applicant's response acceptable because all waste collection and monitor tanks are equipped with overflows. **RAI 186-2009, Question 11.02-17** is closed.

With the exception of the confirmatory items described above, which the staff has found acceptable and will confirm in the next revision of the DCD, the staff finds that the LWMS design complies with requirements of GDC 60, as it relates to the ability of the LWMS to control releases of liquid radioactive effluents. The staff also finds that the LWMS complies with the requirements of 10 CFR 50.34a, as it relates to the inclusion of sufficient design information in demonstrating compliance with the design objectives for equipment necessary to control releases of liquid effluents to the environment.

GDC 61 requires that the LWMS be designed to assure adequate safety under normal and postulated accident conditions. DCD Tier 2, Table 11.2-1, "Equipment Codes (Extracted from Table 1, RG 1.143)," provides the equipment codes for the LWMS. The LWMS was found to perform no safety-related functions, but the containment isolation valves on the discharge line from the reactor coolant drainage system perform a safety function and are designed to seismic Category I criteria.

From review of DCD Tier 1, Section 2.7.4, "Radwaste Systems," DCD Tier 2, Section 3.2, "Classification of Structures, Systems, and Components," and DCD Tier 2, Section 11.2, the staff did not find the seismic and quality group classification (safety classes) of the LWMS or components for conformance to RG 1.143, Regulatory Position C.5. RG 1.143, Regulatory Position C.5 states, "Any systems or components in a RW-IIa facility that store, process, or handle radioactive waste in excess of the A_1 quantities given in Appendix A, "Determination of A_1 and A_2," to 10 CFR Part 71, are classified as RW-IIa. These systems or components that process radioactive waste in excess of the A_2 quantities but less than the A_1 quantities given in 10 CFR Part 71, Appendix A, are classified as RW-IIb. All other components are classified as RW-IIc. This classification may be modified for specific radwaste components. In **RAI 186-2009, Question 11.02-15**, the staff requested the applicant to discuss the LWMS safety classes (RW-IIa, RW-IIb, or RW-IIc) in the DCD to justify how RG 1.143, Regulatory Position C.5 is met. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 186-2009, Question 11.02-15**, the applicant stated the A/B is classified as RW-IIa and referred to the component classifications presented in DCD Tier 2, Section 3.2 and Table 3.2-2. The staff found this to be unacceptable because the component classifications presented in DCD Tier 2, Section 3.2 and Table 3.2-2 do not include the three safety classes for radioactive waste management facilities. As a result, in **RAI 462-3752, Question 11.02-27**, the staff requested that the applicant discuss each of the LWMS components, the quantities of radioactive waste they process, and the appropriate classifications (RW-IIa, RW-IIb, or RW-IIc) for the LWMS systems or components that process radioactive waste. By letter dated November 17, 2009, the applicant responded to the above RAI.

In response to **RAI 462-3750, Question 11.02-27**, the applicant commits to add Table 11.2-20, to identify the safety classes of the LWMS components to DCD Tier 2, Section 11.2. The applicant determined the safety classes of the LWMS components based on the A1 and A2 quantities in 10 CFR Part 71 in accordance with RG 1.143, the liquid inputs in DCD Tier 2, Table 11.2-2, and the realistic source term developed using the recommendations in ANSI/ANS-18.1-1999, "Radioactive Source Term for Normal Operation of Light Water Reactors." The applicant commits to add DCD Tier 2, Table 11.2-20 to identify the WHT, waste monitor tank, detergent drain tank, detergent drain monitor tank, chemical drain tank, ion exchange columns, and detergent drain filters as RW-IIc, and the filter as RW-IIa. The staff reviewed the applicant's response and found it to be acceptable because it conforms to RG 1.143, Regulatory Position C.5. **RAI 186-2009, Question 11.02-15** is closed, but **RAI 462-3752, Question 11.02-27** is being tracked as **Confirmatory Item 11.02-6**.

From review of DCD Tier 2, Section 11.2.2 and Figure 11.2-1 (Sheet 3 of 3), the staff identified apparent discrepancies and inconsistencies related to the ability of the LWMS to ensure adequate safety under normal and postulated accident conditions for compliance with GDC 61, and to ensure that liquid waste processing systems have adequate capacity to process the anticipated wastes. In **RAI 186-2009, Questions 11.02-10**, the staff requested the applicant to address a discrepancy on waste inputs in DCD Tier 2, Section 11.2.2.1.2.1 and Figure 11.2-1 (Sheet 3 of 3); verify the waste inputs and pumps described in DCD Tier 2, Section 11.2.2.1.2.3 and Figure 11.1-1 (Sheet 3 of 3); and address an inconsistency in component nomenclature in DCD Tier 2, 11.2.2 and Figure 11.2-1 (Sheet 3 of 3). By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 186-2009, Questions 11.02-10**, the applicant proposed to revise DCD Tier 2, Section 11.2.2.1.2.1 to describe that liquids drain to the CVDT or to the suction of the C/V reactor coolant drain pump located in containment; replace “CVDT pump” with “C/V reactor coolant drain tank pump” in DCD Tier 2, Figure 11.2-1 (Sheet 3 of 3); and replace “C/V reactor coolant drain tank pumps” with “C/V reactor coolant drain pumps” in DCD Tier 2, Table 11.2-4. The staff reviewed the additional information and presents the following evaluation.

In **RAI 186-2009, Questions 11.02-10**, the staff requested the applicant to justify discrepancies in DCD Tier 2, Section 11.2.2.1.2.1 and Figure 11.2-1 (Sheet 3 of 3) concerning inputs to the reactor coolant drainage subsystem. The applicant proposed to add a description in the DCD to indicate that the inputs to the CVDT drain to the CVDT or the suction of the C/V reactor coolant drain pump. The staff found the applicant's response to be acceptable because the design discrepancy was addressed. The staff confirmed that Revision 2 to the DCD included this information.

The staff requested the applicant to verify information concerning the CVDT inputs and pumps in DCD Tier 2, Section 11.2.2.1.2.3 and Figure 11.2-1 (Sheet 3 of 3). The applicant stated the reactor cavity drain input and the permanent cavity seal drain input in DCD Tier 2, Section 11.2.2.1.2.3 and Figure 11.2-1 (Sheet 3 of 3) are the same inputs. The staff found the applicant's response to be acceptable because the naming convention was clarified. The staff confirmed that Revision 2 to the DCD included this information.

Lastly, in **RAI 186-2009, Questions 11.02-10**, the staff requested the applicant to explain why the component names are not consistent in DCD Tier 2, Section 11.2.2 and Figure 11.2-1 (Sheet 3 of 3). The applicant revised the DCD by adjusting the CVDT pump name to be consistent throughout the DCD. The staff finds the applicant's response acceptable because the component name was clarified. The staff confirmed that Revision 2 to the DCD included this information. **RAI 186-2009, Question 11.02-10** is closed.

Both, the DCD Tier 2, Section 11.2.3.1 and Table 1.8-2 provide a COL information item for the COL applicant to address the site-specific P&ID. Under COL Information Item 11.2(6), the COL applicant is required to provide the P&ID. Because these diagrams require site-specific information which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.2(6) acceptable.

With the exception of the confirmatory items described above, which the staff has found acceptable and will confirm in the next revision of the DCD, the staff finds that the LWMS design meets the requirements of GDC 61, as it relates to ensuring adequate safety under normal and postulated accident conditions. The staff also finds that the LWMS design meets the provisions that liquid waste systems have adequate capacity to process the anticipated wastes.

11.2.4.1.1 Epoxy Coatings

In Revision 1 of **RAI 164-1925, Question 11.02-2** and **RAI 185-2031, Question 11.04-1**, the staff requested that the applicant provide or justify the exclusion of ITAAC to ensure the construction and equipment codes of stainless-steel liners (for the LWMS) and steel liners (for the SWMS) in cells/cubicles are complete and acceptable. By letter dated February 18, 2009, the applicant responded to the above RAI. By letters dated January 9, 2009, and February 18, 2009, the applicant responded to **RAI 164-1925, Question 11.02-1** and **RAI 91-1496, Question 12.03-12.04-2**, evaluated in Section 12.03-12.04 of this SE, and introduced a design change which replaced the stainless steel to line cell/cubicles of the LWMS and replaced the steel to line the spent resin storage tanks (SRST) rooms in the SWMS, discussed in Section 11.4 of this SE, initially proposed in Revisions 0 and 1 to the DCD Tier 2, Chapter 11, with epoxy coatings.

In response to **RAI 164-1925, Question 11.02-2** and **RAI 185-2031, Question 11.04-1**, by letters dated January 9, 2009, and February 18, 2009, the applicant introduced a design change which replaced the stainless steel to line cell/cubicles in the LWMS and replaced the steel to line the SRST rooms with an epoxy coating. Therefore, the staff's questions pertaining to stainless-steel and steel liners for consideration as an acceptable design feature to mitigate the release of radioactive materials resulting from the postulated failure of a liquid waste tank located outside of containment described in BTP 11-6 (Revision 3), "Postulated Radioactive Releases due to Liquid-Containing Tank Failures," are no longer relevant. Coatings are typically applied to protect the surfaces of facilities and equipment from corrosion and contamination, and are not approved for retention of liquids per BTP 11-6. As a result, **RAI 164-1925, Question 11.02-2 and RAI 185-2031, Question 11.04-1** are closed, but the issue they raised regarding the acceptability of an epoxy coating as an acceptable liner remained. Therefore, the staff, in follow-up **RAI 403-3027, Questions 11.02-18 and 11.02-19**, asked the applicant to justify epoxy coatings as an acceptable liner to minimize contamination of the environment and groundwater, justify the capability of epoxy coatings to retain liquids, and describe the maintenance and inspection program that will be implemented to ensure the integrity of epoxy coatings for sealing floor and wall surfaces to minimize contamination of the facility. By letter dated July 15, 2009, the applicant responded to the above RAI.

In response to **RAI 403-3027, Questions 11.02-18 and 11.02-19**, the applicant commits to use normal construction testing practices with qualified coating inspections using the guidance in ASTM D4537-04a, "Standard Guide for Establishing Procedures to Qualify and Certify Personnel Performing Coating Work Inspection in Nuclear Facilities," in the initial test program (ITP). The applicant commits to using proven coating systems applied directly to the concrete which are developed and qualified in accordance with accepted nuclear industry standards and have been subject to testing programs such as radiation tolerance and decontamination properties under the ANSI, by various independent laboratories such as Oak Ridge National Laboratory, Idaho Nuclear, and the Western New York Nuclear Research Center, and the recommendations in ANSI N512-1974, "Protective Coatings (Paints) for the Nuclear Industry" (formerly ANSI N5.9-1967). The applicant provided American Society for Testing of Materials (ASTM) typical coating systems and dry film thicknesses that will be considered as qualified for Coating Nuclear Service Level I used "for those systems applied to structures, systems and other safety related components which are essential to the prevention of, or the mitigation of the consequences of postulated accidents that could cause undue risk to the health and safety of the public." These vapor permeability vendor data on epoxy coatings show the very low moisture vapor permeability which retards leakage of radioactivity into the environment. The applicant also commits to revise DCD Tier 2, Table 1.9.1-1, "US-APWR Conformance with Division 1 Regulatory Guides (Sheet 4 of 15)," to address ASTM standard revisions in RG 1.54, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants," that may be different than those specifically referenced in DCD Tier 2, Sections 11.2 and 11.4 to conform with the current revisions of industry standards applicable to epoxy coatings.

By letter dated July 15, 2009, the applicant responded to the staff's requests in **RAI 401-3031, Question 11.04-18**, to justify the use of epoxy coatings as an acceptable liner; describe the maintenance and inspection program that will be implemented to ensure the integrity of epoxy coatings for sealing floor and wall surfaces to minimize contamination of the facility; clarify how guidance in BTP 11-3 (Revision 3), "Design Guidance for Solid Radioactive Waste Management Systems Installed in Light-Water-Cooled Nuclear Power Plants," is applied to epoxy coatings; and identify the described ITP on coating systems, construction practices and qualified inspections for lining the SRST rooms in the SWMS. The applicant referenced their response as applied to **RAI 403-3027, Question 11.02-18** to justify epoxy coatings and related Service Level II coatings and ASTM standards that will be applied to the epoxy coatings in the SRST rooms. The applicant stated the potential liquid release from a SRST is bounded by the failed liquid tank analysis described in DCD Tier 2, Section 11.2.3.2, "Radioactive Effluent Releases due to Liquid Containing tank Failures." The applicant considers the use and purpose of epoxy coatings, although not specifically mentioned in BTP 11-3, consistent with the NRC guidance which includes general provisions to minimize contamination of the facility and the environment, to the extent practical, in accordance with 10 CFR 20.1406. The applicant revised DCD Tier 2, Sections 11.4.2, "Design Criteria," 11.4.1.4, "Method of Treatment," 11.4.2.5, "Operation and Personnel Doses," Section 11.4.9, "References," and Table 11.4-5, "Equipment Malfunction Analysis" to address epoxy coatings and compliance with 10 CFR 20.1406 and 10 CFR 20.1302, and conformance to BTP 11-6 and RG 4.21 to minimize the potential for contamination of groundwater in the event of a tank failure or overflow.

The staff reviewed the applicant's description on the non safety-related epoxy coatings for use in the cells/cubicles in the LWMS and SRST rooms in the SWMS and found them to be acceptable. While not approved as a mitigative design feature in BTP 11-6, coatings can be used as a method to reduce the need for decontaminating equipment and structures as described in RG 4.21. Further, RG 1.54 describes that protective coatings are used extensively in nuclear power plants to protect the surfaces of facilities and equipment from corrosion and radioactive contamination and for wear protection during plant operation and maintenance activities, and also provides guidance on acceptable quality assurance practices for safety-related protective coating work in Service Level I and II areas of nuclear facilities. **RAI 401-3031, Question 11.04-18** is closed. However, because the additional design information provided in the applicant's response to **RAI 401-3031, Question 11.04-18** was not included in the DCD, the staff requested in **RAI 523-4246, Question 11.02-29**, for the applicant to include the design information on typical Service Level concrete coating types, dry film coating thicknesses, and vapor permeability in the DCD; state in DCD Tier 2, Chapter 14 that an ITP will be utilized for the epoxy coatings using normal construction testing practices with qualified coating inspections in guidance with ASTM D4537-04a; and describe in DCD Tier 2, Sections 11.2 and 11.4 how the technical procurement and the construction and inspection activities for epoxy coatings, and the operational maintenance and assessment program (i.e., in-service epoxy coatings monitoring program) will be addressed by the COL applicant using guidance in

ASTM D5144-08, ASTM D3843-00 (Reapproved 2008), ASTM D4537-04a, ASTM D5163-03 (Reapproved 2008), ASTM D1653-08, ASTM D5163-03 (Reapproved 2008), RG 1.54, and EPRI Report Topical Report-109937. The staff also requested the applicant to describe the testing and inspection requirements for the LWMS evaluated in Section 11.2.4.9 of this SE. By letter dated March 15, 2010, the applicant responded to the above RAI.

In response to **RAI 523-4246, Question 11.02-29**, the applicant commits to add Tables 11.2-20, "Typical Service Level II Concrete Systems Epoxy Coatings" and 11.4-7 "Typical Service Level II Concrete Systems Epoxy Coatings" to provide the Service Level concrete coating types, dry film coating thicknesses, and vapor permeability. The applicant also commits to revise DCD Tier 2, Sections 11.2.1.4 and 11.4.2.1.4 to describe the respective tables containing the epoxy coating design information that will be used to line cells/cubicles in the LWMS and SRST rooms in the SWMS. The applicant also commits to add COL Information Items 11.2(7) and 11.4(9) to require implementation milestones for the epoxy coatings program addressed in RG 1.54 or more current guidance in applicable industry standards. Because the epoxy coatings programs is an operational program and will require site-specific information, which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Items 11.2(7) and 11.4(9) acceptable. **RAI 523-4246, Question 11.02-29** is being tracked as **Confirmatory Item 11.02-8.**
DCD Tier 2, Section 11.2.2.2.2, "Tanks," describes coatings to line cells/cubicles housing liquid tanks with epoxy to a height that is sufficient to hold the tank containing significant quantities of radioactive material in the event of a tank failure. The epoxy, defined as a non-porous material forming a seal that is impermeable, durable, and with readily cleanable surfaces that facilitate decontamination, serves as a barrier to minimize contamination of the facility, environment, and groundwater, from any leaks from the equipment using the guidance in RG 4.21 for compliance with 10 CFR 20.1406.

The applicant conservatively defined significant quantities of radioactivity as those radionuclide concentrations in DCD Tier 2, Table 11.2-17, which are shown to be below the ECLs of 10 CFR Part 20, Appendix B, Table 2, Column 2 with the exception of tritium (H-3). The applicant intends to house the WHT, waste monitor tanks, A/B sump tank, A/B equipment drain sump tank, R/B sump tank, SRST of the SWMS, HT, and boric acid tanks (BAT) which contain significant quantities of radioactivity in curbed cubicles coated with an epoxy to a wall height sufficient to contain the entire tank contents. The applicant states the equipment cubicles in the LWMS are coated with the same epoxy, but are not curbed because housed equipment such as pumps and filters do not contain significant amounts of radioactivity during processing or after equipment is flushed to remove remaining radioactive material.

Liquid containing tanks that are not housed in epoxy-lined cubicles are the detergent drain tank, detergent drain monitor tank, and the chemical drain tank. These tanks do not contain significant quantities of radioactivity and are processed when they are filled reducing the likelihood of a tank failure. The detergent drain tank pump and the detergent drain monitor tank pump of the detergent drain subsystem are not housed in a cubicle, but in a contained portion of the A/B. This subsystem does not typically contain any significant levels of radioactivity. DCD Tier 2, Section 12.3.1.1.2.D, states, "…potentially contaminated areas and equipment within the plant is facilitated by the application of decontaminable paints and suitable smooth-surface coatings to the concrete floors and walls." The applicant intends to apply decontaminable paints and suitable smooth-surface coatings to all areas inside the A/B including the floor under the pumps of the detergent drain subsystem thereby minimizing risk of contamination to the facility, environment, or groundwater.

The applicant revised DCD Tier 2, Section 11.2.2.2 to state Service Level II coatings applied to the cell/cubicles that house those tanks of the LWMS are subject to the limited QA provisions, selection, qualification, application, testing, maintenance and inspection provisions of RG 1.54 (Revision 1), “Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants,” and industry standards referenced in RG 1.54. The applicant commits to performing an initial post-construction inspection by personnel qualified using guidance of ASTM D 4537, “Standard Guide for Establishing Procedures to Qualify and Certify Inspection Personnel for Coating Work in Nuclear Facilities Testing and Materials,” and the inspection plan guidance of ASTM D 5163, “Standard Guide for Condition Assessment of Coating Service Level Coating Systems in Nuclear Power Plants.” The guidance in RG 1.54 describes the non safety-related Service Level II coatings as being used in areas where coatings failure could impair, but not prevent, normal operating performance. These coatings function to provide corrosion protection and decontaminability in areas outside the reactor containment that are subject to radiation exposure and contamination.

Key industry standards cited in RG 1.54 applicable to epoxy coatings in the US-APWR design are ASTM D5144-08, “Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants,” for the qualification and selection of protective coatings for the surfaces of nuclear power generating facilities, and guidance on the application and maintenance of protective coatings; ASTM D3843-00 (R2008), “Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities,” for QA requirements applicable to safety-related protective coating work in Service Level I areas of nuclear facilities; ASTM D4537-04a, “Standard Guide for Establishing Procedures to Qualify and Certify Personnel Performing Coating Work Inspection in Nuclear Facilities,” for requirements on the development of procedures for the qualification of personnel performing coating work inspections; ASTM D5163-03 (R2008), “Standard Guide for Establishing a Program for Condition Assessment of Coating Service Level I Coating Systems in Nuclear Power Plants,” for procedures on an in-service monitoring program to evaluate the condition and performance of Service Level I coating systems in operating nuclear power plants; and Electric Power Research Institute (EPRI) (Revision 1), “Guideline on Nuclear Safety-Related Coatings,” (formerly Topical Report-109937) for guidance to assist nuclear plant personnel in developing, maintaining, and periodically assessing the effectiveness of safety-related coatings programs.

The staff reviewed the applicant’s response and found it to be acceptable because the design information for epoxy coatings and conformance to current industry standards will be included in the DCD and because COL Information Items 11.2(7) and 11.4(9) require the COL applicant to implement an epoxy coatings program. **RAI 403-3027, Question 11.02-18; RAI 403-3027, Question 11.02-19**; and **RAI 401-3031, Question 11.04-18** are closed.

11.2.4.2 Cost-Benefit Analysis

DCD Tier 2, Section 11.2.1.5, “Site-Specific Cost-Benefit Analysis,” describes the LWMS design for use at any site with flexibility to incorporate site-specific requirements with minor modifications such as preference of technologies, the degree of automated operation, and radioactive waste storage. RG 1.110, describes an acceptable method of performing a cost-benefit analysis (CBA) to demonstrate that the LWMS design includes all items of reasonably demonstrated technology for reducing cumulative population doses from releases of radioactive materials from each reactor to ALARA levels. The applicant states that for the US-APWR design, the CBA demonstrates that the addition of items of reasonably demonstrated technology will not provide a more favorable cost benefit, but does not include the CBA in DCD Tier 2, Section 11.2.1.5. The COL applicant will provide the site-specific CBA to demonstrate compliance with the requirements of 10 CFR Part 50 Appendix I, Sections II.A and II.D under COL Information Item 11.2(5). Because the CBA requires site-specific information, which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.2(5) acceptable

11.2.4.3 Mobile or Temporary Equipment

DCD Tier 2, Section 11.2.1.6, "Mobile or Temporary Equipment," discusses the provision for a mobile system or temporary equipment to process liquid waste that may be installed in the A/B. The mobile system or temporary equipment is not included in the LWMS designed with permanently installed equipment. Although COL Information Item 11.2(1) regarding the mobile system or temporary equipment is presented in DCD Tier 2, Section 11.2.4, "Combined License Information," the staff found no explicit statement in DCD Tier 2, Section 11.2.1.6 to direct the COL applicant to take responsibility for this COL information item. The staff requested that the applicant, in **RAI 164-1925, Question 11.02-3,** include a statement in DCD Tier 2, Section 11.2.1.6 to address COL Information Item 11.2(1). The staff also requested that the applicant include a similar statement in the relevant DCD section to address COL Information Item 11.2(2) regarding the site-specific information of the LWMS described in DCD Tier 2, Section 11.2.4. By letter dated February 18, 2009, the applicant responded to the above RAI.

In response to **RAI 164-1925, Question 11.02-3**, the applicant stated the description of COL Information Item 11.2(1) is presented in DCD Tier 2, Section 11.2.1.6. Under COL Information Item 11.2(1), the COL applicant will ensure the mobile and temporary liquid waste processing equipment and its interconnection to plant systems complies with the requirements of 10 CFR 50.34a, 10 CFR 20.1406, and RG 1.143. The applicant also stated the description of COL Information Item 11.2(2) is presented in DCD Tier 2, Section 11.2.3.1, "Radioactive Effluent Releases and Dose Calculation in Normal Operation." Under COL Information Item 11.2(2), the COL applicant will provide the site-specific detailed design information on the release of the physical location and configuration of the treated effluent. This site-specific information is to include the release point, effluent temperature and flow rate, and the size and shape of flow orifices. The staff confirmed that Revision 2 to DCD Sections 11.2.1.6 and 11.2.3.1 included this information. **RAI 164-1925, Question 11.02-3** is closed. Because the mobile or temporary equipment requires site-specific design information, which is outside the scope of the requested DC, the staff also finds COL Information Item 11.2(1) acceptable. The staff's evaluation of COL Information Item 11.2(2) is presented below.

11.2.4.4 Development of Liquid Effluent Source Term and Compliance with ECLs

DCD Tier 2, Section 11.2.3.1, "Radioactive Effluent Releases and Dose Calculation in Normal Operation," states the applicant calculated the expected annual average liquid effluent releases with the PWR-GALE computer code, input design values in DCD Tier 2, Table 11.2-9, "Input Parameters for the PWR-GALE Code (Sheets 1 of 2)," and decontamination factors in DCD Tier 2, Table 11.2-7, "Decontamination Factors." The decontamination factors in DCD Tier 2, Table 11.2-9 is taken from NUREG-0017 (Revision 1), "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)." The current version of the PWR-GALE code distributed by the Radiation Safety Information Computational Center (RSICC), Oak Ridge, Tennessee is the GALE86 code (hereafter referred to as the NRC PWR-GALE code). The applicant describes various assumptions in their calculations which consider processing by the LWMS (to remove radioactive constituents in the waste stream through filters, ion exchange, etc.) without reuse, treatment of the SG blowdown and return to the condenser, and dilution of 12,900 gpm from the cooling tower blowdown. DCD Tier 2, Tables 11.2-10, “Liquid Releases Calculated by the PWR-GALE Code (Ci/yr) (Sheets 1 and 2),” and 11.2-11, “Liquid Releases with Maximum Defined Fuel Defects (Ci/yr) (Sheets 1 and 2),” present the expected annual liquid effluent releases for normal operation including AOOs and annual liquid effluent releases with maximum defined fuel defects, respectively.

DCD Tier 2, Section 11.2.3.1 provides a COL information item, which requires the COL applicant to address the release physical location and configuration of the treated liquid effluent. Under COLI information Item 11.2(2), the COL applicant is required to provide the detailed site-specific LWMS design information such as radioactive release points, effluent temperature, and the shape of flow orifices. Because the detailed site-specific LWMS design information is outside the scope of the requested DC, the staff finds the inclusion of COL 11.2(2) acceptable.

11.2.4.5 Compliance with 10 CFR Part 20

10 CFR 20.1302 requires that an applicant demonstrate compliance with the dose limits of 10 CFR 20.1301, in part, by showing that the annual average of liquid effluent release concentrations in unrestricted areas do not exceed the ECLs specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. DCD Tier 2, Table 11.2-12, “Comparison of Annual Average Liquid Release Concentrations with 10CFR20 (Expected Releases) (Sheets 1 and 2),” shows that the sum-of-ratios of expected annual liquid effluent releases compared to their respective ECL is less than unity (calculated as 8.1E-02). DCD Tier 2, Table 11.2-13, “Comparison of Annual Average Liquid Release Concentrations with 10 CFR 20 (Maximum Releases) (Sheets 1 and 2),” also shows that the sum-of-ratios of annual liquid effluent releases with maximum fuel defects is less than unity (calculated as 9.12E-01). These sum-of-ratios of liquid effluent releases comply with the unity rule specified in 10 CFR Part 20, Appendix B.

Because the applicant used a proprietary version of the NRC PWR-GALE code and insufficient information was available for the staff to confirm the calculated liquid effluent releases and doses, in **RAI 164-1925, Question 11.02-7** and **RAI 189-2006, Question 11.03-6**, the staff requested that the applicant, provide the basis for all input design values and assumptions used in the applicant's PWR-GALE code calculations of effluent releases in DCD Tier 2, Sections 11.2 and 11.3. By letters dated February 18, 2009, and March 10, 2009, respectively, the applicant responded to the above RAI evaluated below.

11.2.4.6 Applicant's PWR-GALE Code

In responses to **RAI 164-1925, Question 11.02-7** and **RAI 189-2006, Question 11.03-6**, by letters dated February 18, 2009, and March 10, 2009, respectively, the applicant provided the basis for some of the input design values and assumptions in their calculation of expected annual normal and maximum liquid effluent releases, and submitted the PWR-GALE code input/output files under 10 CFR 2.390(a)(4). In the response, the applicant provided pointers to information in other DCD Tier 2 sections, references to NUREG-0017 and WASH-1258, Vol. 1, “Final Environmental Statement-Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion “As Low As Practicable” for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents,” details on calculations of the fraction of primary coolant activity and total decontamination factors on the waste streams, corrections made to annual maximum liquid effluent releases (except for detergent waste and corrosion and activation products which are applied directly) and the adjustment of 0.16 Ci/yr for AOOs to the expected annual liquid effluent releases.

The staff reviewed the applicant's PWR-GALE code input/output files and evaluated the input design values and assumptions used to calculate the liquid effluent releases and determined that the input design values were consistent with the guidance in NUREG-0017. The staff also verified the calculated decontamination factors for the liquid waste streams. The applicant applied a cation demineralizer flow rate (CBFLR) input value of 7 gpm in place of the maximum design flow rate of 110 gpm in their calculation to assume a more conservative value evaluated below.

The staff performed calculations of annual liquid effluent releases using the GALE86 (CCC-506), "Calculation of Routine Radioactive Releases in Gaseous and Liquid Effluents from Boiling Water and Pressurized Water Reactors," code distributed by the RSICC for comparison to the applicant's PWR-GALE code calculations using the input design values in DCD Tier 2, Table 11.2-9, "Input Parameters for the PWR-GALE Code (Sheets 1 and 2)." Table 11.2.1 of this SE shows that the sum-of ratios calculated with the NRC PWR-GALE code which is about 8 percent higher, but less than unity, than the sum-of ratios calculated with the applicant's PWR-GALE code. The annual liquid effluent releases calculated with the NRC PWR-GALE code are used as source term inputs in the NRCDose V2.3.14 code which contains the LADTAP II code to evaluate the applicant's LADTAP II code calculations of liquid effluent doses to members of the public discussed in Section 11.2.4.5 of this SE.

Because the applicant used a proprietary version of the NRC PWR-GALE code, the staff was not able to reproduce the liquid effluent releases in DCD Tier 2, Tables 11.2-10 (Sheets 1 and 2) and 11.2-11 (Sheets 1 and 2) using the input design values in DCD Tier 2, Table 11.2-9 (Sheets 1 and 2). The staff also found an apparent difference in the calculation results attributed to another modification made to the NRC PWR-GALE code on the source term specification identified during the Luminant Generation Company, LLC, Comanche Peak Nuclear Power Plant (CPNPP) Units 3 and 4, COL (Reference COLA for US-APWR) FSAR Chapter 11 site audit (ML092730519) discussed later in this section.

In comparing the CBFLR input value of 7 gpm to the design value of 110 gpm, the staff observed a decrease in the calculated total annual liquid effluent release when the CBFRL input value was increased in the NRC PWR-GALE code calculation. Because a lower demineralizer flow rate relates to a reduction or removal of radionuclides in the waste stream, a higher total liquid effluent release and sum-of-ratios is expected. The staff finds that using a CBFLR value of 7 gpm in the calculation of liquid effluent releases is conservative and acceptable.

The staff also found that use of the built-in plant capacity factor value of 0.8 (80 percent) in the NRC PWR-GALE (involves DCD Tier 2, Sections 11.2 and 11.3) and RATAF (described in Section 11.2.4.8 of this SE) codes was not fully described. The staff acknowledges that the methodology for calculating effluent releases in the NRC PWR-GALE code is based on data from operating plant primary coolant concentrations that are over 30 years old and does not consider improvements in radiochemistry and fuel performance of current plant operating experience, and the reduction in the occurrence and severity of fuel defects. In **RAI 523-4246, Question 11.02-30**, the staff requested that the applicant provide the basis for applying the built-in plant capacity factor of 80 percent given that the current fleet of operating reactors is operating at factors in excess of 90 percent. The staff also requested the applicant to discuss the impacts on the expected annual effluent releases and subsequent public doses from normal routine releases and AOOs due to a higher plant capacity factor. By letter dated March 15, 2010, the applicant responded to the above RAI.

In response to **RAI 523-4246, Question 11.02-30**, the applicant stated except for H-3, the methodology for calculating liquid effluent releases does not utilize the plant capacity factor, and the difference between the built-in and expected plant capacity factor has no effect on the liquid effluent releases in DCD Tier 2, Tables 11.2-10, "Liquid Releases Calculated by the PWR-GALE Code (Ci/yr) (Sheets 1 of 2)," and 11.2-11, "Liquid Releases Calculated by the PWR-GALE Code (Ci/yr) (Sheets 2 of 2)," with the applicant's PWR-GALE code. The expected annual liquid effluent releases in DCD Tier 2, Tables 11.2-11 and 11.2-12, "Comparison of Annual Average Liquid Release Concentrations with 10CFR20 (Expected Releases) (Sheets 1 and 2)," assume a dilution flow from the circulating water system that corresponds to 292 days of operation which equals the 80 percent plant capacity factor. As the plant capacity factor increases, the annual dilution flow also increases for all radionuclides, reducing the annual liquid effluent release concentrations. As a result, the built-in plant capacity factor of 80 percent is conservative to estimate annual liquid effluent releases. The PWR-GALE code assumes an annual liquid effluent release of 0.4 Ci/yr per MWt for H-3. Since the H-3 release rate is linearly proportional to the plant capacity factor and the dilution flow used to calculate liquid effluent releases, an increase in the H-3 releases resulting from a higher plant capacity factor would be canceled out by the increased dilution. The applicant added a qualifier in the footnote to DCD Tier 2, Table 11.2-9, "Input Parameters for the PWR-GALE Code (Sheets 1 and 2)," on use of the built-in plant capacity factor of 80 percent.

Based on the above discussion, the staff finds the applicant's response acceptable. However, because the staff was not able to confirm the applicant's calculation of liquid effluent releases which are used as source term inputs to calculate the doses, the staff conducted an audit to resolve RAIs specific to this subject area described below.

The annual liquid effluent releases with maximum defined fuel defects in DCD Tier 2, Table 11.2-11 (Sheets 1 and 2) are determined as the ratio of the design basis coolant concentrations in DCD Tier 2, Table 11.1-2 to the realistic primary coolant concentrations in DCD Tier 2, Table 11.1-9 (Sheets 1 and 2) times the amount released per radionuclide and path (shim bleed, misc. wastes, turbine building) of the realistic primary coolant concentrations, and the guidance in NUREG-0017. No adjustments were made to liquid effluent releases for detergent waste or to corrosion and activation products, as these releases do not depend on fuel defects. The total liquid effluent release with maximum defined fuel defects includes an adjustment of 0.16 Ci/yr for AOOs. The sum-of-ratios reported in DCD Tier 2, Table 11.2-13 (Sheets 1 and 2) is less than unity and complies with the ECLs in 10 CFR Part 20, Appendix B, Table 2, Column 2.

From review of the US-APWR Reference COL, CPNPP, Units 3 and 4, COL FSAR Chapter 11, the staff conducted an audit at the CPNPP site in Granbury, Texas held between June 23 - 24, 2009 (ML092730519). The purpose of the audit was to gather additional information on calculations of effluent releases and doses, and designs of the proposed evaporation pond and interim waste storage facility. During the audit, another modification was discovered that involved a change to the DCD source term specification in the applicant's PWR-GALE code which is based on the NRC PWR-GALE code. The built-in noble gas containment leak rate value, evaluated in Section 11.3.4.4.2 of this SE, was also modified in the NRC PWR-GALE code. This modification was discussed in a closed session of a Category 2 public meeting held on May 18, 2009, at the NRC, Rockville, Maryland (ML091250106). Consequently, the staff was unable to confirm whether the expected annual effluent releases calculated with the applicant's PWR-GALE code, which are used as source terms to calculate doses in the CPNPP, Units 3 and 4, COL FSAR Chapters 11 and 12, met compliance with the NRC regulations. As an audit finding, the staff requested the applicant to provide additional information evaluated in Sections 11.2 and 11.3 of this SE and/or addressed in the staff's evaluation of the CPNPP, Units 3 and 4, COL FSAR Chapter 11. As a result, the CPNPP, Units 3 and 4, COL FSAR under concurrent review was also revised from the audit findings.

In **RAI 402-3028, Question 11.03-12**, evaluated in Section 11.3 of this SE, the staff requested that the applicant provide an executable copy of their PWR-GALE code and source code. The staff also requested the applicant to identify all modifications made to the NRC PWR-GALE code, the specific lines of source code changed, and provide the QA/quality control (QC) documentation. By letter dated July 15, 2009, the applicant responded to the above RAI.

Under 10 CFR 2.390(a)(4), the applicant submitted the specific lines of original source code modified in the NRC PWR-GALE code relating to the ANSI/ANS-18.1-1999 source term specification. The applicant described the QA/QC documentation (written in Japanese) for their PWR-GALE code as consisting of a computer software validation and installation plan; computer software validation and installation; user document; configuration control; and in-use check. The staff requested the applicant to provide English translations of these documents. Under 10 CFR 2.390(a)(4), the applicant submitted the QA/QC documentation for their PWR-GALE code.

The staff reviewed the additional information and confirmed the specific lines of source code changed in the source term specification. However, in a teleconference call held on January 20, 2010, the staff informed the applicant that their PWR-GALE code could not execute with the files received, and requested all code files to confirm the applicant's results and conclusions. The staff discussed with the applicant a QA/QC document which identified a batch file not previously submitted that appeared to be required for execution of the applicant's PWR-GALE code. Under 10 CFR 2.390(a)(4), the applicant submitted the batch file, but the staff was not able to execute the code in the format received.

Because the staff was unable to confirm the liquid effluent releases calculated with the applicant's PWR-GALE code and effluent doses, the staff conducted an audit (ML102810271) of the applicant's PWR-GALE code at the MHI office in Arlington, Virginia, held between July 28 - 29, 2010. Prior to the PWR-GALE code audit, the applicant submitted, under 10 CFR 2.390(a)(4), their proprietary version of the NRC PWR-GALE code containing a local batch file in order to execute the code. Using the applicant's PWR-GALE code, the staff confirmed the applicant's calculations of expected annual liquid effluent releases. **RAI 164-1925, Question 11.02-7 and RAI 523-4246, Question 11.02-30,** as it relates to the built-in capacity factor, are closed.

From the PWR-GALE code audit findings, the staff requested the applicant in **RAI 624-4972, Question 11.02-33**, to provide the basis for several input design values used in the applicant's PWR-GALE code calculation to include the primary coolant mass (PCVOL) value of 646,000 lb (a factor in the 2E-4/d noble gas containment leakage rate calculation), letdown cation demineralizer rate (CBFLR) value of 7 gpm, liquid mass in each SG (WLI) value of 135,000 lb, and the SG blowdown rate (BLWDWN) value of 155,400 lb/hour (hr) and the blowdown treatment method value of 0; and the calculation packages of liquid effluent releases (both normal and maximum releases) and comparisons to the ECLs in 10 CFR Part 20, Appendix B, Table 2, and the LADTAP II code calculations of liquid effluent doses for demonstration of compliance to the NRC regulations. The staff also requested that the applicant revise DCD Tier 2, Sections 11.2 and 11.3 to make reference to the applicant's PWR-GALE code and describe the specific modifications to the NRC PWR-GALE code such as the noble gas containment leak rate change from 3E-02/d to 2E-4/d, the updated ANSI/ANS-N18.1-1999 primary coolant concentrations with the addition of Ba-137m and correction for Y-93 (water) secondary coolant concentration (Errata sheet for ANSI/ANS-18.1-1999), and to discuss the QA/QC documentation to validate the applicant's PWR-GALE code. By letter dated September 24, 2010, the applicant responded to the above RAI. The additional information provided in this response is also presented, in part, in the applicant's technical report described below.

Under 10 CFR 2.390(a)(4), the applicant submitted Technical Report MUAP-10019P (Proprietary), Revision 0 (R0), "Calculation Methodology for Radiological Consequences in Normal Operation and Tank Failure Analysis," in response to **RAI 629-4972, Question 11.02-33**, dated October 5, 2010. Technical Report MUAP-10019P (R0), describes the applicant's methodology, gaseous and liquid effluent and dose calculation results, basis for input design values used in the analysis of radiological consequences during normal operation including AOOs, and gas and liquid tank failure events to demonstrate compliance with the NRC regulations. Technical Report MUAP-10019P also summarizes the QA/QC documentation describing the validation procedures for the applicant's proprietary version of the NRC PWR-GALE code used to calculate expected annual liquid and gaseous effluent releases during normal operation including AOOs for a plant referencing the US-APWR design.

The staff reviewed Technical Report MUAP-10019P and found the applicant's methodology and basis for the selected input design values, as it relates to the calculation of annual liquid effluent releases and doses during normal operation including AOOs acceptable. Technical Report MUAP-10019P/ NP (Non-Proprietary) (R0) should be referenced in the DCD but was not; therefore the staff issued **RAI 5533, Question 11.02-34** requesting that the applicant reference this technical report. **RAI 5533, Question 11.02-34** is being tracked as **Open Item 11.02-2**. Additionally, the response to **RAI 629-4972, Question 11.02-33**, **Item 2** was incomplete because the calculation packages were not provided. The staff issued **RAI 629-4972, Question 11.02-33, Item 2**, requesting that the applicant submit these calculation packages. **RAI 629-4972, Question 11.02-33, Item 2** is also being tracked as **Open Item 11.02-1.**

Table 11.2.1. Comparison of the NRC and applicant's PWR-GALE code calculations of expected annual liquid effluent releases and sums-of-ratios.

Nuclide	ECL (μCi/ml)	Applicant's PWR-GALE (Ci/yr)	Release[1] (μCi/ml)	Release[1] /ECL	NRC PWR-GALE (Ci/yr)	Release[2] (μCi/ml)	Release[2] /ECL
Na-24	5.E-05	4.70E-03	2.29E-10	4.58E-06	1.30E-03	6.33E-11	1.27E-06
P-32	9.E-06	1.80E-04	8.77E-12	9.74E-07	1.80E-04	8.77E-12	9.74E-07
Cr-51	5.E-04	6.00E-03	2.92E-10	5.85E-07	5.00E-03	2.44E-10	4.87E-07
Mn-54	3.E-05	4.50E-03	2.19E-10	7.31E-06	4.00E-03	1.95E-10	6.50E-06
Fe-55	1.E-04	7.70E-03	3.75E-10	3.75E-06	7.30E-03	3.56E-10	3.56E-06
Fe-59	1.E-05	2.30E-03	1.12E-10	1.12E-05	2.20E-03	1.07E-10	1.07E-05
Co-58	2.E-05	9.80E-03	4.77E-10	2.39E-05	8.40E-03	4.09E-10	2.05E-05
Co-60	3.E-06	1.40E-02	6.82E-10	2.27E-04	1.40E-02	6.82E-10	2.27E-04
Ni-63	1.E-04	1.70E-03	8.28E-11	8.28E-07	1.70E-03	8.28E-11	8.28E-07
Zn-65	5.E-06	2.20E-04	1.07E-11	2.14E-06	6.00E-05	2.92E-12	5.85E-07
W-87	3.E-05	3.50E-04	1.71E-11	5.68E-07	1.00E-04	4.87E-12	1.62E-07
Np-239	2.E-05	5.30E-04	2.58E-11	1.29E-06	1.50E-04	7.31E-12	3.65E-07
Rb-88	4.E-04	2.80E-02	1.36E-09	3.41E-06	7.80E-03	3.80E-10	9.50E-07
Sr-89	8.E-06	1.50E-04	7.31E-12	9.13E-07	1.00E-04	4.87E-12	6.09E-07
Sr-90	5.E-07	1.80E-05	8.77E-13	1.75E-06	1.00E-05	4.87E-13	9.74E-07
Sr-91	2.E-05	6.80E-05	3.31E-12	1.66E-07	2.00E-05	9.74E-13	4.87E-08
Y-91m	2.E-03	4.40E-05	2.14E-12	1.07E-09	1.00E-05	4.87E-13	2.44E-10
Y-91	8.E-06	9.00E-05	4.38E-12	5.48E-07	9.00E-05	4.38E-12	5.48E-07
Y-93	2.E-05	2.90E-04	1.41E-11	7.06E-07	8.00E-05	3.90E-12	1.95E-07
Zr-95	2.E-05	1.30E-03	6.33E-11	3.17E-06	1.10E-03	5.36E-11	2.68E-06
Nb-95	3.E-05	2.00E-03	9.74E-11	3.25E-06	1.90E-03	9.26E-11	3.09E-06
Mo-99	2.E-05	1.70E-03	8.28E-11	4.14E-06	5.20E-04	2.53E-11	1.27E-06
Tc-99m	1.E-03	1.70E-03	8.28E-11	8.28E-08	4.60E-04	2.24E-11	2.24E-08
Ru-103	3.E-05	3.40E-03	1.66E-10	5.52E-06	1.10E-03	5.36E-11	1.79E-06
Rh-103m	6.E-03	3.10E-03	1.51E-10	2.52E-08	8.50E-04	4.14E-11	6.90E-09
Ru-106	3.E-06	4.70E-02	2.29E-09	7.63E-04	2.00E-02	9.74E-10	3.25E-04
Ag-110m	6.E-06	1.80E-03	8.77E-11	1.46E-05	1.40E-03	6.82E-11	1.14E-05
Sb-124	7.E-06	4.30E-04	2.09E-11	2.99E-06	4.30E-04	2.09E-11	2.99E-06
Te-129m	7.E-06	7.80E-05	3.80E-12	5.43E-07	2.00E-05	9.74E-13	1.39E-07
Te-129	4.E-04	3.10E-04	1.51E-11	3.78E-08	8.00E-05	3.90E-12	9.74E-09
Te-131m	8.E-06	2.50E-04	1.22E-11	1.52E-06	7.00E-05	3.41E-12	4.26E-07
Te-131	8.E-05	7.60E-05	3.70E-12	4.63E-08	2.00E-05	9.74E-13	1.22E-08
I-131	1.E-06	2.00E-03	9.74E-11	9.74E-05	3.60E-03	1.75E-10	1.75E-04
Te-132	9.E-06	4.70E-04	2.29E-11	2.54E-06	1.30E-04	6.33E-12	7.04E-07
I-132	1.E-04	3.10E-04	1.51E-11	1.51E-07	2.60E-04	1.27E-11	1.27E-07
I-133	7.E-06	8.10E-04	3.95E-11	5.64E-06	1.20E-03	5.85E-11	8.35E-06
I-134	4.E-04	8.90E-05	4.34E-12	1.08E-08	8.00E-05	3.90E-12	9.74E-09
Cs-134	9.E-07	1.20E-02	5.85E-10	6.50E-04	7.00E-02	3.41E-09	3.79E-03
I-135	3.E-05	7.80E-04	3.80E-11	1.27E-06	1.00E-03	4.87E-11	1.62E-06
Cs-136	6.E-06	2.20E-02	1.07E-09	1.79E-04	6.20E-03	3.02E-10	5.03E-05
Cs-137	1.E-06	1.80E-02	8.77E-10	8.77E-04	9.50E-02	4.63E-09	4.63E-03
Ba-140	8.E-06	5.80E-03	2.83E-10	3.53E-05	2.30E-03	1.12E-10	1.40E-05
La-140	9.E-06	8.00E-03	3.90E-10	4.33E-05	2.20E-03	1.07E-10	1.19E-05
Ce-141	3.E-05	2.90E-04	1.41E-11	4.71E-07	2.50E-04	1.22E-11	4.06E-07
Ce-143	2.E-05	5.00E-04	2.44E-11	1.22E-06	1.40E-04	6.82E-12	3.41E-07
Pr-143	2.E-05	7.90E-05	3.85E-12	1.92E-07	2.00E-05	9.74E-13	4.87E-08
Ce-144	3.E-06	5.60E-03	2.73E-10	9.09E-05	4.40E-03	2.14E-10	7.14E-05
Pr-144	6.E-04	1.70E-03	8.28E-11	1.38E-07	4.60E-04	2.24E-11	3.73E-08
H-3	1.E-03	1.60E+03	7.79E-05	7.79E-02	1.60E+03	7.79E-05	7.79E-02
Sum-of-Ratios =				8.10E-02			8.73E-02

Notes:
Rh-106, Ag-110, and Ba-137m are not included in 10 CFR Part 20, Appendix B, Table 2, Column 2, so they are excluded from the sum-of-ratios. The allowable sum-of-ratios is 1.0.

1. Calculation with applicant's PWR-GALE code, dilution flow of 12,900 gpm, 292 discharge days, and CBFLR value of 7 gpm.
2. Calculation with NRC PWR-GALE code, dilution flow of 12,900 gpm, 292 discharge days, and CBFLR value of 7 gpm.

11.2.4.7 Compliance with Liquid Effluent Dose Limits for Members of the Public

Under the requirements of 10 CFR Part 50, Appendix I, Sections II.A and II.D, an applicant is responsible for addressing the requirements of 10 CFR Part 50, Appendix I, design objectives in controlling doses to a maximally exposed member of the public and populations living near the proposed nuclear power plant. The requirements define dose objectives for liquid effluents, and require a cost-benefit analysis in justifying installed processing and treatment equipment of the LWMS, including any augmentation to the design in complying with 10 CFR Part 50, Appendix I. DCD Tier 2, Section 11.2.1.5 states the COL applicant will perform the CBA. The applicant demonstrates compliance with the numerical design objectives of 10 CFR Part 50, Appendix I for calculating doses to the maximally exposed offsite individual using the guidance and methodology described in NUREG/CR-4013, "LADTAP II - Technical Reference and User Guide," with the LADTAP II computer code.

DCD Tier 2, Section 11.2.3.1,"Radioactive Effluent Releases and Dose Calculation in Normal Operation," states the individual doses were evaluated with the LADTAP II code and the input design values in DCD Tier 2, Table 11.2-14, "Input Parameters for the LADTAP II Code." The estimated doses from liquid effluents for the individual age groups and exposure pathways are presented in DCD Tier 2, Table 11.2-15, "Individual Dose from Liquid Effluents." The results show maximum exposed individual (MEI) doses of 1.98 mrem/year (yr) (Child-Total Body), 2.54 mrem/yr (Child-Liver), and 1.84 mrem/yr (Child-Thyroid), which demonstrate compliance with 10 CFR Part 20.1301(e) in meeting the EPA's environmental radiation protection standards of 40 CFR Part 190 for fuel-cycle facilities including nuclear power reactors. The EPA standards specify annual dose limits of 25 mrem/yr (whole body), 75 mrem/yr (thyroid), and 25 mrem/yr (any other organ) for members of the public exposed to planned discharges of radioactive materials. The estimated individual doses calculated with the LADTAP II code are less than the criteria of 3 mrem/yr (total body) and 10 mrem/yr (limiting organ) specified in 10 CFR Part 50, Appendix I. Because these doses could not be confirmed, in **RAI 164-1925, Question 11.02-4**, the staff requested that the applicant provide the basis for all input design values used in the LADTAP II code calculation and the input/output files. By letter dated February 18, 2009, the applicant responded to the above RAI.

In response to **RAI 164-1925, Question 11.02-4**, the applicant provided the basis for some input design values and assumptions in the LADTAP II code calculation and submitted the LADTAP II code input/output files under 10 CFR 2.390(a)(4). The applicant provided pointers to Tier 2 information and references to 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."

The staff reviewed the applicant's LADTAP II code input/output files and response evaluating the doses to members of the public in unrestricted areas from liquid effluent releases for compliance with 10 CFR Part 50, Appendix I; 10 CFR 20.1302, and 40 CFR Part 190. Input values pertaining to environmental characteristics such as the hydrologic model, water type, dilution factors, irrigation rates, usage and consumption, and exposure pathways considered, etc. rely on site-specific information are addressed by the COL applicant in COL Information Item 11.2(4) evaluated below.

In a comparative analysis, the staff performed liquid effluent dose calculations with the NRCDose 2.3.14 (CCC-684) code, "Code System for Evaluating Routine Radioactive Effluents from Nuclear Power Plants with Windows Interface," distributed by the RSICC, which contains the LADTAP II code, also distributed by RSICC, using the input design values listed in DCD Tier 2, Table 11.2-14 and information provided in the applicant's response. For the source term, the staff applied the annual liquid releases calculated with the NRC PWR-GALE code in place of the expected annual liquid releases presented in DCD Tier 2, Table 11.2-10 (Sheets 1 and 2) calculated with the applicant's PWR-GALE code.

The staff observed in the applicant's LADTAP II output file, a H-3 ingestion dose factor (DF(ing)) of 2.03E-07 mrem/pCi in the DF(ing) tables. Table E-13 to RG 1.109 lists a H-3 DF(ing) of 2.03E-07 mrem/pCi for the total body, while Table 3.8 of NUREG/CR-4013, LADTAP II - Technical Reference and User Guide" (published after RG 1.109) states that the quality factor for the H-3 organ DF(ing) (except for bone) was reduced for all age groups from 1.7 to 1.0, and was corrected to 1.16E-07 mrem/pCi in the LADTAP II dose factor file. The corrected H-3 DF(ing) of 1.16E-07 mrem/pCi is applied in the LADTAP II and NRCDose 2.3.14 codes distributed by RSICC. The staff finds this acceptable as Table 11.2.3 of this SE shows that the applicant's calculations of liquid effluent doses with the LADTAP II code using the higher H-3 dose factoring from RG 1.109 is conservative compared to the NRCDose 2.3.14 code, and within 10 percent agreement for the Drinking Water pathway for the Child-Total Body when the corrected H-3 DF(ing) is applied (H-3 contributes about 98 percent of the total dose in the Drinking Water pathway for the Child-Total Body with the NRCDose 2.3.14 code).

Under COL Information Item 11.2(4) in DCD Tier 2, Section 11.2.3.1, the COL applicant is required to calculate doses to members of the public using site-specific parameters following the guidance of RGs 1.109 and 1.113, and compare doses from liquid effluents with the 10 CFR Part 50, Appendix I; 10 CFR 20.1302; and 40 CFR Part 190. The staff finds that because the site-specific input parameters values used in the LADTAP II code calculation of liquid effluent doses are outside the scope of the requested DC, the inclusion of COL Information Item 11.2(4) acceptable.

The annual individual-pathway-organ doses, for one unit, calculated with the LADTAP II code in DCD Tier 2, Table 11.2-15 are determined from the input design values in DCD Tier 2, Table 11.2-9 (Sheets 1 and 2), and the liquid effluent releases calculated by the applicant's PWR-GALE code in DCD Tier 2, Table 11.2-10 (Sheets 1 and 2). As discussed in Sections 11.2.4.4 and 11.2.4.6 of this SE, the staff confirmed the applicant's calculations of the expected annual liquid effluent releases and doses for normal operation including AOOs. **RAI 164-1925, Question 11.02-4 and RAI 523-4246, Question 11.02-30** as it relates to the applicant's calculations of effluent releases and doses, are closed.

Table 11.2.3. Comparison of the NRC and applicant's estimated annual individual doses from liquid effluent releases.

Computer Code	Design Objective[2] (mrem/yr)	Applicant (mrem/yr)	NRC (mrem/yr)	Ratio[3] NRC/Applicant
LADTAP II[1]	3 (Total Body) 10 (Organ) 10 (Organ)	1.98 (Child) 2.54 (Child-Liver) 1.84 (Child-Thyroid)		
NRCDose 2.3.14	3 (Total Body) 10 (Organ) 10 (Organ)		1.23 (Child) 1.83 (Child-Liver) 1.06 (Child-Thyroid)	6.21E-01 (Child) 7.20E-01 (Child-Liver) 5.76E-01 (Child-Thyroid)

Notes:

1. H-3 DF(ing) of 2.03E-07 mrem/pCi from RG 1.109 applied in the applicant's LADTAP II code calculation instead of the corrected H-3 DF(ing) of 1.16E-07 mrem/pCi from NUREG/CR-4013.
2. Numerical design objectives in 10 CFR Part 50, Appendix I for estimating annual doses above background from liquid effluents for any individual in an unrestricted area, for one unit, from all exposure pathways are 3 mrem/yr to the total body or 10 mrem/yr to any organ.
3. Ratio to the NRCDose 2.3.14 code using liquid effluent release from the NRC PWR-GALE code with CBFLR value of 7 gpm.

11.2.4.8 Failed Liquid Tank Analysis

Revisions 0 and 1 to DCD Tier 2, Sections 11.2 and 11.4 proposed to line cells/cubicles with stainless-steel in the LWMS and with steel in SRST rooms in the SWMS. BTP 11-6 (Revision 3), “Postulated Radioactive Releases due to Liquid-Containing Tank Failures,” describes provisions for acceptable design features such as steel liners to mitigate the release of radioactive materials resulting from the postulated failure of a liquid waste tank located outside of containment. The applicant introduced a design change in Revision 2 to the DCD that replaced steel liners, an acceptable mitigative design feature, with epoxy coatings. Section B.3, “Mitigating Design Features,” of BTP 11-6 states, in regards to coatings, “[c]redit is not allowed for retention by coatings or leakage barriers outside the building foundation.” When a mitigative design feature such as steel is proposed by the applicant and is found to be acceptable by the staff, a liquid tank failure analysis is not needed. Because the applicant changed the design from steel to epoxy coatings, the applicant was required to address the radiological consequences from a postulated failure of a liquid containing tank using the guidance in SRP Section 11.2, RG 1.206, and BTP 11-6, in the DCD.

Revision 2 to DCD Tier 2, Section 11.2.3.2, “Radioactive Effluent Releases due to Liquid Containing tank Failures,” describes the consequences of a postulated failed liquid tank with the numerical design objectives of 10 CFR Part 50, Appendix I and the ECLs of 10 CFR Part 20, Appendix B, Table 2, Column 2 using the guidance in BTP 11-6 and NUREG-0133, Appendix A. Both the DCD Tier 2, Section 11.2.3.2 and Table 1.8-2 provide a COL information item for the COL applicant to address the site-specific hydrogeological data (such as contaminant migration time), and analysis to demonstrate that the potential groundwater contamination resulting from radioactive release due to liquid containing tank failure is bounded by the analysis in the DCD. Because the hydrogeological data requires site-specific information which is outside the scope of the requested DC, the staff found the inclusion of COL Information Item 11.2(3) acceptable. However, COL Information Item 11.2(3) was revised by the applicant in the new approach to address the liquid tank failure analysis. The staff's evaluation of revised COL Information Item 11.2(3) is presented later in this section.

The applicant's initial evaluation in DCD Tier 2, Section 11.2.3.2 considered three LWMS tanks for the liquid tank failure analysis: HT, WHT, and the BAT. DCD Tier 2, Table 11.2-16, “Parameters for Calculation of Liquid Containing Tank Failures,” describes the parameter values and assumptions on tank volumes, input flow rates, fractions of primary coolant activities, hydrological travel time, hydrological dilution factors, and tank factors for the HT, WHT, and BAT. DCD Tier 2, Table 11.2-17, “Calculation Results of Effluent Concentrations due to Liquid Containing Tank Failures,” presents critical receptor concentrations calculated with the RATAF code and ECL comparisons for the HT, WHT, and BAT, and report ECL fractions less than unity. The applicant also compared the Cs-134 and Cs-137 primary coolant concentrations calculated with the RATAF code to the realistic source term concentrations in DCD Tier 2, Table 11.1-9, “Realistic Source Terms (Sheets 1 and 2).” DCD Tier 2, Table 11.2-18, “Equipment Malfunction Analysis (Sheets 1 of 2)” evaluates the failure of sumps, sump pumps, and drainage equipment in the LWMS. The applicant states the release impacts associated with these equipment failures involve smaller amounts of liquid waste which are bounded by the failed liquid tank analysis. From review of DCD Tier 2, Sections 11.1.2 and 11.2.3.2, the staff issued several RAIs summarized below.

The staff’s review of DCD Tier 2, Section 11.1.2 determined that Tc-99 was not identified in the source term. Tc-99, a radionuclide found in principle fluid streams of a reference PWR and produced in the reactor core in amounts several orders of magnitude greater than I-129, could become an important contributor to dose from groundwater because of its long half-life and low retardation in soil. Therefore, in **RAI 29-595, Question 11.01-2**, the staff requested that the applicant provide Tc-99 concentrations in the primary and secondary coolant under design basis and realistic conditions, or justify their exclusion as the dose consequence analysis for liquid waste system failures in accordance with SRP Section 2.4.13 and BTP 11-6 which considers the most adverse contamination in groundwater and highest potential exposure consequences to users of water resources, including long-lived fission and activation products and environmentally mobile radionuclides. By letter dated August 6, 2008, the applicant responded to the above RAI.

In response to **RAI 29-595, Question 11.01-2**, the applicant provided core inventories of Cs-137 (1.9E+07 Ci), Tc-99 (2.3E+03 Ci), and I-129 (5.6E+00 Ci) calculated with the ORIGEN-2 code, and performed an analysis comparing Tc-99 and Cs-137 activities to ECLs and half-lives, and presented Tc-99 concentrations in the HT, WHT, and BAT due to a failed liquid tank as 8.8E-09 µCi/ml, 9.8E-10 µCi/ml, and 1.2E-07 µCi/ml, respectively. The applicant concluded that the dose consequence of Tc-99 is relatively small compared to Cs-137 having a core inventory several orders of magnitude larger than Tc-99 and a larger contribution to the ECL. The staff reviewed the applicant's response and found that I-129, a long-lived and environmentally mobile radionuclide produced in the core, was also not identified in the source term. As a result, the staff closed **RAI 29-595, Question 11.01-2** and, in follow-up **RAI 164-1925, Question 11.02-6, Item 1**, requested that the applicant include in DCD Tier 2, Section 11.2.3.2, the Tc-99 and I-129 concentrations in the liquid tank failure analysis, or justify their exclusion in an evaluation which considers the environmental (fate and transport) characteristics of Tc-99, I-129, and Cs-137; and clarify the applicant's previous response in RAI 29, Question 11.01-2 to neglect the contribution of Tc-99 and I-129 because the same hydrological travel speed and time is used for Cs-137 which “conservatively neglects the adsorption effect by the soil.” By letter dated June 18, 2009, the applicant responded to the above RAI. The staff closed **RAI 164-1925, Question 11.02-6, Item 1** because the applicant addressed long-lived fission and activation products which are and environmentally mobile in the new approach on the liquid tank failure analysis evaluated later in this section.

The design change in Revision 2 to DCD Tier 2, Section 11.2.3.2 on the replacement of steel liners with epoxy coating raised new issues. As a result, in **RAI 164-1925, Question 11.02-6, Items 2(a)** through **2(g)**, the staff requested that the applicant fully describe in DCD Tier 2, Section 11.2.3, the approach used to demonstrate that liquid effluents processed by the LWMS and released into the surface or groundwater from a failed liquid tank failure comply with 10 CFR Part 20, Appendix B, Table 2, Column 2 under the unity rule and the Total Effective Dose Equivalent (TEDE) of 50 mrem/yr. Specifically, in **RAI 164-1925, Question 11.02-6**, the staff requested that the applicant provide calculation details in developing the source term as radionuclide distributions and concentrations for the tank inventories, and the basis for all input design and assumptions in Item 2(a); provide tank inventories and identify the tank selected to contain the highest inventory for the liquid tank failure analysis in Item 2(b); clarify Note 1 in DCD Tier 2, Table 11.2-17 in Item 2(c); discuss DCD Tier 2, Table 11.2-18, “Equipment Malfunction Analysis (Sheets 1 and 2)” in the DCD in Item 2(d); provide the basis for the dilution water of 4.4E+10 gal in Item 2(e); identify any credits applied in engineered design features for mitigating radiological consequences of the tank failure in Item 2(f); and provide the resulting concentrations at the receptor location in Item 2(g). By letter dated February 18, 2009, the applicant responded to the above RAI summarized below.

In response to **RAI 164-1925, Question 11.02-6, Item 2(a)**, the applicant identified the RATAF code used to calculate the tank and critical receptor concentrations and ECL fractions and provided the basis for input design values such as tank volumes, tank factors, hydrological dilution factor, and hydrological travel time, and those input values shared with the PWR-GALE code in DCD Tier 2, Table 11.2-9. The applicant stated the hydrological travel time value of 365 days considered for all tanks will be re-evaluated if not shown to be within the DCD evaluation.

In response to **RAI 164-1925, Question 11.02-6, Item 2(b)**, the applicant provided the failed liquid tank inventories and concentrations for the HT, WHT, and BAT based on the input design values described in response to **RAI 164-1925, Question 11.02-6, Item 2(a)**. The applicant provided a discussion to select the BAT as the tank containing the highest inventory and concentration for the liquid tank failure analysis from an evaluation of ten liquid containing tanks in the US-APWR design. The applicant's selection of the BAT is discussed in the staff's evaluation of the RATAF code input/output files presented later in this section.

In response to **RAI 164-1925, Question 11.02-6, Item 2(c)**, the applicant described that the RATAF code output calculation for "All Others" includes radionuclides with ECL fractions less than 1E-03. As such, the liquid tank failure analysis excludes these radionuclides since their contribution to the ECL is less than 1 percent for all radionuclides.

In response to **RAI 164-1925, Question 11.02-6, Item 2(d)**, the applicant stated it was not necessary to describe the events in DCD Tier 2, Table 11.2-18 since tank failure analysis in DCD Tier 2, Section 11.2.3.2 provides greater release impact. Because the DCD was not revised to include a discussion on Table 11.2-18, the staff issued follow-up **RAI 403-3027, Question 11.02-20, Item 5** evaluated later in this section.

In response to **RAI 164-1925, Question 11.02-6, Item 2(e)**, the applicant provided the basis of the 4.4E+10 gal dilution volume applied in the hydrological dilution factor. The applicant described this volume to be an order of magnitude comparable to the Squaw Creek Reservoir at the Comanche Peak site (US-APWR Reference COL). The applicant stated the dilution volume of 4.4E+10 gal will be re-evaluated if not shown to be within the DCD evaluation.

In response to **RAI 164-1925, Question 11.02-6, Item 2(f)**, the applicant described credits taken in the failed tank analysis such as removal and concentration effects of the demineralizers and the boric acid evaporator (BA Evap), radioactive decay during travel time, and the hydrological dilution factor.

In response to **RAI 164-1925, Question 11.02-6, Item 2(g)**, the applicant described that the resulting radionuclide concentrations at the receptor location are obtained directly from the RATAF code calculation. The staff's evaluation on the RATAF code calculations of critical receptor concentrations are presented later in this section.

The staff closed **RAI 164-1925, Question 11.02-6, Items 2(a) through 2(g)** above because the applicant proposed a new approach to address the liquid tank failure analysis discussed later in this section.

However, the applicant's response to **RAI 164-1925, Question 11.02-6**, by letter dated February 18, 2009, raised an issue on the calculation method. Because the RATAF code is based on the GALE (1975) code which predates both the source term specification in the PWR-GALE code used to calculate liquid effluent releases in DCD Tier 2, Section 11.2 and ANSI/ANS-18.1-1999 used to develop the realistic source terms in DCD Tier 2, Section 11.1, in follow-up **RAI 403-3027, Question 11.02-20**, the staff requested that the applicant clarify an assumption related to neglecting adsorption in soil in Item 1; justify use of the RATAF code based on GALE (1975) code in Item 2; revise the DCD to include the approach and methodology in Item 3; provide the RATAF code input/output files in Item 4; and discuss the information presented in DCD Tier 2, Table 11.2-18 in the DCD in Item 5. By letter dated July 16, 2009, the applicant responded to the above RAI summarized below.

In response to **RAI 403-3027, Question 11.02-20, Item 1**, the applicant clarified the approach taken in the liquid tank failure analysis. The applicant described the conservative model calculated with the RATAF code is based on an unmitigated release of the entire tank contents to the groundwater system with subsequent mixing and migration within the groundwater system with no other credit for dilution water or retardation or suspension of radionuclides in the subsurface media. The tank contents are diluted only with the body of water in the vicinity of ponds surrounding the site. The liquid tank failure analysis assumes the entire contents of the tank are released directly into the groundwater system which mixes and moves with the groundwater system. No credit is taken for any mitigative design feature. Other discharges and groundwater are not credited as dilution water and no credit is taken for retardation or suspension of radionuclide in the subsurface media that would either filter or reduce radionuclide concentrations by the soil. The staff found the assumptions regarding no credits taken for discharges and groundwater as dilution water and for retardation or suspension of radionuclide in the subsurface media by the soil acceptable as this conservative approach results in the highest critical receptor concentrations.

In response to **RAI 403-3027, Question 11.02-20, Item 2**, the applicant justified the RATAF code referenced in NUREG-0133 as the methodology used for the liquid tank failure analysis. The RATAF (CCC-681), "Code System for the Radioactive Liquid Tank Failure Study," and the NRC PWR-GALE codes, distributed by RSICC, share general user input values such as thermal power level, mass of primary coolant, primary system letdown rate, and letdown cation demineralizer flow rate. The RATAF code requires specific user inputs on the hydrological dilution factor, hydrological travel time, tank volumes, tank factors, inlet stream flow rates, inlet activities expressed as a fraction of primary coolant activities, and DF to calculate tank concentrations. The RATAF code is based on calculating liquid tank concentrations at 80 percent capacity with the design basis fission product source of 1 percent of the operating fission product inventory in the core being released to the primary coolant for a PWR, which would result in an ECL equal to 10 CFR Part 20, Appendix B, Table 2, Column 2 at the nearest potable water and surface water supplies in an unrestricted area. In contrast, the concentrations and total inventory of radioactive materials in BTP 11-6 are based on the failed fraction of 0.12 percent of the fuel producing power in a PWR in NUREG-0017. The staff finds use of the RATAF code as referenced in NUREG-0133, Appendix A and SRP Section 11.2 acceptable. However, an additional issue was raised regarding the built-in capacity factor in the RATAF code that resulted in follow-up **RAI 523-4246, Question 11.02-30** evaluated in Section 11.2.4.6 of this SE and discussed below.

In response to **RAI 403-3027, Question 11.02-20, Item 3**, the applicant revised DCD Tier 2, Section 11.2.3.2 to clarify the calculation model and assumptions used in the liquid tank failure analysis. The released liquid is diluted with 4.4E+10 gallons of water before reaching a potable water supply in an unrestricted area. The applicant added a column and notes to DCD Tier 2, Table 11.2-17 to present HT, WHT, and BAT concentrations based on 1 percent failed fuel as calculated with the RATAF code (Note 3 to Table 11.2-17), and reflect an adjustment of 0.12 percent failed fuel (except for H-3) based on BTP 11-6 at the critical receptor (Note 4 to Table

11.2-17). The applicant reported sum-of-ratios at the critical receptor for the HT, WHT, and BAT (2.0E-2, 2.1E-2, and 2.2E-2, respectively) with the assumed dilution, hydrological travel time, and LWMS design specifications for meeting compliance with the ECLs in 10 CFR Part 20, Appendix B, Table 2, Column 2. The applicant compared the primary coolant concentrations of H-3, Cs-134, and Cs-137 calculated with the RATAF code to the realistic source terms in DCD Tier 2, Table 11.1-9 calculated using the methodology in ANSI/ANS-18.1-1999. Based on the comparison, the applicant concluded that the RATAF code was conservative since the primary coolant concentrations calculated with the RATAF code were higher than or equal to the respective realistic source term concentrations. The staff's evaluation on the initial source term selection (i.e., alternative approach to use realistic source terms in lieu of design basis source terms) in the liquid tank failure analysis is presented later in this section. The applicant also revised DCD Tier 2, Section 11.2.3.2, to discuss the impact of using the RATAF code with a built-in plant capacity factor of 80 percent. The staff finds this acceptable because the reported critical receptor concentrations are very small, given the calculation model and assumptions, such that any adjustment on the capacity factor between 80 percent and 100 percent will not significantly increase liquid releases. The staff confirmed that Revision 2 to DCD Tier 2, Section 11.2.3.2 included this information.

Under 2.390(a)(4), **RAI 403-3027, Question 11.02-20, Item 4**, by letter dated July 16, 2009, the applicant provided a copy of the RATAF code input/output files. The staff reviewed ten liquid containing tanks for the liquid tank failure analysis: HT, WHT, BA Evap, BAT, volume control tank (VCT), A/B sump tank, R/B sump tank, primary water makeup tank (PWMT), RWSAT, and the chemical drain tank. The applicant discussed its selection of the BAT as the tank assumed to fail from its volume and concentration. The staff reviewed the RATAF code input/output files for the ten liquid tanks and the basis and assumptions used in developing the source terms, radionuclide distributions, and concentrations to ensure that the highest potential radioactive material inventory was selected among the expected types of liquid and wet waste streams processed by the LWMS for the failed liquid tank analysis. The staff verified the input design values, tank capacities, and calculated outputs of tank inventories, critical receptor concentrations, and ECL fractions. The staff confirmed that the calculated overall tank factors which considers the type of processing the waste has undergone prior to its entry into the tank, radionuclide removal by demineralizers or other treatment equipment upstream of the failed tank, and effects of radionuclide concentration in the evaporator are consistent with the guidance in NUREG-0017, Table I-3, “Decontamination Factors for PWR Liquid Waste Treatment Systems.” The staff also confirmed the calculated hydrological dilution factor for the ten liquid tanks evaluated. As a result, the staff determined that the BAT results in the highest concentration of radioactive materials at the nearest potable water supply in an unrestricted area given the US-APWR design specificities.

The staff closed **RAI 403-3027, Question 11.02-20, Items 1 through 4** above because the applicant proposed a new approach to address the liquid tank failure analysis evaluated later in this section.

However, additional issues were raised in the applicant’s response to **RAI 403-3027, Question 11.02-20, Item 4**, by letter dated July 16, 2009, regarding liquid tank design features. In follow-up **RAI 523-4246, Question 11.02-28**, the staff requested that the applicant provide details describing the design features of the BA Evap (1,770 gal) and the PWMT (140,000 gal) evaluated with the RATAF code; clarify an apparent inconsistency on the RWSAT input volume used in the RATAF code and design information in DCD Tier 2, Section 6.3.2.2.3, “Refueling Water Storage Pit,” and Table 12.1-1, “Radiation Sources Parameters (Sheet 4 of 6);” revise

DCD Tier 2, Table 11.2-17 to include tank concentrations calculated with the RATAF code based on 1 percent failed fuel defect; and discuss the results in DCD Tier 2, Sections 11.2.3.2 and 2.4.13, “Accident Releases of Radioactive Liquid Effluent in Ground and Surface Waters.” By letter dated March 15, 2010, the applicant responded to the above RAI.

In response to **RAI 523-4246, Question 11.02-28**, the applicant stated the BA Evap is located in the A/B at grade level to facilitate drainage to equipment at lower floors for maintenance and cleaning. The BA Evap is housed in a shielded cubicle. The cubicle floor and walls are coated with non-porous epoxy material (coating) to facilitate decontamination. The cubicle is equipped with a leak detection system which alarms to the radwaste control room and MCR for operator action which terminates BA Evap operation and drains to the BAT and LWMS for processing depending on the BA Evap operation stage. The two PWMT and RWSAT are described by the applicant as located inside a tank house adjacent to the plant north wall of the A/B. The tank house is constructed of a concrete foundation and short concrete retaining walls around the liquid tanks. The tank house design includes full height walls and roof to prevent infiltration of rain to minimize cross-contamination and a pit for leak detection and leakage collection to avoid release of contamination to the environment. The concrete foundation, short walls, and pit are coated with non-porous epoxy material (coating) to facilitate decontamination. Routine epoxy coating inspections and maintenance are to be included in the plant epoxy coating inspection and maintenance program evaluated in Section 11.2.4.1.1. The applicant also corrected the RWSAT capacity for refueling operations located outside containment to 29,410 ft^3 (220,000 gal) and in DCD Tier 2, Section 6.3.2.2.3, “Refueling Water Storage Pit” from DCD Tier 2, Figure 6.2.2-7, “Required Water Volumes vs. Pit Capacities.” Accordingly, the RWSAT geometry model for the shielding analysis to determine the transmitted dose and radiation zone, and the source activity and source strength in DCD Tier 2, Tables 12.2-1, “Radiation Sources Parameters (Sheet 4 of 6),” and 12.2-50, “Miscellaneous Sources - Refueling Water Storage Auxiliary Tank” were revised. The source activity and strength, and radiation zone for the RWSAT are evaluated in Section 12.2 of this SE. Based on the above, the staff finds the applicant’s description on the tank house design, as it relates to including an epoxy coating inspection and maintenance program, acceptable. **RAI 523-4246, Question 11.02-28** is being tracked as **Confirmatory Item 11.02-7**.

In response to **RAI 403-3027, Question 11.02-20, Item 5**, by letter dated July 16, 2009, the applicant revised DCD Tier 2, Section 11.2.3 to discuss the malfunction analysis in DCD Tier 2, Table 11.2-18 and the failure of sumps, sump pumps, and drainage equipment as bounded by the liquid tank failure analysis. The staff finds that the malfunction analysis is bounded by the liquid tank failure analysis. The staff also confirmed that Revision 2 to the DCD included this information. **RAI 403-3027, Question 11.02-20, Item 5** is closed.

From the staff’s concurrent review of the CPNPP, Units 3 and 4 COL FSAR (US-APWR Reference COL) and issuance of RAI 4315 (CP 145), by letter dated February 26, 2010, requesting that the COL applicant justify the applicability of the liquid tank failure evaluation in the DCD as the bounding analysis for the site-specific evaluation to satisfy COL Information Item 11.2(3), the applicant changed the approach and method on the liquid tank failure analysis in the DCD. In response to RAI 4315 (CP 145), by letter dated June 16, 2010, the applicant revised DCD Tier 2, Section 11.2.3.2 and deleted the liquid tank failure analysis which used site-specific information; revised COL Information Item 11.2(3); and performed new calculations of failed liquid tank concentrations using an alternative approach described below.

The staff reviewed the applicant's response to RAI 4315 (CP 145), by letter dated June 16, 2010, and found it unacceptable because the approach uses the methodology in ANSI/ANS-18.1-1999 to develop realistic source terms in lieu of design basis source terms to evaluate a postulated liquid tank failure which is considered as an accident-like event. The staff also determined that the approach to use realistic source terms in the liquid tank failure analysis is not conservative or consistent with the NRC guidance as these concentrations are less than design basis source term concentrations. The staff discussed its evaluation with the applicant during a Category 1 public meeting at the NRC, located in Rockville, Maryland and held on June 28, 2010 (ML101650152). The staff's evaluation of RAI 4315 (CP 145) is presented in the CPNPP, Units 3 and 4 COL FSAR Chapter 11 SER. The staff's path forward to resolve this issue in the DCD was to conduct an audit described in Sections 11.2 and 11.3 of this SE and below.

At the MHI PWR-GALE code audit located in Arlington, Virginia, held between July 28 - 29, 2010 (ML102810271), the applicant presented a new approach on the liquid tank failure analysis. Following the audit, by letter dated September 8, 2010, the applicant submitted a revision to DCD Tier 2, Section 11.2.3.2.

By letter dated September 8, 2010, the applicant revised Note 1 to DCD Tier 2, Table 11.2-16, "Parameters for Calculation of Source Term for Liquid Containing Tank Failures," to remove prior assumptions related to dilution water of 4.4E+10 gal in the definition of the hydrological factor applied to tanks. The staff finds the revision to Note 1 acceptable because the applicant will use the RATAF code, based on 1 percent failed fuel defect, to calculate source terms for the HT, WHT, and BAT without dilution water and hydrogeological factors which are site-specific information addressed by the COL applicant under revised COL Information Item 11.2(3) evaluated later in this section. The applicant added Note 4 to describe input values of 1E-20 for the dilution factor and zero for the travel time parameters, and Note 5 to address RATAF input values similar to those used in the applicant's PWR-GALE code calculations in DCD Tier 2, Table 11.2-9. The staff finds the applicant's commitment to add the information presented in Notes 4 and 5 in the revision to DCD Tier 2, Table 11.2-16 acceptable.

By letter dated September 8, 2010, the applicant provided a markup to DCD Tier 2, Table 11.2-17, "Source Term for Liquid Containing Tank Failures," to replace the HT, WHT, and BAT and critical receptor concentrations, previously limited to three radionuclides, and credits of 4.4E+10 gal dilution water and 1-year travel (decay) time in the RATAF code calculation. The resulting expanded radionuclide distributions and concentrations of corrosion, activation, and fission products for failed tank concentrations are determined by a significantly reduced dilution factor (1E-20) and no travel (decay) time in the new approach. The applicant added Note 1 to identify additional radionuclides (i.e., Mn-56, Zn-65, W-187, Y-92, Ag-110m) from the RATAF code calculation, and Note 2 to describe adjustment of the RATAF code output to 0.12 percent fuel defect level, except corrosion and activation products, for conformance to BTP 11-6. The staff finds the applicant's commitment to add the information presented in Notes 1 and 2 in the revision to DCD Tier 2, Table 11.2-17 acceptable. The staff also finds the applicant's commitment to include the expanded radionuclide distributions for failed tank concentrations calculated with the RATAF code in the revision to DCD Tier 2, Table 11.2-17 acceptable.

By letter dated September 8, 2010, the applicant provided a markup to COL Information Item 11.2(3) directing the COL applicant to provide the site-specific hydrogeological data and perform the analysis to demonstrate that the potential groundwater or surface water contamination concentration resulting from a radioactive release due to failed liquid tank meets the requirements of 10 CFR Part 20, Appendix B, Table 2, Column 2. Because the hydrogeological data requires site-specific information which is outside the scope of the requested design certification, the staff finds the applicant's commitment to include the revision to COL Information Item 11.2(3) acceptable.

From the PWR-GALE code audit discussed in Sections 11.2 and 11.3 of this SE, the applicant submitted Technical Report MUAP-10019 (Revision 0), “Calculation Methodology for Radiological Consequences in Normal Operation and Tank Failure Analysis,” under 10 CFR 2.390(a)(4), by letter dated October 5, 2010. Technical Report MUAP-10019P/NP (R0) describes the applicant's methodology, gaseous and liquid effluent and dose calculation results, basis for input design values used in the analysis of radiological consequences during normal operation including AOOs, and gas and liquid tank failure events to demonstrate compliance with the NRC regulations. Technical Report MUAP-10019P/NP (R0) also summarizes the QA documentation and validation procedures for the applicant's proprietary version of the NRC PWR-GALE code to calculate expected annual liquid and gaseous effluent releases during normal operation including AOOs for a plant referencing the US-APWR design. The information relevant to the new liquid tank failure analysis in Technical Report MUAP-10019P/NP (R0) is described in Section 4, “Radioactive Effluent Releases due to Liquid Containing Failures - Tank Activities,” Appendix A, “Basis for PWR-GALE code inputs,” and Tables 16, “Input parameters for the RATAF code,” and 17, “Source term for Liquid Containing Tank Failures.”

The staff reviewed Technical Report MUAP-10019P (R0) and finds the applicant's description on the new approach for the liquid tank failure analysis in the revision to DCD Tier 2, Section 11.2.3.2 acceptable because it conforms to the guidance in SRP Section 11.2, RG 1.206, and BTP 11-6. The staff also finds the methodology, basis, and assumptions for calculating failed liquid tank concentrations with the RATAF code in Technical Report MUAP-10019P/NP (R0) acceptable as the RATAF code is referenced in NUREG-0133. However, the RATAF code input/output files for demonstration of conformance on the new approach for the liquid tank failure analysis, by letter dated September 10, 2010, were not provided to update the RATAF code input/output files submitted in response to **RAI 403-3027, Question 11.02-20, Item 4**, by letter dated letter July 16, 2009. Therefore, in **RAI 5533, Question 11.02-34**, the staff requested that the applicant provide this information on the new approach for the liquid tank failure analysis. **RAI 5533, Question 11.02-34**, regarding the RATAF code input/output files on the new approach for the liquid tank failure analysis, is being tracked as **Open Item 11.02-2**. Additionally, the applicant’s commitment to revise DCD Tier 2, Section 11.2.3.2, and Tables 11.2-16 and 11.2-17 with the updated information on the new approach to address the liquid tank failure analysis, by letter dated September 10, 2010, and Technical Report MUAP-10019P/NP (R0), by letter dated October 5, 2010, is being tracked as **Confirmatory Item 11.02-11**.

11.2.4.9 Minimization of Contamination

DCD Tier 2, Section 11.2.1.2, “Design Criteria,” identifies design features to minimize the release of radioactive liquid to the groundwater and environment to meet compliance with 10 CFR 20.1406, and to facilitate eventual decommissioning and minimize the generation of radioactive waste.

The design features described in DCD Tier 2, Chapter 11 include overflow connections at least as large as the inlet on waste collection and monitor tanks; overflow locations above high-level alarm setpoints; coating of curbed cells/cubicles housing liquid tanks where significant quantities of radioactivity with non-porous impermeable epoxy material up to a wall height equivalent to one full tank volume of liquid for that tank in the event of an overflow or break; leak detection; level detecting instrumentation measuring current tank inventories, high- and low-level alarms with annunciation in the radwaste control room in the A/B and MCR; butt welding of component connections, high-level alarms to shut off the feed pumps or alert operators to re-direct flow to other storage tanks; tank overflows at least as large as the largest inlet into the sumps; direction of overflow from tanks or standpipes to near-by sumps with liquid level detection where at high liquid levels the level switch automatically activates the sump pump and forwards liquids to the WHT for processing; and the liquid radwaste radiation monitor and dual isolation valves installed on the sole discharge line to the environment. The LWMS is designed to reduce volumes of liquid wastes and, to the extent practicable, to minimize contamination to the facility and to the environment to facilitate eventual decommissioning. The COL applicant is required to ensure that mobile and temporary liquid waste processing equipment and its interconnections to plant systems meet the requirements of 10 CFR 20.1406.

Additional design and operational features of SSCs intended to minimize contamination to the facility and environment and meet compliance with 10 CFR 20.1406 using the guidance of RG 4.21 are evaluated in Section 12.3 of this SE. The applicant added DCD Tier 2, Section 12.3.1.1.1.2, “Balance of Plant Equipment,” to discuss design features related to radiation protection. This section includes discussion of pumps, tanks, heat exchangers, valves, piping, and other equipment, with respect given to maintaining personnel exposure ALARA also evaluated in Section 12.3 of this SE.

11.2.4.10 DCD Tier 1 Information

DCD Tier 1, Section 2.7.4.1, “Liquid Waste Management Systems (LWMS),” describes the LWMS as a non safety-related system (except for the containment isolation valves associated with the discharge line from the tank for the reactor coolant drainage system that perform a safety function) designed to safely monitor, control, collect, process, handle, store, and dispose of liquid radioactive waste generated as a result of normal operation including AOOs; comply with the ALARA principle; and provide containment isolation of the LWMS lines penetrating containment. DCD Tier 1, Table 2.7.4.1-1, “Liquid Waste Management System Inspections, Tests, Analyses, and Acceptance Criteria,” describes ITAAC for the LWMS. The ITAAC for the LWMS equipment, components, and piping associated with the containment isolation system that performs a safety function to prevent or limit the release of fission products to the environment in the event of an accident is evaluated in Section 6.2 of this SE.

The ITAAC for the radioactive waste systems in DCD Tier 2, Section 14.3.4.7, “ITAAC for Plant Systems,” in DCD Tier 2, Table 14.3-6, “Plant Systems,” includes verifying the performance of the LWMS as permanently installed systems or in combination with mobile processing equipment in DCD Tier 1 information. The ability to maintain concentrations below 10 CFR Part 20 limits and doses to members of the public depends on initially confirming LWMS design aspects including the number and sizing of storage tanks, processing equipment, effluent radiological monitoring and sampling systems, automatic control features in terminating releases that exceed alarm set points, and process dilution before release into the environment. Accordingly, in **RAI 523-4246, Question 11.02-32**, the staff requested that the applicant include in DCD Tier 1, Section 2.7.4.1.1, “Design Description, System Purpose and Functions” the relevant information derived from the LWMS design description in DCD Tier 2 such as the ability of the LWMS to process liquid waste prior to release and ensure compliance with the ECLs in 10 CFR Part 20, Appendix B, Table 2, Column 2, the dose limits in 10 CFR Part 20, and the dose objectives in 10 CFR Part 50, Appendix I for liquid effluents when the plant is operational; the process design of the LWMS subsystems and how the initial loading of the subsystem demineralizers and vessels includes the appropriate of types of filtration and adsorption media that will meet or exceed the decontamination factors listed in DCD Tier 2, Table 11.2-7; and in DCD Tier 1, Table 2.7.4.1-1, the assigned ITAAC to confirm the liquid radwaste discharge radiation monitor and dual isolation valves installed on the sole discharge line to monitor and control effluents to the environment, source test of the radiation monitor, alarms, indications, and automatic initiation functions as described in DCD Tier 1, Section 2.7.4.1.1 and DCD Tier 2, Sections 11.2.2.1 and 11.5.2.5.1. By letter dated March 15, 2010, the applicant responded to the above RAI.

In response to **RAI 523-4246, Question 11.02-32** , the applicant added a description of the LWMS under "System Purpose and Functions" to DCD Tier 1, Section 2.7.4.1.1, "Design Description," to process liquid waste prior to release and ensure compliance with the ECLs in 10 CFR Part 20, Appendix B, Table 2, Column 2, dose limits in 10 CFR Part 20, and the dose objectives in 10 CFR Part 50, Appendix I for liquid effluents when the plant is operational. Under "Key Design Features" to DCD Tier 1, Section 2.7.4.1.1, the applicant added a description of the LWMS on removal of ionic species and impurities by processing equipment such as ion exchange columns and filters to meet the requirements in 10 CFR Part 20, Appendix B and 10 CFR Part 50, Appendix I to ensure that the effluent releases do not exceed NRC regulatory limits. Under "Alarms, Displays, and Controls" to DCD Tier 1, Section 2.7.4.1.1, the applicant added information on initiation of the radiation monitor alarm upon detection of radioactivity levels in the waste stream exceeding the predetermined setpoint and automatic closure of the isolation discharge valves and operator actions. Further, the applicant added Item 6 to DCD Tier 1, Table 2.7.4.1.1 to address ITAAC for the LWMS described in Tier 2 information necessary to meet the relevant regulatory requirements.

The applicant revised DCD Tier 2, Section 11.2.1.4 to state demineralizers are procured with the capability to remove ionic species and impurities for meeting compliance with 10 CFR Part 20, Appendix B and 10 CFR Part 50, Appendix I. An inspection of the amount of filtration and demineralizer media will be conducted to verify the loading meets vendor recommendations for the demineralizer capabilities, and replacement filters, charcoal, and resins are purchased to meet performance standards and support the DF in DCD Tier 2, Table 11.2-7 developed from the methodology in NUREG-0017. The staff reviewed the applicant's response and found it to be acceptable because the applicant commits to include this information in the next revision of the DCD. **RAI 523-4246, Question 11.02-32** is being tracked as **Confirmatory Item 11.02-10**.

11.2.4.11 Technical Specifications

A review of DCD Tier 2, Chapter 16, "Technical Specifications," indicates that there are no TS directly associated with liquid waste storage and processing. However, DCD Tier 2, Chapter 16, TS 5.5.1, "Offsite Dose Calculation Manual, ODCM," and TS 5.5.4, "Radioactive Effluent Controls Program," provide methods and requirements in controlling releases of radioactive effluents and maintaining public doses ALARA. DCD Tier 2, Chapter 16, TS 5.5.12, "Explosive Gas and Storage Tank Radioactivity Monitoring Program," provides controls to ensure that the quantity of radioactivity contained in all unprotected outdoor liquid radwaste tanks results in concentrations less than the limits of 10 CFR Part 20, Appendix B, Table 2, Column 2 at the nearest potable water supply and the nearest surface water supply in an unrestricted area, in the event of an uncontrolled release of the tank's contents in accordance with BTP 11-6, "Postulated Radioactive Release due to Tank Failures." DCD Tier 2, Chapter 16, TS 5.6.1, “Annual Radiological Environmental Operating Report,” and TS 5.6.2, “Radiological Effluent Release Report,” specify annual reporting requirements in describing the results of the radiological monitoring program and provide summaries of the quantities of radioactive liquid effluents released in the environment.

As stated in TS 5.5.1, Licensee initiated changes to the ODCM shall be documented and contain the appropriate analyses or evaluations justifying any changes to maintain levels of radioactivity in effluent in compliance with the requirements of 10 CFR 20.1302; 40 CFR Part 190; 10 CFR 50.36a; and 10 CFR Part 50, Appendix I. TS also require the radioactive effluent controls program, contained in the ODCM, to include instrumentation to monitor and control liquid effluent discharges; meet limits on effluent concentrations released to unrestricted areas; monitor, sample, and analyze liquid effluents before and during releases; set limitations on annual and quarterly dose commitments to a member of the public; and assess cumulative doses from radioactive liquid effluents. The use of an ODCM is mandated under the operational programs described in DCD Tier 2, Section 13.4 “Operational Program Implementation.”

The staff found these requirements acceptable because the implementation of such programs will be addressed in a plant and site-specific ODCM under COL Information Item 11.5(2) in DCD Tier 2, Section 11.5.5 as described in DCD Tier 2, Table 1.8-2. The staff’s evaluation of COL Information Item 11.5(2) is presented in Section 11.5 of this SE.

11.2.4.12 Preoperational Testing

DCD Tier 2, Section 14.2.12, “Individual Test Descriptions,” describes individual test abstracts of preoperational and startup tests to verify that the plant systems and components meet design and performance objectives.

The principle test for the LWMS in Section 14.2.12.1.80, “Liquid Waste Management System Preoperational Test,” is to verify control circuitry and operation of system pumps and valves, and system operation and performance characteristics. There are several tests associated with the LWMS. These are described in DCD Tier 2, Section 14.2.12.1.78, “Process and Effluent Radiological Monitoring System, Area Radiation Monitoring System and Airborne Radioactivity Monitoring System,” to demonstrate operation of the process and effluent radiological monitoring including the liquid radwaste discharge radiation monitor; Section 14.2.12.1.83, “Steam Generator Blowdown System Preoperational Test,” to ensure the condenser, waste water system, or the LWMS receives discharge from the SG blowdown system; Section 14.2.12.1.84, “Sampling System Preoperational Test,” to demonstrate capability of the laboratory equipment used for the analysis of effluent samples to determine compliance with the ECLs of 10 CFR Part 20, Appendix B, Table 2, Column 2; and Section 14.2.12.1.116, “Equipment and Floor Drainage System Test,” which may be performed in conjunction with DCD Tier 2, Section 14.2.12.1.80.

In **RAI 523-4246, Question 11.02-31**, the staff requested the applicant to provide the test methods in DCD Tier 2, Section 14.2.12.1.80 to verify manual and automatic system controls on key system alarms such as high-level alarms associated with the tanks simultaneously activated in the MCR, and other alarms such as radiation monitor and dual isolation valves to monitor and control effluent discharge to the environment and indications described in FSAR Tier 2, Revision 2, Section 11.2.2.1. By letter dated March 15, 2010, the applicant responded to the above RAI.

In response **RAI 523-4246, Question 11.02-31**, the applicant commits to add C.3. "Test Methods" in DCD Tier 2, Section 14.2.12.1.80 to include the verification of the response to normal control, alarms and indications during preoperational testing of the LWMS as described in DCD Tier 2, Section 11.2. The preoperational testing includes process parameters such as liquid levels within tanks, processing flow rates, differential pressures across filters, ion exchange columns, and indication and/or alarms and system controls (e.g., interlocks) in order to provide operational information and assess LWMS performance described in DCD Tier 2, Section 11.2.2.1. Preoperational testing on alarms and controls associated with the radiation monitor and dual isolation valves to monitor and control effluent discharge to the environment is addressed in the DCD Tier 1 Information section of this SE. The staff reviewed the applicant's response and found it to be acceptable because the applicant commits to include test methods to verify normal control, alarms, and indications during preoperational testing in the next revision of the DCD. **RAI 523-4246, Question 11.02-31** is being tracked as **Confirmatory Item 11.02-9**.

From review of DCD Tier 2, Sections 11.2 and 11.4, the staff requested the applicant in **RAI 523-4246, Question 11.02-29** to include a new section in DCD Tier 2, Section 11.2 to address LWMS testing and inspection requirements such as preoperational tests, initial testing, and epoxy coating requirements such as QA, selection, qualification, testing, maintenance and inspection, conformance to guidance documents, etc. similar to information described in DCD Tier 2, Section 11.4.6 (with pointer to DCD Tier 2, Section 11.4.1.3). By letter dated March 15, 2010, the applicant responded to the above RAI.

In response to **RAI 523-4246, Question 11.02-29**, the applicant commits to add DCD Tier 2, Section 11.2.4, "Testing and Inspection Requirements," to describe the preoperational testing to demonstrate acceptable performance of the LWMS processing and storage subsystems during normal operation including AOOs as described in DCD Tier 2, Section 14.2, "Initial Plan Test Program." During initial testing of the system, performance of the process and utility such as nitrogen supply and mobile systems are tested to demonstrate conformance with design flows and process capabilities and an integrity test is performed on the system upon completion of construction. The capability and integrity of the systems is verified by periodic inspections and display devices are provided on vital parameters required in routine testing and inspection. Cubicles containing significant quantities of radioactive material are lined with an impermeable epoxy coating and subject to the limited QA provisions, selection, qualification, application, testing, and maintenance and inspection provisions in RG 1.54 for Service Level II coatings. Post-construction initial inspection is performed by personnel qualified in accordance with ASTM D 4537 using the inspection plan guidance in ASTM D 5163.

The applicant also commits to revise DCD Tier 2, Sections 11.2.5 and 11.4.5 to reference RG 1.54 for Service Level II protective epoxy coatings applied to line cells/cubicles in the LWMS and SRST rooms in the SWMS. The applicant also commits to add COL Information Item 11.02(7) to identify implementation milestones for the epoxy coatings program. The staff reviewed the applicant's response and found it to be acceptable because the epoxy coatings program addresses the guidance in RG 1.54, recognizing that more recent standards may be used if referenced in DCD Tier 2, Section 11.2. The staff also finds COL Information Item 11.02(7) acceptable because it is an operational program which identifies implementation milestones for the epoxy coatings program, and the applicant commits to include this information in the next revision of the DCD **RAI 523-4246, Question 11.02-29** is being tracked as **Confirmatory Item 11.02-8**.

11.2.5 Combined License Information Items

Table 11.2-1 provides a list of LWMS related COL information item numbers and descriptions from DCD Tier 2, Table 1.8-2:

Table 11.2-1 US-APWR Combined License Information Items

Item No.	Description	DCD Tier 2 Section
11.2(1)	The COL applicant is responsible for ensuring that mobile and temporary liquid radwaste processing equipment and its interconnection to plant systems conforms to regulatory requirements and guidance such as 10 CFR 50.34a (Reference 11.2-5), 10 CFR 20.1406 (Reference 11.2-7) and RG 1.143 (Reference 11.2-3), respectively.	11.2.4
11.2(2)	Site-specific information of the LWMS, e.g., radioactive release points, effluent temperature, shape of flow orifices, etc., is provided in the reference combined license application (RCOLA).	11.2.3.1
11.2(3)	The COL applicant is responsible for the site-specific hydrogeological data and for performing an analysis to demonstrate that the potential groundwater or surface water contamination resulting from a radioactive release due to liquid containing tank failure meets the 10 CFR 20, Appendix B, Table 2 ECLs.	11.2.3.2
11.2(4)	The COL applicant is to calculate doses to members of the public following the guidance of RG 1.109 (Reference 11.2-15) and RG 1.113 using site-specific parameters, and compares the doses due to the liquid effluents with the numerical design objectives of Appendix I to 10 CFR Part 50 (Reference 11.2-10) and compliance with requirements of 10 CFR 20.1302 and 40 CFR Part 190.	11.2.3.1
11.2(5)	The COL applicant is to perform a site-specific cost benefit analysis to demonstrate compliance with the regulatory requirements.	11.2.1.5
11.2(6)	The COL applicant is to provide P&IDs.	11.2.2
11.2(7)	The COL Applicant is responsible for identifying the implementation milestones for the coatings program used in the LWMS. The coatings program addresses RG 1.54 Revision 1, recognizing that more recent standards may be used if referenced in DCD Section 11.2.	11.2.4

As previously evaluated, the staff concludes the above list of COL information items to be complete and adequately describes the actions necessary for the COL applicant.

11.2.6 Conclusions

Except for the open and confirmatory items identified below, the staff concludes that the LWMS, as a permanently installed system, includes the equipment necessary to collect, process, handle, store, and dispose of liquid radioactive wastes generated as a result of normal operation including AOOs. The applicant provided sufficient design information to demonstrate that it has met the requirements of 10 CFR Part 50.34a; 10 CFR Part 50, Appendix A, GDC 60 and 61; and NRC guidance and SRP acceptance criteria. This conclusion is based on the following:

- The US-APWR design demonstrates compliance with 10 CFR 50.34a, as it relates to the inclusion of sufficient design information and system design features that are necessary for collecting, storing, processing, and controlling and monitoring the safe discharges of liquid wastes. The design conforms to the guidelines of SRP Section 11.2.

- The US-APWR design meets the requirements of 10 CFR Part 50, Appendix A, GDC 60 with respect to controlling releases of liquid effluents by monitoring LWMS discharges through a single discharge line. All LWMS releases are monitored by a radiation monitor, which will generate a signal to terminate liquid waste releases before discharge concentrations exceed a predetermined radiation monitor set point. The COL applicant is required to determine the operational setpoint for LWMS radiation monitors in a plant and site-specific ODCM under COL Information Item 11.5(2), as described in DCD Tier 2, Table 1.8-2. As part of this commitment, the COL applicant is required to demonstrate compliance with 10 CFR Part 20, Appendix B, Table 2, Column 2. The COL applicant is responsible for assuring that the design objectives in 10 CFR Part 50, Appendix I, are satisfied under COL Information Item 11.5(1), as described in DCD Tier 2, Table 1.8-2. As part of this commitment, the COL applicant will be responsible for demonstrating through the ODCM, compliance with the dose limits for members in 10 CFR 20.1301 before releasing radioactive materials in unrestricted areas, and compliance with 10 CFR 20.1301(e), which incorporates by reference 40 CFR Part 190 for facilities within the nuclear fuel cycle including nuclear power plants.

- The US-APWR demonstrates compliance with the requirements of 10 CFR Part 50, Appendix A, GDC 61 by meeting the guidelines of RG 1.143 by using providing sufficient storage space and treatment capacity to assure adequate safety under normal operation, AOOs, and postulated accident conditions. This commitment fulfills the requirements of 10 CFR 20.1406 and guidance of RG 4.21 and RG 1.143 in minimizing the contamination of the facility and generation of radioactive waste and concerns of IE Bulletin 80-10 in avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled radioactive releases to the environment.

- A COL applicant referencing the US-APWR DC will demonstrate compliance with 10 CFR Part 50, Appendix I, Section II.D design objectives for offsite individual doses and population doses resulting from liquid effluents by preparing a site-specific cost-benefit analysis using NRC guidance under COL Information Item 11.2(5), as described in DCD Tier 2, Table 1.8-2.

- The US-APWR design provides sufficient information and design features satisfying the guidance of RG 1.143 for radioactive waste processing systems in establishing the seismic and quality group classifications for system components and structures housing LWMS components.

For the following open items, tracked under **RAI 629-4972, Question 11.02-33, Item 2,** and **RAI 5533, Question 11.02-34**, the staff concludes, using the information presented in the application, that the applicant has not fully demonstrated compliance with NRC regulations and guidance controlling radioactive releases to the environment and associated doses to members of the public. The regulations are contained in 10 CFR 20.1301; 10 CFR 20.1302; 40 CFR Part 190 as referenced in 10 CFR 20.1301(e); and 10 CFR Part 20, Appendix B, Table 2, Column 2. The guidance is contained in SRP Section 11.2 and BTP 11-6. For the following confirmatory items, tracked under **RAI 164-1925, Question 11.02-6, Items 2(a) and 2(b); RAI 462-3752, Question 11.02-22; RAI 462-3752, Question 11.02-24, RAI 462-3752, Question 11.02-25; RAI 462-3752, Question 11.02-27; RAI 462-3752, Question 11.02-28; RAI 523-4246, Question 11.02-29; RAI 523-4246, Question 11.02-31; and RAI 523-4246, Question 11.02-32; and DCD Section 11.2.3.2 revision,** the staff will confirm that these items are incorporated into the next revision of the DCD.

11.3 Gaseous Waste Management Systems

11.3.1 Introduction

During plant operation, fission product gases, radioactive particulates and vapors, and radiolytic decomposition gases (e.g., hydrogen and oxygen) are generated and conveyed by system processes to various plant systems. In pressurized water reactors, gaseous wastes and process vents are characterized by the presence of noble gases, radioiodines, particulates, carbon-14, and tritium, among others. Process gases originate from primary coolant degasification systems, venting of tanks and vessels, the SG blowdown flash tank, and the main condenser evacuation system, among others. Other sources of gaseous radioactivity include containment purges and radioactivity captured by various building ventilation systems, including those of the fuel, auxiliary, radwaste, turbine, and containment buildings. The GWMS is designed to collect, process, store, monitor, and control releases of radioactive gases generated during plant operation and maintenance. For process streams containing radioactivity, treatment methods include the use of HEPA and charcoal filters, gas decay tanks filled with activated charcoals, and detectors monitoring radiation and radioactivity levels. Fission product gases (e.g., Kr and Xe) are dynamically absorbed by activated charcoal media in decay tanks, allowing for radioactive decay before being discharged to the environment via a plant vent stack. For process streams that contain hydrogen and oxygen, in addition to radioactive materials, the treatment methods include the use of hydrogen and oxygen recombiners, instrumentation to control hydrogen and oxygen levels, gas driers and coolers, and waste gas compressors. The purpose of this system is to control and avoid the generation of potentially explosive gas mixtures. Airborne radioactive materials present in buildings are handled via each building's ventilation exhaust system using HEPA and charcoal filters. The sources of radioactivity for such systems include process leakage, steam discharges, and work being conducted in radiological controlled work areas where open systems are being maintained.

11.3.2 Summary of Application

DCD Tier 1: The applicant provided a system description in DCD Tier 1, Section 2.7.4.2 "Gaseous Waste Management System," summarized here, in part, as follows:

The GWMS is located in the A/B and is a non safety-related system with non-seismic components. The portions of the A/B that house the principal GWMS equipment are designed to seismic Category II.

The GWMS is designed to monitor, control, collect, process, handle, store, and dispose of gaseous radioactive waste generated as the result of normal operation including AOOs. Gas surge tanks provide temporary storage of radioactive gas for the decay of the short-lived isotopes that contribute the majority of radioactivity. Charcoal beds provide for the delay and decay of radioactive gases before release into the environment. Gaseous waste streams are monitored for both hydrogen and oxygen content to prevent flammable mixture. The nitrogen waste gas is compressed by waste gas compressor packages. Treated waste gas is verified with radiation monitors before release to the environment. Upon detection of radiation levels above a setpoint, the radiation monitors alarm and send a signal to close the GWMS discharge valve.

Gaseous waste from the HT, VCT, and RCDT is continuously drawn by a gas compressor and directs the gaseous waste into the gas surge tanks for radioactive decay of short-lived isotopes. The gaseous waste is then processed through the dryer, the charcoal bed absorbers, and sent to the plant stack for release to the environment.

Detailed descriptions on the GWMS design and operation features are provided in DCD Tier 2, Section 11.3, “Gaseous Waste Management System.”

DCD Tier 2: The applicant has provided a system description in DCD Tier 2, Section 11.3, summarized here, in part, as follows:

DCD Tier 2, Section 11.3 describes the design of the GWMS and its functions in monitoring, controlling, collecting, processing, handling, storing, and disposing of gaseous radioactive waste generated as the result of normal operation and AOOs. The GWMS collects gas mixtures containing hydrogen and oxygen, noble gas fission products, and radioiodines and radioactive particulates, among others. The GWMS is a non safety-related system and serves no safety functions. The discharge isolation valve closes on low ventilation system exhaust flow rate and when the radiation monitor setpoint is exceeded. A failure of the GWMS does not compromise safety-related systems or components and does not prevent safe-shutdown of the plant. The A/B which houses the GWMS is designed to seismic Category II requirements evaluated in Section 3.2 of this SE. DCD Table 11.3-3, “Equipment Malfunction Analysis (Sheets 1 and 2),” describes the failure scenarios considered for the GWMS.

DCD Tier 2, Section 3.2 describes the seismic and quality group classification and corresponding codes and standards that apply to the design of the GWMS components and piping and structures housing the system. The GWMS is housed in a reinforced concrete structure to provide adequate shielding and minimize radiation exposures to personnel during operation and maintenance. The staff’s evaluation of these personnel radiation exposures is presented in Section 12.4 of this SE.

DCD Tier 2, Figure 11.3-1, “Gaseous Waste Management System Process Flow Diagram (Sheets 1 to 3),” presents the process design of the GWMS (Sheets 1 and 2) and design operating parameters such as flow rates, temperatures, pressures for the major gaseous waste streams (Sheet 3). DCD Tier 2, Table 11.3-2, “Gaseous Waste Processing System Component Data,” provides a listing of system components and information characterizing volumetric capacities and processing flow rates of major components. DCD Tier 2, Figures 12.3-1, “Radiation Zones for Normal Operation/Shutdown Auxiliary Building Sectional View A-A (Sheet 14 of 34),” and 12.3-1, “Radiation Zones for Normal Operation/Shutdown Auxiliary Building at Elevation -26’-4” (Sheet 15 of 34),” present the general arrangement of the A/B where the major components of the GWMS are located.

DCD Tier 2, Section 9.4, “Air Conditioning, Heating, Cooling, and Ventilation Systems,” presents design information on ventilation systems servicing buildings where radioactive systems are located as well as systems used to collect gases vented from tanks and vessels. The staff’s evaluation of these ventilation systems are presented in Section 9.4 of this SE. DCD Tier 2, Section 11.3.2 describes design information on the vent stack and release point described about the same height as the top of the containment. The site-specific plant vent stack design will be provided by the COL applicant. DCD Tier 2, Figure 12.3-10, “The sampling point of the airborne radioactivity monitors,” depicts airborne radioactivity monitors sampling locations installed in the in the fuel handling area, annulus and safeguard area, R/B, A/B, and sample and lab area. The detailed flow diagram of the HVAC system depicting the installed airborne radioactivity monitors and release to the environment via the plant vent stack is shown in DCD Tier 2, Figure 9.4.3-1, "Auxiliary Building HVAC System Flow Diagram."

DCD Tier 1, Section 2.7.5, "Heating, Ventilation, and Air Conditioning (HVAC) Systems," describes the MCR HVAC system as designed to exclude entry of airborne radioactivity into the control room envelope (CRE) and remove radioactive material from the CRE environment. DCD Tier 1, Figure 2.7.5.1-1, "Main Control Room HVAC System," displays the MCR HVAC system, a safety-related system (except for the toilet/kitchen exhaust and smoke purge fans), located in the R/B designed to protect operators against a release of radioactive material, and to provide conditioning air to maintain the proper environmental condition of the MCR and other areas within the CRE. The MCR HVAC system is designed to exclude entry of airborne radioactivity into the CRE and remove radioactive material from the CRE environment.

The GWMS consists of processing equipment, associated monitoring instrumentation, and control components. Waste gas is treated by the GWMS in two ways. The first method reduces the volume of the waste gases by recombining of hydrogen and oxygen into water. The recombination reduces the explosion potential within the GWMS. Moisture in the waste gas is removed in the waste gas dryer skid which protects the charcoal adsorber beds and is returned to the LWMS for processing. Because a buildup of explosive mixtures of hydrogen and oxygen is possible, the GWMS must be designed either to withstand the effects of a hydrogen explosion, or to have design features that preclude the buildup of explosive gas mixtures in accordance with the guidance in SRP Section 11.3. The US-APWR is designed to preclude the generation and accumulation of explosive gas mixtures.

The second method for treating waste gases is to provide the means to store and hold the waste gases for radioactive decay. The holdup allows time for the decay of short-lived radioactivity in the waste gases and provides the means to confirm that radioactivity levels released to the environment meet regulatory requirements.

The major components of the GWMS include:

- Two waste gas compressors
- One waste gas dryer skid
- Four charcoal bed adsorbers
- Four waste gas surge tanks
- Two hydrogen/oxygen analyzer units
- Two waste gas coolers
- Nitrogen purge line
- Two normal range, one mid-range, and one high-range radiation monitors
- Sampling points
- Piping and valves

The two waste gas compressors are sized to handle 100 percent of the rated load during normal operation including AOOs and continuously draw gases from various systems in the plant and compress the gases into the waste gas surge tanks. The waste gas compressors are water sealed centrifugal units that contain gas coolers and moisture separators equipped with a level control valve using PMW as seal water. One waste gas compressor is used for normal operation and is capable of handling the cover gas from the HT while the second serves as backup and for redundancy. The waste gas compressors continuously keep the GWMS piping system pressurized preventing airborne contaminants from entering into the system.

The waste gas dryer skid removes moisture from the waste gas and protects the charcoal bed adsorbers. One waste gas cooler is sized to handle 100 percent of the rated load during normal operation including AOOs while the second serves as backup for redundancy. This redundancy permits the operators to cycle between the molecular sieve tanks when one becomes saturated with moisture. A gas sample tap located downstream of the waste gas dryer skid permits waste gas sampling. The design information on the waste gas skid described in DCD Tier 2, Table 11.3-2, "Table 11.3-2 GWMS Major Equipment Design Information (Sheets 1 of 2)," consists of four major components:

- Two waste gas coolers
- One moisture separator tank
- Three molecular sieve dryer tanks
- Three blower fans

The waste gas coolers lower the temperature of waste gases exiting the molecular sieve dryer tanks dryer allowing entrained moisture to condense before the waste gases enter the moisture separator tank. The cooling water for the waste gas cooler heat exchangers is provided by the component cooling water system (CCWS). The staff's evaluation of the CCWS is presented in Section 9.2.2 of this SE.

Condensed moisture in the waste gas is collected in the moisture separator tank and routed to the LWMS for processing. A level transmitter and level control valve controls the water seal level in the moisture separator. The PMW is used to maintain the water seal during initial startup and normal operation. An alarm is activated in the radwaste control room when the water level in level transmitter is too high.

Remaining moisture in the waste gas stream is removed by the molecular sieve tank before it reaches the charcoal bed adsorbers. The waste gas dryer skid contains three molecular sieve tanks each filled with desiccant to capture moisture during processing of the waste gas. One molecular sieve tank is required to be in service at any one time, the second as backup for redundancy, while the third is in regeneration and cooling mode. An external electric heater is used during the regeneration mode to heat trapped moisture in the waste gas tank. Nitrogen is used to remove any moisture trapped in the desiccant. During the regeneration mode, the purged waste gas is routed back to the waste gas cooler to condense moisture in the waste gas. When maintenance is required, nitrogen is used to purge the waste gas from the waste gas tanks. Each molecular sieve tank is equipped with a single fan for cooling the exterior of the waste gas tank surface when the regeneration mode is complete.

The four charcoal bed adsorbers are arranged in two parallel trains and consist of two charcoal bed adsorbers in series. Two trains are arranged in series and are in service during normal operations. If one train is not available due to moisture saturation and/or maintenance, the train is taken out of service to replace the charcoal and/or perform maintenance. A train of charcoal bed adsorbers can be isolated and bypassed with sequenced valves using a one-step control if it becomes saturated with moisture. Gaseous effluent is monitored by a radiation monitor and the discharge side of the charcoal bed adsorbers. The waste gas flow is diverted to the waste gas surge tank for reprocessing through the charcoal if the radioactivity exceeds the discharge setpoint. Discharge of the waste gas can be suspended until the radiation level is below the discharge setpoint or until the train is returned to service. The life expectancy of the charcoal bed adsorbers are not affected from airborne contaminants due to continuous pressurization of the system by the waste gas compressors. The charcoal bed adsorbers are designed to last several years before requiring maintenance or replacement. DCD Tier 2, Table 11.3-1, "System Design Parameters," provides the dynamic adsorption values of krypton (Kr) and xenon (Xe) isotopes on the charcoal bed adsorbers and other GWMS design parameters. The charcoal design quantity specification of 70 ft^3 per column (total of 4 columns) is given in DCD Tier 2, Table 11.3-2, "GWMS Major Equipment Design Information (Sheets 2 of 2)."

Four vertical cylindrical carbon steel waste gas tanks are sized to retain waste gases discharged from the waste gas compressor during normal operation, AOOs, and plant shutdown conditions. Waste gas surge tank design specifications are provided in DCD Tier 2, Table 11.3-2. The interconnected and independent waste gas surge tanks are available and serve redundant functions to receive compressed gases from the waste gas compressors, discharge, temporary storage of cover gas, and backup in the event of a gas explosion. Pressure control valves installed in each waste gas surge tank provide automatic isolation when a predetermined high-pressure setpoint is reached with alarms in the radwaste control room and MCR.

Each of the two hydrogen/oxygen analyzer units comprises dual analyzers for hydrogen and one oxygen located downstream of the waste gas dryer to continuously monitor the concentration of oxygen upstream of the charcoal delay beds, and control the oxygen content of the waste stream to preclude the formation of a flammable mixture. One hydrogen/oxygen analyzer measures the respective concentrations during normal operation while the second serves as backup for redundancy to conform with the guidance in SRP Section 11.3 and Section 4.7, "Design for Explosive Conditions," of ANSI/ANS-55.4-1993 (R2007), "Gaseous Radioactive Waste Processing Systems for Light water Reactor Plants." Hydrogen/oxygen waste gas waste gas surge tank design specifications are provided in DCD Tier 2, Table 11.3-2.

Two normal range radiation monitors are provided for normal operation and AOOs (one is required for operation and the other serves as standby for redundancy), and one mid-range and one high-range radiation monitor for post accident conditions.

A nitrogen purge line is provided for the waste gas surge tanks, molecular sieve tanks, hydrogen and oxygen analyzers, waste gas compressors, and charcoal bed adsorbers to purge each vessel with nitrogen for regeneration after possible moisture contamination, to dilute potentially explosive gas mixture concentrations below the flammability limit, and to remove air/oxygen from a system after maintenance.

GWMS process equipment is controlled and monitored from the Radwaste Control Room. Instrument components are located in accessible areas to facilitate maintenance, calibration, and operation activities. The sensing elements for instruments are located behind shield walls. DCD Tier 2, Table 11.3-10, "Instrument Indication and Alarm Information Page," identifies the indications and alarms for the GWMS instrumentation.

Interconnections between plant systems preclude the contamination of non-radioactive systems and uncontrolled releases of radioactivity to the environment. The GWMS design includes at least two isolation valves located between the clean and contaminated systems to minimize the potential for contamination of clean systems to meet compliance with 10 CFR 20.1406. Gaseous and airborne radioactive materials are processed in the GWMS from the R/B, A/B, and Access Building (AC/B), and released via the plant vent stack.

In assessing the radiological impacts associated with radioactive gaseous effluent discharges, DCD Tier 2, Tables 11.2-9, “Input Parameters for the PWR-GALE Code (Sheets 1 and 2),” and 11.3-8, “Input Parameters for the GASPAR II Code,” present information supporting the development of the gaseous effluent source term, and compliance with the ECLs of 10 CFR Part 20, Appendix B, Table 2, Column 1; 10 CFR 20.1301(e) in meeting the EPA environmental radiation protection standards of 40 CFR Part 190; and the numerical guides and design objectives of 10 CFR Part 50, Appendix I. The applicant's results shows the expected annual releases of airborne radioactivity and gaseous effluent concentrations in unrestricted areas and gaseous effluent doses to members of the public will meet compliance with the NRC regulations. The applicant's results also demonstrate compliance with the ALARA requirements of 10 CFR Part 50, Appendix I and the acceptance criteria in SRP Section 11.3 for an evaluation of a postulated leak of radioactivity from a GWMS component.

ITAAC: The ITAAC associated with DCD Tier 2, Section 11.3, Gaseous Waste Management System,” are given in DCD Tier 1, Section 2.7.4.2, “Gaseous Waste Management System (GWMS),” and Table 2.7.4.2-1, “Gaseous Waste Management System Inspections, Tests, Analyses, and Acceptance Criteria.” DCD Tier 2, Section 14.3.4.7, “ITAAC for Plant Systems,” summarizes how ITAAC were developed for DCD Tier 1, Section 2.7.4.2.

TS: There is information pertinent to TS associated with the GWMS in DCD Tier 2, Sections 11.3.3.2, “Radioactive Effluent Releases and Dose Calculation due to Gaseous Waste Management System Leak or Failure,” and 11.3.3.3, “Offsite Dose Calculation Manual,” and DCD Tier 2, Chapter 16, TS 5.5.1, “Offsite Dose Calculation Manual (ODCM),” TS 3.4.16 and TS B 3.4.16, “RCS Specific Activity,” and TS 5.5.12, “Explosive Gas and Storage Tank Radioactivity Monitoring Program,” and Section 3.3.3, “Post Accident Monitoring (PAM) Instrumentation.”

10 CFR 20.1406: There is information pertinent to 10 CFR 20.1406 in DCD Tier 2, Sections 11.3.1.4, “Method of Treatment,” and 11.3.2.1.6, “Charcoal Adsorbers.”

COL information or action items: (See Section 11.3.5 below).

Technical Report(s): There is a technical report associated with this area of review described in “Calculation Methodology for Radiological Consequences in Normal Operation and Tank Failure Analysis,” Technical Report MUAP-10019P (R0), Technical Report MUAP-10019NP (R0), MHI, dated September 2010.

Topical Report(s): There are no topical reports associated with this area of review.

US-APWR Interface Issues Identified in the DCD: There are no US-APWR interface issues associated with this area of review.

Site Interface Requirements Identified in the DCD: There are no site interface requirements associated with this area of review.

Cross-cutting Requirements (Three Mile Island [TMI], Unresolved Safety Issue [USI]/Generic Safety Issue [GSI], Op Ex): There are no cross-cutting issues for this area of review.

RTNSS: There are no RTNSS issues for this area of review.

CDI: This section of the DCD does not contain CDI that is outside the scope of the US-APWR certification.

11.3.3 Regulatory Basis

The relevant requirements of NRC regulations for the gaseous waste management systems and the associated acceptance criteria are given in SRP Section 11.3 of NUREG-0800 summarized below. Review interfaces with other SRP sections can be found in NUREG-0800, Section 11.3.

1. 10 CFR 20.1301, "Dose limits for individual members of the public" as it relates to dose limits for individual members of the public.

2. 10 CFR 20.1302, "Compliance with dose limits for individual members of the public," as it relates to limits on doses to members of the public and gaseous effluent concentrations and doses in unrestricted areas.

3. 10 CFR 20.1406, "Minimization of contamination," as it relates to facility design and operational procedures for minimizing facility contamination and the generation of radioactive waste.

4. 10 CFR Part 20, Appendix B, Table 2, Column 1, as it relates to the airborne (gaseous) effluent concentration limits for release to the environment.

5. 10 CFR 50.34a, as it relates to the inclusion of sufficient design information to demonstrate compliance with the design objectives for equipment necessary to control releases of radioactive gaseous effluents to the environment.

6. 10 CFR 50.36a, as it relates to TS requiring that operating procedures be developed for radiological monitoring and sampling equipment as part of the administrative controls and surveillance on effluent controls in meeting the ALARA criterion and 10 CFR 20.1301 dose limits.

7. 10 CFR Part 50, Appendix I, Sections II.C, II.B, and II.D, as they relate to numerical guidelines and design objectives and limiting conditions for operation in meeting dose criteria and the criterion of "As Low As is Reasonably Achievable" in Appendix I.

8. 10 CFR Part 50, Appendix A, GDC 60, as it relates to the design of GWMS to control releases of gaseous radioactive effluents.

9. 10 CFR Part 50, Appendix A, GDC 64, as it relates to the design of GWMS to monitor for radioactivity that may be released from normal operations including AOOs and from postulated accidents.

11. 10 CFR Part 50, Appendix A, GDC 61, as it relates to the design of the GWMS to ensure adequate safety under normal operations and postulated accident conditions.

12. 40 CFR Part 190 (the EPA generally applicable environmental radiation standards), as implemented under 10 CFR 20.1301(e), as it relates to controlling doses within EPA generally applicable environmental radiation standards.

13. 10 CFR 52.47(b)(1), which requires that applications for DC to contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the DC is built, will operate in accordance with the DC and provisions of the Atomic Energy Act and the NRC regulations.

The following RGs contain the regulatory positions and guidance for meeting the relevant requirements of the regulations identified above:

1. RG 1.109, “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,” as it relates to demonstrating compliance with the numerical guidelines for dose design objectives and the ALARA criterion of 10 CFR Part 50, Appendix I.

2. RG 1.110, “Cost Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors,” as it relates to performing a cost-benefit analysis for reducing cumulative doses to populations by using available technology.

3. RG 1.111, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,” dated July 1977, it relates to the modeling and derivations of atmospheric dispersion and deposition parameters in demonstrating compliance with the numerical guidelines and ALARA criterion of 10 CFR Part 50, Appendix I.

4. RG 1.112, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors,” as it relates to the acceptable methods for calculating annual average releases of radioactivity in effluents.

5. RG 1.206, “Combined License Applications for Nuclear Power Plants,” as it relates to the minimum information requirements specified in 10 CFR 52.79, “Contents of applications; technical information in Final Safety Analysis Report,” to be submitted in a COL application.

6. RG 1.140, “Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants,” as it relates to the design, testing, and maintenance of normal ventilation exhaust systems at nuclear power plants.

7. RG 1.143, “Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants,” as it relates to the seismic design and quality group classification of components used in the GWMS and the structures housing this system, as well as provisions used to control leakages.

8. RG 1.33, “Quality Assurance Program Requirements (Operation),” as it relates to QA for the operation of the GWMS provisions for the sampling and monitoring of radioactive

materials in process and effluent streams and control of radioactive effluent releases to the environment.

9. RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," as it relates to minimizing the contamination of equipment, plant facilities, and environment, and minimizing the generation of radioactive waste during plant operation.

10. BTP 11-5, "Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure," as it relates to the assessment of radiological impacts associated with the failure of a GWMS component.

11. NUREG-0017 (Revision 1), "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs) (PWR-GALE Code)," as it relates to the methodology to calculate gaseous and liquid effluent releases.

12. NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," dated April 1991, as it relates to ODCM guidance for PWR plants.

13. NUREG/CR-4653, "GASPAR II - Technical Reference and User Guide," as it relates to the methodology to calculate gaseous effluent doses.

14. IE Bulletin 80-10, as it relates to methods and procedures used in avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled releases of radioactivity.

15. ANSI/ANS-18.1-1999, "Radioactive Source Term for Normal Operation of Light Water Reactors," as it relates to the methodology for determining the source term for normal reactor operations including anticipated accidental occurrences.

11.3.4 Technical Evaluation

GDC 3 requires that SSCs important to safety, including the gaseous waste handling and treatment systems, shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions, such as those from a detonation of explosive hydrogen and oxygen gas mixtures. GDC 60 requires that the nuclear power unit design include provisions to handle radioactive wastes produced during normal reactor operation including AOOs. GDC 61 requires that the fuel storage and handling, radioactive waste, and other systems which may contain radioactivity be designed to assure adequate safety under normal and postulated accident conditions. GCD 64 requires that the GWMS is designed to monitor radiation levels and radioactivity in effluents, as well as radioactive leakages and spills, during routine operation including AOOs.

The relevant requirements of GDCs 60 and 61 are met by using the Regulatory Positions contained within RG 1.143 as they relate to the seismic design, quality group classification of components used in the GWMS and structures housing the systems, provisions used to control leakage, and definitions of discharge paths beginning with interfaces with plant primary systems and terminating at the point of controlled discharges to the atmosphere via the plant vent stack. Other relevant aspects of RG 1.143 address design and construction methods, materials specifications, welding, and inspection and testing standards for GWMS components and piping. The COL applicant is responsible for testing all gaseous waste processing subsystems installed in the plant as described in DCD Tier 2, Chapter 14, “Verification Programs.” Section 20.1406 of 10 CFR Part 20 requires applicants for standard DCs to describe how the facility design will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

The staff reviewed the system construction standards; system process flow outlines and descriptions; sources of waste gases; sampling collection points; flow paths of gases through subsystems, including potential bypasses; and provisions for monitoring radioactivity levels or concentrations in process streams and before being released via the plant vent stack. The review addressed system construction standards, seismic design, and quality group classification of components. The evaluation addressed provisions to control waste gas and purge gas flows as part of the subsystem used for the analysis of combustible gas mixtures, and automatic control functions to preclude the buildup of explosive mixtures in complying with GDC 3 and the acceptance criteria of SRP Section 11.3.

The evaluation of the GWMS includes reviews of the design basis, design objectives, design criteria, methods of treatment, and system P&ID and process flow diagrams showing methods of operation and factors that influence waste treatment (e.g., system interfaces and potential bypass routes to nonradioactive systems). The evaluation addresses expected releases of radioactivity and associated concentrations and doses to members of the public, and methods, assumptions, and principal parameters used in calculating effluent source terms, releases of radioactive materials in gaseous effluents, and associated doses to members of the public. The review considers methods and programs used to control and monitor releases of gaseous effluents into the environment, such as radiation monitoring methods and use of filtration and adsorption media, and decay tanks.

The radiological impacts associated with radioactive gaseous and airborne effluent releases associated with the GWMS are described in DCD Tier 2, Tables 11.3-4, “Input Parameters and Calculation Results of Radioactive Effluent Releases and Dose due to the Gaseous Waste Management System Leak or Failures (Sheet 1 and 2),” to 11.3-7, “Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Maximum Releases).” The information describes the gaseous effluent source term and doses and demonstrates compliance with 10 CFR 20.1301; 10 CFR 20.1302; 10 CFR 10 CFR Part 20, Appendix B, Table 2, Column 1 and 10 CFR Part 50, Appendix I.

DCD Tier 2, Section 11.5.2.9 includes COL Information Items 11.5(2) and 11.5(3) requiring the COL applicant to prepare the ODCM and develop the REMP, respectively, using Nuclear Energy Institute (NEI) ODCM Template 07-09A (Revision 0, dated March 2009). The use of an ODCM is described in DCD Tier 2, Section 13.4, “Operational Program Implementation.” The operational program addresses the development of a site-specific REMP meeting the provisions of GL 89-01, “Implementation of Programmatic and Procedural Controls for Radiological Effluent Technical Specifications,” (RETS) Supplement No. 1, dated November 14, 1990; Radiological Assessment Branch Technical Position (Revision 1, dated November 1979) included in Appendix A to NUREG-1301, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors,” dated April 1991, as ODCM guidance for PWR plants; and the guidance in NUREG-0133, “Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants,” dated October 1978. Alternatively, a COL applicant may use the NEI07-09A to meet this regulatory milestone until a plant and site-specific ODCM is prepared, before fuel load, under the requirements of a license condition described in FSAR Section 13.4 of a COL application. The staff has reviewed NEI 07-09A and determined it to be acceptable (ML091050234). COL Information Items 11.5(2) and 11.5(3) are evaluated by the staff in Section 11.5 of this SE.

11.3.4.1 Design Considerations

The GWMS comprises two gas compressors, a gas dryer skid, four charcoal delay beds, four gas surge tanks, two hydrogen monitoring units, and an oxygen monitoring unit containing dual oxygen analyzers.

The main sources of plant radioactive gaseous inputs managed by the GWMS include the waste gases from the VCT, the containment vessel reactor coolant drain tank (CVDT), and the HT. One gas compressor is in continuous operation to draw gaseous waste into the gas surge tank where short-half-life isotopes decay. After the gas has been allowed to sufficiently decay, it is routed through the gas dryer skid, where moisture is removed, and is then sent to the charcoal bed adsorbers.

DCD Tier 2, Section 11.3.2.1.6, “Charcoal Adsorbers,” described the charcoal bed adsorbers as configured in two parallel trains with two charcoal bed adsorbers in series per train. Normally, both trains are in service, and with one train out of service, the system operates at half of its capacity. SRP Section 11.3, Acceptance Criteria 2 states the GWMS should be designed to meet the anticipated processing requirements of the plant, have adequate capacity to process gaseous wastes even when major processing equipment is down, and is capable of operating within the design objectives during normal operation including AOOs. In **RAI 188-2007, Question 11.03-4**, the staff requested the applicant to verify that the GWMS has adequate capacity to process the anticipated wastes when one train of charcoal adsorbers is out of service. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 188-2007, Question 11.03-4**, the applicant revised DCD Tier 2, Section 11.3.2.1.6 to state the charcoal bed adsorbers are sized to have sufficient capacity to process the anticipated wastes based on a 1 percent failed fuel fraction (design basis) at full flow. Two trains of charcoal bed absorbers are arranged in parallel, and when one train is not available, the other train is used to treat waste gases. Additionally, the discharge can be temporarily suspended until the radiation level is below the discharge setpoint or the out-of-service train is returned to service. The staff reviewed the applicant’s response and finds it acceptable because processing capacity and flexibility have been clarified. The staff also confirmed that Revision 2 to DCD Tier 2, Section 11.3.2.1.6 included this information. Therefore, **RAI 188-2007, Question 11.03-4** is closed.

The staff reviewed the GWMS process flow diagrams in DCD Tier 2, Figure 11.3-1, “Gaseous Waste Management System Process Flow Diagram (Sheets 1 through 3),” for all sources and volumes of gaseous process and effluent streams; points of collection of gaseous waste; flow paths of gas through the system (including bypasses); treatment provided for radio-nuclides and holdup or decay time; and points of release of gaseous effluents to the environment. The system design and design criteria were evaluated with the guidance in RG 1.143 and information provided by the applicant, as they relate to gaseous wastes produced during normal operation and AOOs. The staff finds that the applicant has provided sufficient information describing the GWMS design, and therefore meets the requirements of 10 CFR 50.34a, as it relates to the control of radioactive materials in gaseous effluents.

GDC 3 requires that SSCs important to safety shall be designed and located to minimize the probability and effect of fires and explosions. SRP Section 11.3, Acceptance Criteria 6 provides guidance on system design if the potential exists for explosive mixtures of hydrogen and oxygen. Revision 1 to DCD Tier 2, Section 11.3 did not address this guidance. DCD Tier 2, Table 11.3-3, "Equipment Malfunction Analysis (Sheet 2 of 2)," states, "…the main process equipment and piping are designed to contain a detonation." DCD Tier 2, Sections 11.3.2.1.3, "Oxygen Analyzer," and 11.3.2.1.4, "Hydrogen/Oxygen Analyzers," describes hydrogen and oxygen generated from the hydrolysis and radiolysis of the coolant-water which can form flammable and explosive mixtures, and hydrogen and oxygen monitoring systems. One oxygen analyzer unit containing dual analyzers is provided to continuously monitor the oxygen concentration downstream of the waste gas dryer and upstream of the charcoal beds. The oxygen content of the waste stream is controlled to preclude the formation of a flammable mixture. Two hydrogen and oxygen gas analyzers are provided to periodically monitor the hydrogen and oxygen concentrations in the GWMS components. From a review of DCD Tier 2, Sections 11.3.2.1.3 and 11.3.2.1.4, the staff noted a lack of detail regarding the monitoring of potentially explosive gas streams. In **RAI 188-2007, Question 11.03-3**, the staff requested the applicant to provide additional information in the DCD to confirm compliance with SRP Section 11.3, Acceptance Criteria 6. The staff also requested the applicant to specify in the DCD which components and piping are designed to withstand a hydrogen explosion. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 188-2007, Question 11.03-3**, the applicant stated the components of hydrogen and oxygen analyzers described in DCD Tier 2, Sections 11.3.2.1.3 and 11.3.2.1.4 are designed to comply with SRP Section 11.3, Acceptance Criteria 6. The applicant removed information on the hydrogen gas analyzer in DCD Tier 2, Table 11.3-3 (Sheet 2 of 2) since malfunction of the hydrogen analyzer is already considered for the oxygen/hydrogen analyzer skids and the oxygen analyzer skid in DCD Tier 2, Table 11.3-3, "Equipment Malfunction Analysis (Sheet 1 of 2)." In accordance with SRP Section 11.3, Acceptance Criteria 6.D, the applicant added information in DCD Tier 2, Section 11.3.2.1.4 on design features for an initial alarm at high concentration setpoint for operator action, and at the "high-high alarm" setting with automatic control features to isolate the sources of gas to the charcoal beds if the oxygen concentration reaches 4 percent.

The staff reviewed the applicant's discussion and found that it did not sufficiently address all aspects of SRP Section 11.3, Acceptance Criteria 6, which provides specific guidance on explosive gas control. Because additional information was required to confirm the guidance in SRP Section 11.3, Acceptance Criteria 6 has been addressed; the staff issued **RAI 535-4287, Question 11.03-17**. In this RAI, the staff requested the applicant to clarify how the malfunction of the hydrogen analyzer is already considered in Table 11.3-3 (Sheet 1 of 2); provide in the DCD additional discussion explaining how manual sampling can support an automatic function, or justify why the current result of a malfunction of the oxygen/hydrogen analyzer skids and oxygen analyzer skid in DCD Tier 2, Table 11.3-3 (Sheet 1 of 2) is acceptable; provide in the DCD indication that monitoring of potentially explosive mixtures is annunciated both locally and in the control room, or justify why annunciation of alarms locally and in the control room is unnecessary (SRP Section 11.3, Acceptance Criteria 6.C); provide in the DCD discussion of provisions for the oxygen analyzer (SRP Section 11.3, Acceptance Criteria 6.D) for the oxygen analyzer, or justify why these provisions are not discussed in the DCD; provide in the DCD discussion of each of the applicable automatic control features in regards to automatic control features initiated at the high-high alarm and whether valves isolating the sources of the gas to the charcoal bed fail in the closed position (SRP Section 11.3, Acceptance Criteria 6.D), or justify why these provisions are not discussed in the DCD; and provide in the DCD a discussion of gas analyzer daily sensor checks, monthly functional checks, quarterly calibrations, and instrumentation (SRP Section 11.3, Acceptance Criteria 6.D), or justify why these checks, calibrations, and non-sparking provisions may not be needed. By letter dated April 20, 2010, the applicant responded to the above RAI.

In response to **RAI 535-4287, Question 11.03-17**, the applicant described the GWMS design with one oxygen analyzer skid and two waste gas analyzers (oxygen/hydrogen) skids which analyze both hydrogen and oxygen. The oxygen analyzer skid contains dual oxygen gas analyzers which both operate continuously to provide two independent measurements to verify that oxygen is not present in potentially explosive concentrations. These two channels are designed to be completely independent from each other. Failure of any one channel will activate signals both locally and in the MCR for operator action. One of the two waste gas analyzers is in service during normal operations while the second serves as a backup. Manual sampling is used to verify the accuracies of the waste gas analyzers, but does not support automatic function due to time required for analysis results.

The applicant commits to revise DCD Tier 2, Sections 11.3.2.1.4 to describe that monitoring of potentially explosives mixture is annunciated both locally and in the MCR for operator actions; 11.3.2.1.4 to state the waste gas analyzer skids will have automatic control features to automatically isolate the feed to the charcoal adsorbers by closing the feed valves, designed to fail close, to the waste gas dryer located upstream of the charcoal adsorber and annunciated both locally and in the MCR for operator actions; 11.3.2.1.3 to state the oxygen gas analyzer skid will have automatic control features to automatically isolate the feed to the charcoal adsorbers by closing the valves to the waste gas dryer and annunciate alarms both locally and in the MCR for operator actions; and DCD Tier 2, Chapter 16, Section 5.5.12, “Explosive Gas and Storage Tank Radioactivity Monitoring Program,” to include a surveillance program to ensure that the hydrogen and oxygen concentration limits in the GWMS are maintained. The surveillance program will include daily sensor checks, monthly functional checks, and quarterly calibration for the oxygen analyzer and the non-sparking type waste gas analyzers. The applicant also commits to revise DCD Tier 2, Table 11.3-3 (Sheets 1 of 2) and clarify information regarding the one oxygen analyzer with dual independent channels and two separate waste gas analyzers discussed in the response.

Based on the discussion above, the staff finds the applicant's response to **RAI 535-4287, Question 11.03-17** acceptable because the applicant provided details to specifically address the SRP Acceptance Criteria referenced above, and the applicant commits to revise the DCD to include this information. **RAI 188-2007, Question 11.03-3** is closed, but **RAI 535-4287, Question 11.03-17** is being tracked as a **Confirmatory Item 11.03-3**.

SRP Section 11.3, Acceptance Criteria 3 states, “The design should include precautions to stop continuous leakage paths (i.e., to provide liquid seals downstream of rupture discs) and to prevent permanent loss of the liquid seals in the event of an explosion due to gaseous wastes produced during normal operation and anticipated operational occurrences.” DCD Tier 2, Section 11.3 describes several design provisions of the GWMS to reduce or minimize explosive mixtures; however, the staff could not find any provisions for isolation of continuous gaseous leakage paths in the event that an explosion was to occur. In **RAI 188-2007, Question 11.03-5**, the staff requested the applicant to verify that the DCD has such provisions in the GWMS design. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 188-2007, Question 11.03-5**, the applicant stated the GWMS does not use rupture discs, and in the event of a loss of system pressure upstream or downstream of the charcoal beds, like leakage or an explosion, an operator closes feed isolation valves remotely to shutdown the system for investigation. The staff reviewed the applicant's response and finds the provisions described for isolation of continuous gaseous leakage paths acceptable, therefore, **RAI 188-2007, Question 11.03-5** is closed.

DCD Tier 2, Appendix 9A.3.129 FA4-101, "Auxiliary Building," describes the potential for a radioactive materials release resulting from a fire within the radwaste areas. From review of DCD Tier 2, Section 11.3 and Table 11.3-3, "Equipment Malfunction Analysis," and DCD Tier 2, Appendix 9A.3, "Fire Hazards Analysis Results," the staff requested the applicant in **RAI 629-4973, Question 11.03-18, Item 5** to evaluate whether a fire due to an external source causing charcoal in the delay beds to reach auto ignition temperatures would have offsite dose consequences, discuss the results of such analysis in DCD Tier 2, Section 11.3, and include charcoal as a potential combustible item in DCD Tier 2, Table 9A-2, "Fire Hazard Analysis Summary (Sheet 236 of 293)," or provide justification why it should not be included. By letter dated September 24, 2010, the applicant responded to the above RAI.

In response to **RAI 629-4973, Question 11.03-18, Item 5**, the applicant states the GWMS meets compliance with SRP Section 11.3, Acceptance Criteria 6.D and is designed to maintain the oxygen concentration below 4 percent by volume by providing sufficient dilution of nitrogen gas as described in DCD Tier 2, Section 11.3.2, "Design Features." The applicant also stated that even though external fire causes the inside temperature of the charcoal beds to reach up to the auto ignition temperature of the charcoal, the charcoal doesn't explode under the oxygen concentration below 4 percent, and are not required to be included as a potential combustible item because the charcoal beds are managed to be protected from fire such that there is no increase of the gaseous effluent release due to the external fire which could affect the charcoal bed. The staff finds that the applicant's response conforms to the guidance in SRP Section 11.3 and is therefore acceptable. **RAI 629-4973, Question 11.03-18, Item 5**, is closed. However, the applicant did not provide a markup of proposed revision to the DCD, or otherwise revise the DCD to include this information. Therefore, the staff issued **RAI 5534, Question 11.03-19**, requesting that the applicant revise the DCD to address charcoal bed combustion, which is being tracked as **Open Item 11.03-2**. As discussed in Section 11.3.4.8, the staff also issued **RAI 5534, Question 11.03-19** requesting that the applicant provide an ITAAC to address explosive monitoring.

GDC 60 requires that the GWMS include design provisions to control releases of radioactive material in gaseous effluents to the environment during normal operation including AOOs. After processing in the charcoal beds, the treated gaseous stream is routed to the vent stack for discharge. Radiation monitors are provided before the discharge valve on the vent stack. Exceeding the radiation setpoint or lack of ventilation flow closes the discharge valve. Liquids generated during the operation of the GWMS are collected and routed to the LWMS for processing. The staff finds that the above described GWMS design provisions which include processing, treatment, radiation monitoring, and controlling gaseous effluent for release into the environment, comply with the requirements of GDC 60.

GDC 61 requires that the GWMS design assure adequate safety under normal and postulated accident conditions. RG 1.143 describes design guidance relating to seismic and quality group classification of GWMS structures and components, involving gaseous wastes produced during normal operation and AOOs. The A/B housing the GWMS is designed to seismic Category II requirements. The GWMS equipment and piping are classified as non-seismic. The seismic and quality group classification of the GWMS building and components are discussed in DCD Tier 2, Section 3.2, "Classification of Structures, Systems, and Components." RG 1.143, Regulatory Position 2.3 states the portions of the gaseous radwaste treatment system that are intended to store or delay the release of gaseous radioactive waste, including portions of structures housing these systems, should be classified as described in Regulatory Position 5, "Classification of radwaste systems for design purposes," and designed in accordance with Regulatory Position 6, "Natural phenomena and man-induced hazards design for radwaste management systems and structures." From a review of DCD Tier 2 information, the staff did not find the safety classifications of the GWMS components identified for conformance to RG 1.143, Regulatory Position C.2.3. In **RAI 188-2007, Question 11.03-1**, the staff requested the applicant to provide additional information in the DCD to justify how the guidance in RG 1.143, Regulatory Position 2.3 is met. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 188-2007, Question 11.03-1**, the applicant stated DCD Tier 2, Section 11.3.1.7, "Seismic Design," indicates the SSC classifications for the GWMS are discussed in DCD Tier 2, Section 3.2. DCD Tier 2, Table 3.2-2, "Classification of Mechanical and Fluid Systems, Components, and Equipment (Sheet 32 of 53)," describes the GWMS components as designed to the codes and standards of Class 6 with the seismic category classifications based on RG 1.143. Because the SSC classifications for the GWMS were not included in DCD Tier 2 information, **RAI 188-2007, Question 11.03-1**, was considered closed, but the issue regarding the SSC classifications remained open. As a result, the staff requested that the applicant in **RAI 535-4247, Question 11.03-16**, provide a discussion of the GWMS components with the safety classifications (RW-IIa, RW-IIb, or RW-IIc). The staff specified that the discussion should include systems or components that process radioactive waste and the quantities of radioactive waste processed. By letter dated April 20, 2010, the applicant responded to **RAI 535-4247, Question 11.03-16**.

In response to **RAI 535-4247, Question 11.03-16**, the applicant commits to add DCD Tier 2, Table 11.3-12, "Component Classification." Table 11.3-12 includes the safety classifications of the waste gas surge tanks and charcoal beds as RW-IIa, waste gas compressor package and waste gas dryer as RW-IIb, and oxygen gas analyzer and waste gas analyzer as RW-IIc. This conforms to the guidance in RG 1.143 Regulatory Position C.2.3, and therefore the staff finds that the above classifications are appropriate for the design of the GWMS, and the applicant has satisfied the requirements of GDC 61 with regard to providing adequate safety under normal conditions.

Based on the discussion above, the staff finds the applicant's response acceptable. **RAI 188-2007, Question 11.03-1** is closed, but **RAI 535-4287, Question 11.03-16** is being tracked as **Confirmatory Item 11.03-2**.

The principal design criteria given in 10 CFR Part 50, Appendix A establish the necessary design, fabrication, construction, testing, and performance requirements for SSCs important to safety that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public. From a review of DCD Tier 2, Sections 11.3.4, 11.3.2, 11.3.2.1.4, and 14.2, and DCD Tier 1, Section 2.7.4.2.1, and the applicant's response to **RAI 533-4261, Question 11.03-15** evaluated in Section 11.3.4.8 of this SE, the staff found insufficient information regarding the safety function description of the GWMS discharge isolation valve. As a result, in **RAI 629-4973, Question 11.03-18, Item 3**, the applicant was asked to describe the safety function of the GWMS discharge isolation valve in DCD Tier 2, Section 11.3 and identify its preoperational test in DCD Tier 2, Section 14.2.12.1.81 by letter dated September 24, 2010, the applicant responded to the above RAI.

In response to **RAI 629-4973, Question 11.03-18, Item 3**, the applicant discussed the containment isolation valves in the LWMS that provide a safety-related function, defined in 10 CFR 50.2, as it relates to the capability to shut down the reactor and maintain it in a safe shutdown condition. The applicant provided the applied isolation valves located in the reactor coolant drain pump discharge line, containment sump pump discharge line, connecting line between containment vessel reactor coolant drain tank gas phase, vent header to the GWMS and nitrogen gas supply system, and the connecting line between above tank gas phase and gas analyzers. As defined in 10 CFR 50.2, the GWMS discharge isolation valves accomplish no safety-related function such as containment isolation. **RAI 629-4973, Question 11.03-18, Item 3** is closed.

Compliance with GDC 60 requires that design provisions for radioactive waste processing systems are included to control releases of radioactive materials in gaseous effluents to the environment during normal operation including AOOs. These design provisions include sufficient holdup capacity or decay time to allow shorter lived radionuclides to decay before they are further processed or released to the atmosphere, proposed types and characteristics of filtration and adsorbent media to treat gaseous process and effluent streams including removal efficiencies and decontamination factors taking into account the expected physical, chemical, and radiological properties of gaseous process and effluent streams.

From review of DCD Tier 2, Sections 11.3.2, "System Description," 11.3.3.1, "Radioactive Effluent Releases and Dose Calculation in Normal Operation," and DCD Tier 2, Figures 9.4.3-1, "Auxiliary Building HVAC System Flow Diagram," and 9.4.5-1, "Annulus Emergency Exhaust System Flow Diagram," the staff determined that HEPA and carbon filtration were missing in the A/B ventilation system for gaseous effluent discharges to the environment via the plant vent stack, which was the only release point for the GWMS and HVAC systems with the R/B, A/B, and AC/B. As a result, in **RAI 629-4973, Question 11.03-18, Item 6**, the staff requested that the applicant justify the absence of HEPA and carbon filtration in the A/B ventilation system for gaseous effluent discharges to the environment via the plant vent stack as the only release point for the GWMS and HVAC systems with the R/B, A/B, and AC/B. By letter dated September 24, 2010, the applicant responded to the above RAI.

In response to **RAI 629-4973, Question 11.03-18, Item 6**, the applicant referenced DCD Tier 2, Figures 9.4.3-1 and 9.4.5-1 which shows the HVAC system flow diagrams of the US-APWR exhaust system. DCD Tier 2, Figure 9.4.3-1 depicts the lines coming from the power source building, fuel handling area, R/B controlled and uncontrolled areas, A/B controlled and uncontrolled areas, and AC/B controlled and uncontrolled areas to the plant vent stack also shown in DCD Tier 2, Figure 9.4.5.1. The applicant states all lines from the buildings in DCD Tier 2, Figure 9.4.3-1 are monitored before reaching the plant vent stack. The gaseous effluent can be routed to the containment low volume purge exhaust filtration units equipped with charcoal and HEPA filters in the event radioactively levels exceed the ECLs in 10 CFR Part 20, Appendix B, Table 2, Column 1 as described in DCD Tier 2, Section 9.4.3.2.1, "Auxiliary

Building HVAC System." The applicant also stated in normal operation conditions, the exhaust gas is routed directly to the plant vent stack without any filtration as shown in DCD Tier 2, Figure 9.4.5-1. In DCD Tier 2, Section 9.4.3.2.1, the exhaust from the A/B HVAC system is combined with the gaseous effluent treated by the GWMS before being routed to the plant vent stack which serves to further dilute the gaseous effluent waste stream.

The combined gaseous effluent waste stream is monitored for high radiation levels before release to the environment. Airborne radioactivity is monitored inside the exhaust air duct form the fuel handling area, penetration and safeguard component area, R/B controlled area, A/B controlled area, and AC/B controlled area (sampling and lab area). When radiation levels exceed a predetermined value, an alarm actuates in the MCR, normal supply and exhaust from the affected area is manually isolated and diverted remotely from the MCR to the containment low volume purge filtration exhaust system. DCD Tier 2, Section 9.4.6.2.4.1, "Containment Low Volume Purge System," describes its connection to the A/B ventilation system with the fuel handling area, penetration and safeguard component area, and controlled areas of the R/B, A/B, and AC/B. Radiation monitors in the normal exhaust ducts described in DCD Tier 2, 12.3.4.2.8, "Airborne Radioactivity Monitors Component Description," in these areas alarm in the MCR upon detecting high radiation for operator action to minimize the potential spread of radioactive contamination for those areas serviced by the A/B HVAC system.

The staff reviewed the applicant's justification regarding the exclusion of HEPA and carbon filtration in the A/B HVAC system design for gaseous effluent discharges to the environment via the plant vent stack and found it to be acceptable as evaluated in Section 11.3.4.4.2. **RAI 629-4973, Question 11.03-18, Item 6** is closed.

DCD Tier 2, Sections 11.3.2, "System Description," and 11.3.3.1, "Radioactive Effluent Releases and Dose Calculation in Normal Operation," describe the plant vent stack and release point design information. In DCD Tier 2, Section 11.3.3.1, the detailed design information for the plant vent stack is to include the height of release, stack diameter, effluent temperature and flow rate, effluent exit velocity, and the size and shape of flow orifices. The plant vent stack runs alongside containment and is the only release point above the top of containment for the GWMS and HVAC systems associated with the R/B, A/B, and AC/B. Although COL Information Item 11.3(3) is listed in DCD Tier 2, Section 11.3.7, "Combined License Information," there was no explicit statement in DCD Tier 2, Sections 11.3.2, "System Description," or 11.3.3.1, "Radioactive Effluent Releases and Dose Calculation in Normal Operation," to direct the COL applicant to take responsibility of COL Information Item 11.3(3). Under COL Information Item 11.3(3), the COL applicant is to provide a discussion of the onsite plant vent stack design parameters and release point specific characteristics, which are outside the scope of the requested DC. Therefore, the staff finds the inclusion of COL Information Item 11.3(3) acceptable, however because the applicant omitted an explicit statement requiring the COL applicant to address this COL information item, in **RAI 189-2006, Question 11.03-10**, the staff requested the applicant do so. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 189-2006, Question 11.03-10**, the applicant added a statement in DCD Tier 2, Section 11.3.2 to require that the COL applicant include the site-specific plant vent stack design to satisfy COL Information Item 11.3(3). The staff confirmed that Revision 2 to DCD Tier 2, Section 11.3.2 included this information. **RAI 189-2006, Question 11.03-10** is closed.

In Revision 2 to DCD Tier 2, Section 11.3.2, the applicant added specific design information on the plant vent stack. The release point of the plant vent stack is circular in shape and has an inner diameter of about 7.3 ft. The height of the release point is at the same height as the top of the containment. The maximum effluent flow rate is about 250,000 cfm and the effluent exit velocity is about 6,000 fpm. During normal operation, the effluent temperature is near ambient temperature inside the building. At accident condition, the maximum effluent temperature is approximately 158 °F. The staff finds this acceptable because specific plant vent stack design information is included in DCD Tier 2, Section 11.3.2

11.3.4.2 Cost-Benefit Analysis

DCD Tier 2, Section 11.3.1.5, "Site-Specific Cost-Benefit Analysis," describes the GWMS design for use at any site with flexibility to incorporate site-specific requirements with minor modifications such as preference of technologies, the degree of automated operation, and radioactive waste storage. RG 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors," describes an acceptable method of performing a CBA to demonstrate that the GWMS design includes all items of reasonably demonstrated technology for reducing cumulative population doses from releases of radioactive materials from each reactor to ALARA levels. The applicant states the CBA for the US-APWR design demonstrates that the addition of items of reasonably demonstrated technology will not provide a more favorable cost benefit, but does not include a CBA in DCD Tier 2, Section 11.3.1.5. The COL applicant will provide the site-specific CBA to demonstrate compliance with the requirements of 10 CFR Part 50, Appendix I, Sections II.A and II.D under COL Information Item 11.3(8). Because the CBA requires site-specific information, which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.3(8) acceptable.

11.3.4.3 Mobile or Temporary Equipment

Revision 1 to DCD Tier 2, Section 11.3.1.6, "Mobile or Temporary Equipment," describes the GWMS as designed with permanently installed equipment and did not address consideration of mobile systems or temporary equipment. However, DCD Tier 2, Section 11.2.1.6, "Mobile or Temporary Equipment," provides a provision for a mobile system or temporary equipment with the permanently installed LWMS equipment that may be installed in the A/B at the discretion of facility operation under a COL information item. Because DCD Tier 2, Section 11.3.2.1, "Component Description," and Table 11.3-11, "Equipment Codes and Standards for Radwaste Equipment (from Table 1, RG 1.143)," present GWMS design information on codes and standards for flexible hoses and hose connections used in conjunction with a mobile radwaste processing system developed in guidance with RG 1.143, the staff requested that the applicant in **RAI 189-2006, Question 11.03-11**, clarify whether a mobile system or temporary equipment is proposed for the GWMS. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response **RAI 189-2006, Question 11.03-11**, the applicant stated the GWMS does not include the use of mobile or temporary equipment with the permanently installed equipment, and there are no connections provided for mobile equipment. The equipment codes and standards on flexible hoses and hose connections for mobile radwaste processing systems from RG 1.143 were included for completeness in DCD Tier 2, Table 11.3-11, but are not part of the GWMS. The applicant revised DCD Tier 2, Section 11.3.1.6 to state the GWMS does not include the use of mobile or temporary equipment. The staff finds the applicant's clarification that the GWMS does not include the use of mobile or temporary equipment with the permanently installed equipment consistent with the revised description in Revision 2 to DCD Section 11.3.1. **RAI 189-2006, Question 11.03-11** is closed.

However, from a review of DCD Tier 2, Section 14.3.7, “ITAAC for Plant Systems,” ITAAC is described for verifying the performance of the GWMS as permanently installed systems or in combination with mobile processing equipment. Since DCD Tier 2, Section 11.3.1.6 was revised in response to **RAI 189-2006, Question 11.03-11, Item 1** to state the GWMS does not include the use of mobile or temporary equipment, the staff requested that the applicant in follow-up **RAI 629-4973, Question 11.03-18, Item 1** address this apparent inconsistency. By letter dated September 24, 2010, the applicant responded to the above RAI.

In response to **RAI 629-4973, Question 11.03-18, Item 1**, the applicant commits to correct DCD Tier 2, Section 14.3.7 to state the GWMS has no mobile or temporary equipment. The staff reviewed the applicant’s response and found it acceptable because the applicant commits to correct this inconsistency in the next revision of the DCD. **RAI 629-4973, Question 11.03-18, Item 1** is being tracked as **Confirmatory Item 11.03-4**.

11.3.4.4 Development of Airborne Effluent Source Term and Compliance with Effluent Concentration Limits

In DCD Tier 2, Section 11.3.3.1, “Radioactive Effluent Releases and Dose Calculation in Normal Operation,” the annual average gaseous effluent releases are calculated using the applicant’s PWR-GALE computer code, the input design parameters in DCD Tier 2, Table 11.2-9, “Input Parameters for the PWR-GALE Code” (Sheets 1 and 2)," and the decontamination factors (DF) in DCD Tier 2, Table 11.2-7, “Decontamination Factors,” from NUREG-0017 (Revision 1), “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWRs) (PWR-GALE Code).” The expected annual gaseous effluent releases and gaseous effluent releases with maximum defined fuel defects are presented in DCD Tier 2, Table 11.3-5, “Calculated Annual Average Release of Airborne Radionuclides by the PWR-GALE Code, Revision 1 (Ci/yr) (Sheets 1 to 3),” and Table 11.3-5, “Calculated Annual Average Release of Airborne Radionuclides (Ci/yr) (Maximum Releases) (Sheets 4 to 6),” respectively. This information is evaluated by the staff for compliance with 10 CFR Parts 20 and 50, and 40 CFR Part 190 below.

11.3.4.4.1 Compliance with 10 CFR Part 20

10 CFR 20.1302 requires that an applicant demonstrate compliance with the dose limits of 10 CFR 20.1301, in part, by showing that the annual average of gaseous effluent release concentrations in unrestricted areas do not exceed the ECLs specified in 10 CFR Part 20, Appendix B, Table 2, Column 1. DCD Tier 2, Table 11.3-6, “Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Expected Releases),” shows that the sum-of-ratios of expected gaseous effluent releases compared to their respective ECL is less than unity (calculated as 9.19E-03). DCD Tier 2, Table 11.3-7, “Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Maximum Releases),” also shows that the sum-of-ratios of gaseous effluent releases with maximum fuel defects is less than unity (calculated as 9.12E-01). These sum-of-ratios for expect and maximum annual gaseous effluent releases comply with the unity rule specified in 10 CFR Part 20, Appendix B.

Because the applicant used a proprietary version of the NRC PWR-GALE (GALE86) code and insufficient information was available for the staff to confirm the calculated gaseous effluent releases, the staff requested the applicant in **RAI 164-1925, Question 11.02-7** and **RAI 189-2006, Question 11.03-6** to provide the basis for all input design values and assumptions used in the applicant's PWR-GALE code calculations of liquid and gaseous effluent releases in DCD Tier 2, Sections 11.2 and 11.3, respectively. By letters dated February 18, 2009, and March 10, 2009, respectively, the applicant responded to the above RAI. The staff's evaluation of the applicant's responses to **RAI 164-1925, Question 11.02-7** and **RAI 189-2006, Question 11.03-6** is presented below.

11.3.4.4.2 Applicant's PWR-GALE Code

In responses to **RAI 164-1925, Question 11.02-7** and **RAI 189-2006, Question 11.03-6**, the applicant provided the basis for some of the input design values and assumptions in their calculations of expected annual normal and maximum gaseous effluent releases. Under 10 CFR 2.390(a)(4), the applicant submitted the PWR-GALE code input/output files. The applicant provided pointers to Tier 2 information with references to NUREG-0017 and WASH-1258 Volume 1, "Final Environmental Statement- Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Practicable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents." The staff reviewed the applicant's PWR-GALE code input/output files, input design values, and assumptions to calculate the gaseous effluent releases, and confirmed that the input design values are consistent with the guidance in NUREG-0017 and WASH-1258, with the exception of the input design value on the reactor coolant leak rate to containment for noble gases discussed below.

In DCD Tier 2, Figure 9.4.3-1, "Auxiliary Building HVAC System Flow Diagram," airborne radioactivity (gaseous effluents) from the fuel handling area is released from the plant vent stack via the A/B HVAC system. From a review of DCD Tier 2 information, the staff found no charcoal or HEPA filters considered in the A/B HVAC system design or in the applicant's PWR-GALE code input file. Note 2 of DCD Tier 2, Table 11.3-5 states the fuel handling area is within the R/B, but is considered separately in the evaluation of airborne radionuclide releases. The R/B in the US-APWR contains the fuel handing area and other equipment compartments. Guidance in NUREG-0017 recommends the source terms of the fuel handing area and other equipment compartments be distinguished from each other. Therefore, the airborne release from other equipment compartments is considered as the release of ventilation air. Airborne radionuclide releases from the A/B includes the R/B in Note 3 to DCD Tier 2, Table 11.3-5. NUREG-0017 defines ventilation exhaust air from the A/B, turbine building (T/B), and spent fuel pool area as ventilation exhaust air from the nuclear island. Auxiliary components which contain radioactive material in the NI are installed in both the A/B and R/B.

For the input design value on the noble gas containment leak rate, in footnote to DCD Tier 2, Table 11.2-9 (Sheets 1 and 2), the applicant states, "…this value of 2E-04/d is determined by the ratio of 10 gallons per day (gpd) (to containment sump in DCD Tier 2, Table 11.2-2) and the reactor coolant mass of 646,000 lbs along with an unit conversion." The noble gas containment leak rate of 2E-04/d (0.02 percent/d) is used in the applicant's PWR-GALE code by modifying the version of the NRC PWR-GALE code distributed by RSICC. In comparison, Section 1.5.1.5, "Noble Gas Releases from Building Ventilation Systems," of NUREG-0017 specifies the built-in (non-user defined value) containment leak rate of 3E-02/d (3 percent/d) for leakage of noble gases from containment.

Because the applicant's calculations could not be confirmed, the staff requested that the applicant in **RAI 402-3028, Question 11.03-12**, provide the unit conversion, justify the noble gas containment leak rate of 2E-04/d, and an executable copy of the applicant's PWR-GALE code and source code. The staff also requested that the applicant identify all modifications made to the NRC PWR-GALE code, specific lines of source code changed, and provide the QA/QC documentation. By letter dated July 15, 2009, the applicant responded to the above RAI.

Under 10 CFR 2.390(a)(4), the applicant submitted the specific lines of original source code modified in the NRC PWR-GALE code relating to the ANSI/ANS-18.1-1999 source term specification and the basis on the noble gas containment leak rate. The applicant described the QA/QC documentation (written in Japanese) for their PWR-GALE code as consisting of the computer software validation and installation plan; computer software validation and installation; user document; configuration control; and in-use check. The applicant later provided English translations of these documents.

The unit conversion associated with the noble gas containment leak rate of 2E-04/d converts the reactor coolant mass of 646,000 lb to units consistent with the expected generation rate of 10 gpd for other leaks and drains as waste inputs given in Table 7, "PWR Liquid Radioactive Waste Processing System Design Processing," to ANSI/ANS-55.6-1997 (R2008), "Liquid Radioactive Waste Processing System for Light Water Reactor Plants," and the water density of 1 ft^3/62.426 lb. The staff reviewed the applicant's unit conversion methodology and confirmed that the noble gas containment leak rate of 2E-04/d is integrated in the applicant's PWR-GALE code. In a teleconference call on January 20, 2010, the staff informed the applicant that their PWR-GALE code could not execute with the files received, and requested all code files to confirm the applicant's results and conclusions. The staff discussed with the applicant a QA/QC document which identified a batch file not previously submitted that appeared to be required for execution of the applicant's PWR-GALE code. Under 10 CFR 2.390(a)(4), the applicant submitted the batch file, but the staff was not able to execute the code in the format received.

The staff calculated annual gaseous effluent releases with the NRC PWR-GALE code for comparison to the applicant's PWR-GALE code calculations. The NRC PWR-GALE code calculation used the input design values in DCD Tier 2, Table 11.2-9, "Input Parameters for the PWR-GALE Code (Sheets 1 and 2)," but with the NUREG-0017 noble gas containment leak rate of 3E-02/d and pre-ANSI-N18.1-1999 source term specification as applied in the NRC PWR-GALE code. Tables 11.3.1 and 11.3.2 of this SE show that the NRC PWR-GALE code calculations range from 5.3 to 23 times greater for I-133 and I-131, respectively, and from 1.5 to 460 times greater for Kr-85 and Xe-133, respectively, when compared to applicant's PWR-GALE code calculations. The annual gaseous effluent releases calculated with the NRC PWR-GALE code, NUREG-0017 noble gas containment leak rate of 3E-02/d, and pre-ANSI/ANS-18.1-1999 source term specification are used in the NRCDose V2.3.14 code containing the GASPAR II code, also distributed by RSICC, in the comparison of gaseous effluent doses to members of the public discussed in Section 11.3.4.6 of this SE.

Although the applicant provided the information requested in **RAI 402-3028, Question 11.03-12**, the staff was unable to confirm the gaseous effluent releases calculated with the applicant's PWR-GALE code and effluent doses (similarly to **RAI 164-1925, Questions 11.02-4 and 11.02-7**, and **RAI 523-4246, Question 11.02-30**, described in Section 11.2 of this SE). The staff conducted an audit of the applicant's PWR-GALE code at the MHI office in Arlington, Virginia, held between July 28 - 29, 2010. Prior to the PWR-GALE code audit,(ML102810271) the applicant submitted under 10 CFR 2.390(a)(4) their proprietary version of the NRC PWR-GALE code containing a local batch file to execute the code by letter dated July 15, 2010. Using the applicant's PWR-GALE code, the staff confirmed the calculations of expected annual gaseous effluent releases.

From the PWR-GALE code audit findings, the staff requested the applicant in **RAI 629-4973, Question 11.03-18, Item 2** to provide the calculation packages that demonstrate compliance to the NRC regulations to include the applicant's PWR-GALE code calculations of gaseous effluent releases (normal and maximum releases) and ECL comparisons of 10 CFR Part 20, Appendix B, Table 1, Column 1; GASPAR II code calculations of gaseous effluent doses; and the waste gas surge tank leak and charcoal bed analysis. The staff also requested the applicant to provide the basis for the 24 hour noble gas transfer (decay) time in the reactor coolant after reactor shut down to evaluate the radiological consequence of the waste gas surge tank leak and satisfy the 300 microgram (µg) dose equivalent Xe-133 TS limit in DCD Tier 2, Section 11.3.3.2.1, "Waste gas surge tank leak," presented in Section 11.3.4.5 of this SE. By letter dated September 24, 2010, the applicant responded to above RAI. The additional information provided in this response is also presented, in part, in the applicant's technical report described below.

Under 10 CFR 2.390(a)(4), the applicant submitted Technical Report MUAP-10019P (R0) in its response to **RAI 629-4973, Question 11.03-18, Item 2**, by letter dated October 5, 2010. Technical Report MUAP-10019P (R0) describes the applicant's methodology, gaseous and liquid effluent and dose calculation results, basis for input design values used in the analysis of radiological consequences during normal operation including AOOs, and gas and liquid tank failure events to demonstrate compliance with NRC regulations. Technical Report MUAP-10019P (R0) also summarizes the QA/QC documentation describing the validation procedures for the applicant's proprietary version of the NRC PWR-GALE code to calculate expected annual liquid and gaseous effluent releases during normal operation including AOOs for a plant referencing the US-APWR design.

The staff reviewed Technical Report MUAP-10019P (R0) and found the applicant's methodology and basis for the selected input design values, as it relates to the calculation of annual gaseous effluent releases and doses during normal operation including AOOs acceptable because it conformed to the guidance in SRP Section 11.2. Technical Report MUAP-10019P/NP (R0) should be referenced in the DCD, but was not, therefore the staff issued **RAI 5533, Question 11.02-34** requesting that the applicant reference this technical report. **RAI 5533, Question 11.02-34** is being tracked as **Open Item 11.02-2**. Additionally, the response to **RAI 629-4973, Question 11.03-18, Item 2** was incomplete because the calculation packages were not provided. **RAI 189-2006, Question 11.03-6,** previously evaluated in Sections 11.2.4.5 and 11.2.4.6, and **RAI 402-3028, Question 11.03-12** are closed, but **RAI 629-4973, Question 11.03-18, Item 2**, regarding the calculation packages, as it relates to gaseous effluent releases and doses, and **RAI 5533, Question 11.02-34** , regarding the Technical Report MUAP-10019P (R0) are being tracked as **Open Items 11.03-1 and 11.02-2** respectively.

11.3.4.5 Failed Gaseous Tank and Charcoal Bed Leak Analysis

DCD Tier 2, Section 11.3.3.2, "Radioactive Effluent Releases and Dose Calculation due to a Gaseous Waste Management System Leak or Failure," presents an alternative method to evaluate the radiological consequences of a postulated leak of noble gases (Xe and Kr isotopes) from the waste gas surge tank in DCD Tier 2, Section 11.3.3.2.1, "Waste Gas Surge Tank," and charcoal bed in DCD Tier 2, Section 11.3.3.2.2, "Charcoal Bed Leak." For the waste gas surge tank evaluation, the source term of noble gases in the reactor coolant is based on the 300 μg dose equivalent Xe-133 TS limit.

The input design values used in the applicant's PWR-GALE code calculation to evaluate the radiological consequences of the charcoal bed leak are listed in DCD Tier 2, Table 11.2-9, "Input Parameters for the PWR-GALE Code (Sheets 1 and 2)," and DCD Tier 2, Table 11.3-4, "Input Parameters and Calculation Results of Radioactive Effluent Releases and Dose due to the Gaseous Waste Management System Leak or Failures (Sheets 1 and 2)." Because details on the calculation basis were not described, the staff requested the applicant in **RAI 189-2006, Question 11.03-8** to provide details of the dose calculation for the charcoal bed leak and the basis for all input design values such as the xenon and krypton holdup times in DCD Tier 2, Table 11.3-4 and the "other parameters" in DCD Tier 2, Table 11.2-9. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 189-2006, Question 11.03-8**, the applicant's basis for the Xe and Kr holdup times of 0.02 d (about 30 minutes) in DCD Tier 2, Table 11.3-4 is taken from BTP 11.5 (Revision 3), "Postulated Radioactive Releases due to a Waste Gas System Leak or Failure." Section B.2.i of BTP 11-5 assumes a 30-minute decay to consider the travel of noble gases through components in the waste gas system and the release point to the nearest exclusion boundary. The basis for all other input design values in the applicant's PWR-GALE code are described in the applicant's response to **RAI 164-1925, Question 11.02-7** evaluated in Sections 11.2 and 11.3 of this SE.

Guidance on the safety analysis for the radiological consequences of a single failure of an active component in the waste gas system is provided in BTP 11-5. BTP 11.5 states the analysis should provide reasonable assurance that in the event of a postulated failure or leak of the waste gas system, the resulting total body exposure to an individual at the nearest exclusion area boundary (EAB) will not exceed 0.1 rem for systems not designed to withstand explosions and earthquakes from a failure to meet its design intent as required by 10 CFR 50.34a(C) and GDC 60.

The safety analysis for a pressurized waste gas tank assumes that the particulates and radioiodines are removed by the radioactive waste treatment equipment. Conservative assumptions in the analysis include a noble gas source term of 1 percent of the operating fission product inventory in the core being released to the reactor coolant which may be developed from the NRC PWR-GALE code, a reasonable time allowed to detect and terminate the release and path to the environment not normally planned, absence of continuous effluent radiation monitoring to automatically isolate and/or terminate the release, a ground level release without credit for a building wake effect, and a short-term (two hours) atmospheric diffusion factor (χ/Q) with no downwind deposition during transport. The analysis should describe the event leading to the release, release path from the affected system and building to the environment, type and duration of the release, basis for the noble gas source term, assumed receptor location, atmospheric dispersion parameters, and other factors. The methodology to evaluate the waste gas tank leak described in BTP 11.5 assumes a noble gas tank inventory at 100 percent capacity based on the maximum expected radioactive source term and system design capacity using the parameters and principal components considered for pretreatment and collection of waste gas to the waste gas system tanks during normal operation including AOOs.

The alternative method described in DCD Tier 2, Section 11.3.3.2.1 for the waste gas surge tank leak evaluates the total body dose at the onsite EAB based on the transfer of noble gases in the reactor coolant mass (646,000 lb) to one of the four waste gas surge tanks one day after reactor shutdown with a release from the A/B into the atmosphere. DCD Tier 2, Section 11.3.3.2.1 and DCD Tier 2, Table 11.3-4 (Sheet 1 of 2) shows a total body dose of 46 mrem at the onsite EAB calculated from the short-term χ/Q of 5.0E-06 s/m^3 in DCD Tier 2, Table 2.0-1 (Sheet 1 of 5), "Key Site Parameters," and the DF from Table B-1, "Dose Factors for Exposure to a Semi-Infinite Cloud of Noble Gases," to RG 1.109, "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."

The safety analysis for the radiological consequences of a single failure of an active component in a waste gas system with charcoal delay or decay beds also described in BTP 11.5 assumes that the charcoal unit is bypassed with an one hour release to the environment, and that remedial action by isolation and starting an alternate charcoal unit could take up to two hours. The analysis should describe the event leading to the release, release path from the affected system and building to the environment, type and duration of the release, basis for the noble gas source term after 30 minutes of decay, assumed receptor location, atmospheric dispersion parameters, and other factors. The methodology to evaluate the charcoal bed leak in BTP 11-5 assumes a radioactive noble gas tank inventory based on the maximum expected radioactive source term and the system design capacity using the parameters and principal components considered for pretreatment and collection of waste gas to the waste gas charcoal delay or decay beds during normal operation including AOOs.

The alternative method described in DCD Tier 2, Section 11.3.3.2.2 for the charcoal bed leak analysis evaluates the total body dose at the onsite EAB based on the ratio of the noble gas activity equal to the 300 µg dose equivalent Xe-133 TS limit to the noble gas activity calculated by the applicant's PWR-GALE code with the noble gases containment leakage rate of 2E-04/d for the expected annual noble gas releases from normal operation including AOOs, and the same without the charcoal bed decayed for 30 minutes. DCD Tier 2, Section 11.3.3.2.2 and DCD Tier 2, Table 11.3-4 (Sheet 2 of 2) shows a total body dose of 2 mrem at the onsite EAB calculated from the short-term χ/Q value of 5.0E-06 s/m^3 in DCD Tier 2, Table 2.0-1, and the dose factors from Table B-1 to RG 1.109.

The staff reviewed the applicant's alternate method on the radiological consequences of a postulated leak of noble gases from the waste gas surge tank and charcoal bed. The staff confirmed the 300 µg dose equivalent Xe-133 TS limit stated in DCD Tier 2, Chapter 16, TS B3.4.16, "RCS Specific Activity," of noble gas activity in the reactor coolant assuming 1 percent failed fuel. The staff's results for the waste gas surge tank leak show that a noble gas source term of 300 µg dose equivalent Xe-133 released instantaneously into the atmosphere is less than the 0.1 rem total body dose limit at the nearest EAB for waste gas systems not designed to withstand explosions and earthquakes in accordance with BTP 11-5.

The charcoal bed analysis shows a total body dose of 2 mrem at the EAB and is based on the applicant's PWR-GALE code (related to **RAI 164-1925, Questions 11.02-4 and 11.02-7**; **RAI 523-4246, Question 11.02-30; RAI 189-2006, Questions 11.03-6 and 11.03-8; and RAI 402-3028, Question 11.03-12**). The radiological consequence of the charcoal bed analysis is bounded by the waste gas surge tank leak analysis. As discussed in Section 11.3.4.4 of this report, the staff confirmed the applicant's PWR-GALE code calculations on the expected annual gaseous effluent releases and doses from normal operation including AOOs.

Because the basis on the 24 hour transfer (decay) time of noble gases was not described, in **RAI 629-4973, Question 11.03-18, Item 2**, the staff requested the applicant provide the basis for the 24 hour transfer time of noble gases in the reactor coolant after reactor shut down to evaluate the radiological consequence of the waste gas surge tank leak and satisfy the 300 μg dose equivalent Xe-133 TS limit in DCD Tier 2, Section 11.3.3.2.1. In the response to **RAI 629-4973, Question 11.03-18, Item 2**, the applicant stated the 24 hour noble gas transfer time for degassing the whole reactor coolant is based on a conservative estimate assuming that the time for degassing is equal to dissolved noble gas transfer time from reactor coolant to a waste gas surge tank. The applicant also stated a Japanese research institute found the time for degassing is over 2 days. Selection of the 24 hour noble gas transfer time is conservative considering radioactive decay. The basis of the 24 hour noble gas transfer time is described in Technical Report MUAP-10019P (R0), evaluated in Section 11.3.4.4.2 of this SE. The staff finds that the applicant's bases of the 24 hour noble gas transfer time in the radiological consequence of the waste gas surge tank leak and the 300 μg dose equivalent Xe-133 TS limit, as described above, are acceptable, however because the calculation packages on the waste gas tank and charcoal bed leak analyses have not yet been provided, **RAI 629-4973, Question 11.03-18, Item 2** is being tracked as **Open Item 11.03-1**.

Table 11.3.1 (1 of 2). NRC PWR-GALE code calculations of expected annual gaseous effluent releases for radioiodines (Ci/yr).

Nuclide	Building Ventilation				Blowdown Vent Offgas	Air Ejector Exhaust	Total
	Fuel Handling	Reactor	Auxiliary	Turbine			
I-131	3.3E-03	1.3E-02	7.9E-02	0.0E+00	0.0E+00	0.0E+00	9.5E-02
I-133	1.2E-02	4.0E-02	2.9E-01	0.0E+00	0.0E+00	0.0E+00	3.4E-01

Table 11.3.1 (2 of 2). NRC PWR-GALE code calculations of expected annual gaseous effluent releases for noble gases (Ci/yr).

Nuclide	Gas Stripping		Building Ventilation			Blowdown Vent Offgas	Air Ejector Exhaust	Total
	Shutdown	Continuous	Reactor	Auxiliary	Turbine			
Kr-85m	0.0E+00	0.0E+00	1.0E+02	4.0E+00	0.0E+00	0.0E+00	2.0E+00	1.1E+02
Kr-85	1.6E+02	1.2E+03	7.2E+02	6.0E+00	0.0E+00	0.0E+00	3.0E+00	2.1E+03
Kr-87	0.0E+00	0.0E+00	3.2E+01	4.0E+00	0.0E+00	0.0E+00	2.0E+00	3.8E+01
Kr-88	0.0E+00	0.0E+00	1.2E+02	7.0E+00	0.0E+00	0.0E+00	3.0E+00	1.3E+02
Xe-131m	2.8E+01	2.0E+02	1.7E+03	1.4E+01	0.0E+00	0.0E+00	7.0E+00	1.9E+03
Xe-133m	0.0E+00	0.0E+00	1.5E+02	2.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E+02
Xe-133	4.0E+00	3.0E+01	6.0E+03	5.6E+01	0.0E+00	0.0E+00	2.6E+01	6.1E+03
Xe-135m	0.0E+00	0.0E+00	6.0E+00	3.0E+00	0.0E+00	0.0E+00	1.0E+00	1.0E+01
Xe-135	0.0E+00	0.0E+00	8.9E+02	2.0E+01	0.0E+00	0.0E+00	9.0E+00	9.2E+02
Xe-137	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xe-138	0.0E+00	0.0E+00	5.0E+00	3.0E+00	0.0E+00	0.0E+00	1.0E+00	9.0E+00
Total								1.1E+04

Notes:
0.0E+00 appearing in the table indicate the gaseous effluent release is less than 1.0 Ci/yr for noble gases and 0.0001 Ci/yr for radioiodines. The NRC PWR-GALE code calculation uses the input design values in DCD Tier 2, Table 11.2-9, but with the NUREG-0017 noble gas containment leak rate of 3E-02/d and pre-ANSI/ANS-18.1-1999 source term specification as applied in the NRC PWR-GALE code.

Table 11.3.2 (1 of 2). Comparison of the NRC and applicant's PWR-GALE code calculations of expected annual gaseous effluent releases for radioiodines.

Nuclide	Building Ventilation				Blowdown Vent Offgas	Air Ejector Exhaust	Ratio NRC/ Applicant
	Fuel Handling	Reactor	Auxiliary	Turbine			
I-131	2.3E+01	2.2E+01	2.2E+01	2.3E+01	0.0E+00	0.0E+00	2.3E+01
I-133	5.4E+00	5.3E+00	5.4E+00	5.4E+00	0.0E+00	0.0E+00	5.3E+00

Table 11.3.2 (2 of 2). Comparison of the NRC and applicant's PWR-GALE code calculations of expected annual gaseous effluent releases for noble gases.

Nuclide	Gas Stripping		Building Ventilation			Blowdown Vent Offgas	Air Ejector Exhaust	Ratio NRC/ Applicant
	Shutdown	Continuous	Reactor	Auxiliary	Turbine			
Kr-85m	1.0E+01	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Kr-85	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.4E+02	0.0E+00	0.0E+00	1.5E+00
Kr-87	8.8E+00	3.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Kr-88	1.6E+01	1.6E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xe-131m	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.6E+02	0.0E+00	0.0E+00	7.3E+00
Xe-133m	1.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.5E+01
Xe-133	9.0E+01	9.0E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xe-135m	1.0E+00	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.5E+00
Xe-135	1.3E+01	1.3E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E+02
Xe-137	1.0E+00	1.0E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Xe-138	2.0E+00	1.9E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.0E+00

Notes:
Value of 0.0E+00 appearing in the table indicates the gaseous effluent release is less than 1.0 Ci/yr for noble gases and 0.0001 Ci/yr for radioiodines. In the comparison, the NRC PWR-GALE code calculation uses the input design values in DCD Tier 2, Table 11.2-9, but with the NUREG-0017 noble gas containment leak rate of 3E-02/d and pre-ANSI/ANS-18.1-1999 source term specification as applied in the NRC PWR-GALE code.

11.3.4.6 Compliance with Airborne Effluent Dose Limits for Members of the Public

Under the requirements of 10 CFR Part 50, Appendix I, Sections II.A and II.D, an applicant is responsible for addressing the requirements of 10 CFR Part 50, Appendix I, design objectives in controlling doses to a maximally exposed member of the public and populations living near the proposed nuclear power plant. The requirements define dose objectives for gaseous effluents, and require a cost-benefit analysis in justifying installed processing and treatment equipment of the GWMS, including any augmentation to the design in complying with 10 CFR Part 50, Appendix I. DCD Tier 2, Section 11.3.1.5 states the COL applicant will perform the CBA. The applicant demonstrates compliance with the numerical design objectives of 10 CFR Part 50, Appendix I for calculating doses to the maximally exposed offsite individual using the guidance and methodology described in NUREG/CR-4653, "GASPAR II –Technical Reference and User Guide," with the GASPAR II computer code.

DCD Tier 2, Section 11.3.3.1,"Radioactive Effluent Releases and Dose Calculations in Normal Operation," describes the maximum individual doses at the EAB are calculated with the GASPAR II code and input design values in DCD Table 11.3-8, "Input Parameters for the GASPAR II Code." DCD Section 2.3.5, "Long-Term Atmospheric Dispersion Estimates for Routine Releases," provides the assumed onsite EAB and offsite χ/Q values of 1.6E-05 s/m^3 and 5.0E-06 s/m^3, respectively, to evaluate the individual doses for compliance with NRC regulations. In the US-APWR design, the onsite EAB χ/Q is selected as representative of plants operated in the US to be about 70 percent of the highest value at the corresponding EAB distance of many existing plants, while the offsite χ/Q is defined almost to envelop χ/Q at locations greater than the EAB distance. DCD Tier 2, Section 2.3.5 assumes an onsite and offsite deposition factor (D/Q) of 4.0E+08 1/m^2 as a conservative and bounding D/Q in the US-APWR design. The long-term onsite EAB χ/Q to estimate external and inhalation doses, offsite χ/Q to estimate food pathway doses for normal routine releases, and respective onsite and offsite D/Q are site-specific. Under COL Information Item 2.3(3), the COL applicant will characterize the atmospheric transport and diffusion conditions necessary for estimating radiological consequences of the routine release of radioactive materials to the atmosphere, and provide realistic estimates of annual average χ/Q and D/Q values as described in SRP Section 2.3.5. The staff's evaluation of the onsite EAB and offsite χ/Q values, onsite and offsite D/Q values, and COL Information Item 2.3(3) are discussed in Section 2.3.5 of this SE.

The calculated doses from gaseous effluent releases for age groups and exposure pathways are presented in DCD Tier 2, Table 11.3-9, "Calculated Doses from Gaseous Effluents (Sheets 1 and 2)." A gamma air dose of 2.10E+01 mrad/yr, beta air dose of 1.62E+00 mrad/yr, total body dose of 1.34E-01 mrem/yr, and skin dose of 1.26E+00 mrem/yr in Table 11.3-9 (Sheet 1), and MEI doses of 1.02E+01 mrem/yr (Child-Bone) and 4.61E+00 mrem/yr (Infant-Thyroid) in Table 11.3-9 (Sheet 2) at the EAB are shown from the GASPAR II code calculation. These doses demonstrate compliance with 10 CFR 20.1301(e) in meeting the EPA's environmental radiation protection standards of 40 CFR Part 190 for fuel-cycle facilities including nuclear power reactors. 40 CFR Part 190 specifies annual dose limits of 25 mrem/yr (whole body), 75 mrem/yr (thyroid), and 25 mrem/yr (any other organ) for members of the public exposed to planned discharges of radioactive materials. The estimated individual doses calculated by the GASPAR II code are less than 10 mrad/yr (gamma air dose), 20 mrad/yr (beta air dose), 5 mrem/yr (total body), 15 mrem/yr (thyroid, skin, or other limiting organ) specified in 10 CFR Part 50, Appendix I. However, the staff was not able to confirm the individual doses in DCD Tier 2, Table 11.3-9 (Sheet 2) because the annual gaseous releases input as the source term in the

GASPAR II code were calculated using the applicant's proprietary version of the NRC PWR-GALE code. The staff requested the applicant in **RAI 189-2006, Question 11.03-7** to provide the basis for all input design values used in the GASPAR II code calculation and the input/output files. By letter dated March 10, 2009, the applicant responded to the above RAI.

In response to **RAI 189-2006, Question 11.03-7**, the applicant provided pointers to Tier 2 information and references to RG 1.109. Under 10 CFR 2.390(a)(4), the applicant submitted the GASPAR II code input/output files. The input values listed in DCD Tier 2, Table 11.3-8 on the plant life of 60 years (DCD Tier 2, Table 1.3-1), EAB χ/Q of 1.6E-05 s/m^3 (DCD Tier 2, Table 2.0-1 (Sheet 1 of 5)), offsite food production χ/Q of 5.0E-06 s/m^3 (DCD Tier 2, Table 2.01-1 (Sheet 2 of 5)), D/Q site boundary of 4.0E+08 1/m^2 (DCD Tier 2, Table 2.01-1 (Sheet 2 of 5)), site boundary distance of 800 meters (0.5 miles) (DCD Tier 2, Sections 2.3.4 and 2.3.5), and food pathway parameters (RG 1.109) are design, assumed, or default values. Input design values such as site boundary distance, χ/Q, and food pathway parameters rely on site-specific information are addressed by the COL applicant in COL Information Item 11.3(6) evaluated below. Under COL Information Item 11.3(6), the applicant will justify or change these values to reflect the site-specific conditions.

In a comparative analysis, the staff performed gaseous effluent dose calculations with the NRCDose 2.3.14 code which contains the GASPAR II code distributed by RSICC using the input design values listed in DCD Tier 2, Table 11.3-8 and supplemental information provided from RAI responses. For the source term, the staff applied the annual gaseous releases calculated with the NRC PWR-GALE code and NUREG-0017 noble gas containment leak rate of 3E-02/d in place of the expected annual gaseous releases presented in DCD Tier 2, Table 11.3-5 (Sheets 1 to 3) calculated with the applicant's PWR-GALE code, noble gas containment leak rate of 2E-04/d, and the updated ANSI/ANS-18.1-1999 source term distribution to the gaseous effluent doses presented in DCD Tier 2, Table 11.3-9 (Sheets 1 and 2).

Table 11.3.3 of this SE shows the comparison of annual doses from gaseous effluents at the EAB. For gamma and beta air doses, and total body and skin doses due to noble gases including argon-41, there is no difference between the staff's and applicant's calculations. However, individual doses calculated by the staff are a factor of 1.71 times higher for the Child-Thyroid (7.15E+00 mrem/yr vs. 4.17E+00 mrem/yr), 1.38 times higher for the Infant-Thyroid (6.38E+00 mrem/yr vs. 4.61E+00 mrem/yr), 2.53 times higher for the Child-Bone (2.58E+01 mrem/yr vs. 1.02E+01 mrem/yr), and 2.26 times higher for the Teen-Bone (1.14E+01 mrem/yr vs. 5.02E+00 mrem/yr). For the dose to the Child-Bone, the results show that the organ dose limit of 15 mrem/yr is exceeded by a factor of 1.72 when gaseous effluent releases and doses are calculated with the NRC PWR-GALE code which applies the NUREG-0017 noble gas containment leak rate of 3E-02/d, pre-ANSI/ANS-18.1-1999 source term specification, and input design values listed in DCD Tier 2, Sections 11.2 and 11.3, and supplemental information provided in RAI responses.

In Section 11.2 of this SE, the staff reviewed the applicant's response to **RAI 523-4246, Question 11.02-30**, pertaining to use of the built-in plant capacity factor of 80 percent in the NRC PWR-GALE code for calculating the expected annual liquid effluent releases. The applicant's PWR-GALE code also applies the same plant capacity factor to calculate the expected annual gaseous effluent releases. An acceptable approach to determine the impact on gaseous effluent releases and doses for plant capacity factors above 80 percent is to increase or bound them by the ratio of the proposed and the built-in plant capacity factor.

To bound any plant capacity factor greater than 80 percent, the applicant applied a ratio of 1.25 (100 percent/80 percent) to the gaseous effluent doses calculated with the GASPAR II code in DCD Tier 2, Table 11.3-9, "Calculated Dose from Gaseous Effluents (Sheets 1 and 2)." When the ratio of 1.25 is applied to the annual offsite airborne concentrations in DCD Tier 2, Tables 11.3-6, "Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Expected Releases)," the adjusted sum-of-ratios (9.19E-03×1.25=1.15E-02) is not significantly affected. However, the adjusted sum-of-ratios in Table 11.3-7, "Comparison of Calculated Offsite Airborne Concentrations with 10 CFR 20 Limits (Expected Releases)," exceeds unity (9.12E-01×1.25=1.14E+00). Adjusting the reported doses in DCD Tier 2, Table 11.3-9 by the ratio of 1.25 results in 2.63E-01 mrem/yr (gamma air dose), 2.03E+00 mrem/yr (beta air dose), 1.68E-01mrem/yr (total body dose), 1.58E+00 mrem/yr (skin dose), and (Child-Bone) dose of 12.8 mrem/yr which are all less than the dose objectives of 10 mrad/yr (gamma air dose), 20 mrad/yr (beta air dose), 5 mrem/yr (total body dose), 15 mrem/yr (skin dose), and 15 mrem/yr (any organ dose), respectively, in 10 CFR Part 50, Appendix I.

The staff finds the applicant's added qualifier on the built-in plant capacity factor of 80 percent in the NRC PWR-GALE code for calculating the annual gaseous effluent releases and doses with the GASPAR II code in DCD Tier 2, Table 11.2-9, "Input Parameters for the PWR-GALE Code (Sheets 1 and 2)," acceptable, because the calculated gaseous effluent doses for normal releases including AOOs are not significantly affected based on the design input values used.

Under COL Information Item 11.3(6), the COL applicant is required to calculate doses to members of the public following the guidance of RG 1.109 and RG 1.111; compare the doses from gaseous effluents with the numerical design objectives of 10 CFR Part 50, Appendix I; and meet compliance with 10 CFR 20.1302 and 40 CFR Part 190. Because the site-specific input parameters values used in the GASPAR II code calculation of gaseous effluent doses are outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.3(6) acceptable.

The annual individual-pathway-organ doses, for one unit, calculated with the GASPAR II code in DCD Tier 2, Table 11.3-9 (Sheets 1 and 2) are determined from the input design values in DCD Tier 2, Table 11.3-8, and the gaseous effluent releases calculated with applicant's PWR-GALE code in DCD Tier 2, Table 11.2-9 (Sheets 1 and 2). As discussed in Sections 11.3.4.4 and 11.3.4.6 of this SE, the staff confirmed the applicant's calculations of the expected annual gaseous effluent releases and doses for normal operation including AOOs. **RAI 189-2006, Questions 11.03-7 and 11.03-8** are closed.

Table 11.3.3. Comparison of calculated annual doses from gaseous effluent releases at the EAB (0.5 miles) between the NRC and applicant's PWR-GALE codes.

Computer Code	Design Objective[1] (mrem/yr)	Applicant (mrem/yr)	NRC (mrem/yr)	Ratio NRC/Applicant
GASPAR II[2]	10 (Air γ)[4,5]	2.10E-01 (Air γ)[4,5]		
	20 (Air β)[4,5]	1.62E+00 (Air β)[4,5]		
	5 (Total Body)[5]	1.34E-01 (Total Body)[5]		
	15 (Skin)[5]	1.26E+00 (Skin)[5]		
	15 (Organ)	4.17E+00 (Child-Thyroid)		
	15 (Organ)	4.61E+00 (Infant-Thyroid)		
	15 (Organ)	1.02E+01 (Child-Bone)		
	15 (Organ)	5.02E+00 (Teen-Bone)		
NRCDose 2.3.14[3]	10 (Air γ)[4]		2.10E-01 (Air γ)[4,5]	1.00E+00
	20 (Air β)[4]		1.62E+00 (Air β)[4,5]	1.00E+00
	10 (Total Body)[5]		1.34E-01 (Total Body)[5]	1.00E+00
	15 (Skin)[5]		1.26E+00 (Skin)[5]	1.00E+00
	15 (Organ)		7.15E+00 (Child-Thyroid)	1.71E+00
	15 (Organ)		6.38E+00 (Infant-Thyroid)	1.38E+00
	15 (Organ)[6]		2.58E+01 (Child-Bone)[6]	2.53E+00
	15 (Organ)		1.14E+01 (Teen-Bone)	2.26E+00

Notes:
1. Numerical design objectives in 10 CFR Part 50, Appendix I for estimating annual doses above background from gaseous effluents to unrestricted areas for any individual in an unrestricted area from all exposure pathways are 10 mrad/yr (gamma air dose), 20 mrad/yr (beta air dose), 10 mrem/yr (total body), or 15 mrem/yr (any organ).
2. Gaseous effluent doses calculated with the GASPAR II code using gaseous effluent releases calculated with the applicant's PWR-GALE code, a proprietary version of the NRC PWR-GALE code.
3. Gaseous effluent doses calculated with the NRCDose 2.3.14 code using gaseous effluent releases calculated with the NRC PWR-GALE code.
4. Gamma (γ) and beta β) air doses are in mrad/yr.
5. Doses from noble gases including argon-41.
6. Calculated organ dose for the Child-Bone exceeds the dose objective of 15 mrem/yr.

11.3.4.7 Minimization of Contamination

The GWMS is designed to reduce volumes of gaseous wastes in the system and to the extent practicable, to minimize contamination to the facility and to the environment to facilitate eventual decommissioning to meet compliance with 10 CFR 20.1406. DCD Tier 2 Section 12.3.1.1.1.2, "Balance of Plant Equipment," describes US-APWR design features related to radiation protection on pumps, tanks, heat exchangers, valves, piping, and other equipment which reduce personnel exposures ALARA. DCD Tier 2 Sections 11.3.1.2, "Design Criteria," and 11.3.1.4, "Method of Treatment," state the GWMS is designed so interconnections between plant systems and the GWMS preclude the contamination of non-radioactive systems and uncontrolled releases of radioactivity to the environment. Additionally, at least two isolation valves are located between the clean and contaminated systems to minimize the potential for contamination of clean systems. Similarly, DCD Tier 2 Section 11.3.2.1.6, "Charcoal Adsorbers," states the double isolation valves are provided at each nitrogen interface point to prevent system contamination. DCD Tier 2 Section 11.3.1.6, "Mobile or Temporary Equipment," states the GWMS does not include the use of mobile or temporary equipment. DCD Tier 2 Section 11.3.2.2, "Design Features," states the GWMS is designed, constructed, and tested to be as leak-tight as practical.

The GWMS is designed to reduce through filtration removal of radioactive iodine (radioiodines) in the charcoal bed absorbers and holdup for decay of noble gases (Kr and Xe isotopes) in the waste gas surge tank radioactivity concentration levels in gaseous wastes held in subsystems and, to the extent practicable, minimize contamination to the facility and environment, and facilitate eventual decommissioning under 10 CFR 20.1406. Continuous use of waste gas compressors keeps the GWMS piping system pressurized to prevent airborne contaminants from entering into the system.

Other design features considered to meet compliance with 10 CFR 20.1406 include diaphragm valves with stem seals which have low leakage; steel piping with butt welded construction to minimize crud traps; collected condensed water in the gas is routed to the LWMS where curbed cells/cubicles housing liquid tanks with significant quantities of radioactivity are coated with non-porous impermeable epoxy coating evaluated in Section 11.2 of this SE; sumps are equipped with level switches to activate alarms for prompt operator action to minimize the spread of contamination; drains and overflows are routed directly to sumps to minimize the spread of radioactive liquid; non-radioactive auxiliary subsystems are isolated from the radioactive process streams; closure of the discharge isolation valve on low ventilation system exhaust flow rate and when the radiation monitor setpoint is exceeded, and annunciation of alarms to alert operators to close the discharge isolation valve and recycle the waste gases for additional treatment upon detection of radiation levels above the setpoint; monitoring hydrogen and oxygen concentrations to prevent explosions and flammable mixtures; and equipment, piping, and instruments are subject to stricter leak rate testing and inspection.

Under COL Information Item 12.1(8), evaluated in Section 12.3 of this SE, the applicant is required to develop operational procedures limiting leakage and the spread of contamination using the guidance of RG 4.21 for the operation and handling of all SSCs which could be potential sources of contamination within the plant.

RG 1.206, Section C.I.11.3 describes the minimum information that should be provided by applicant's to address system design features and operational procedures to ensure that interconnections between plant systems and mobile processing equipment avoids contamination of nonradioactive systems and uncontrolled releases of radioactivity in the environment using guidance in IE Bulletin 80-10 and RG 1.11. Because conformance with IE

Bulletin 80-10 was not addressed in DCD Tier 2, Section 11.3.1.2, the staff requested the applicant in **RAI 629-4973, Question 11.03-18, Item 4** to identify compliance with IE Bulletin 80-10 as considered in the GWMS design and also to address the same in DCD Tier 2, Sections 11.2, 11.4, "Solid Waste Management System," and 11.5, "Process Effluent Radiation Monitoring and Sampling Systems," and DCD Tier 2, Section 1.9, "Conformance with Regulatory Criteria." By letter dated September 24, 2010, the applicant responded to above RAI.

In response to **RAI 629-4973, Question 11.03-19, Item 4**, the applicant commits to revise DCD Tier 2, Sections 11.3.1.2 and 11.3.8 to identify conformance to IE Bulletin 80-10. IE Bulletin 80-10 referenced in RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," evaluated in Section 12 of this SE, is used, in part, to meet compliance with 10 CFR 20.1406.

The staff found the applicant's approach to meet compliance with 10 CFR 20.1406, as it relates to facility design and operational procedures for systems in minimizing the contamination of the facility and generation of radioactive waste, and the programmatic aspects and design features of SSCs intended to minimize contamination; and conformance to IE Bulletin 80-10, as it relates to avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled radioactive releases to the environment, acceptable. **RAI 629-4973, Question 11.03-18, Item 4** is being tracked as **Confirmatory Item 11.03-5**.

11.3.4.8 DCD Tier 1 Information

DCD Tier 1, Section 2.7.4.2, "Gaseous Waste Management Systems (GWMS)" describes the GWMS as a non safety-related system designed to: monitor, control, collect, process, handle, store, and dispose of gaseous radioactive waste generated as the result of normal operation including AOOs; provide sufficient capacity and flexibility to collect and process incoming radioactive waste gases for release; monitor hydrogen and oxygen content to prevent flammable mixtures; provide adequate delay and decay time before the waste gases before release into the environment through charcoal beds; and closure of the GWMS discharge valves upon detection of radiation levels above the set point. DCD Tier 1, Table 2.7.4.2-1, "Gaseous Waste Management System Inspections, Tests, Analyses, and Acceptance Criteria," describes the ITAAC for the GWMS. The ITAAC for the radioactive waste systems in DCD Tier 2, Section 14.3.4.7, "ITAAC for Plant Systems," and Table 14.3-6, "Plant Systems," includes verifying the performance of the GWMS as permanently installed systems.

The ability to maintain gaseous effluent concentrations below the dose limits in 10 CFR Part 20 depends upon the GWMS design, including the number and sizing of gas delay beds, processing equipment, effluent radiological monitoring and sampling systems, automatic control features in terminating releases that exceed alarm setpoints, in-plant process dilution before release via the plant vent stack, and instrumentation used to monitor and prevent the accumulation of explosive gas mixtures. Because this GWMS design feature is important to safety, the staff determined that ITAAC should be included to confirm design features in DCD Tier 2 information such as the proper initial introduction of charcoal absorbent and desiccant media in the system as it relies on such media to successfully process and treat gaseous wastes before discharge to the environment. Without confirming the initial introduction of the proper types and amounts of charcoal media and desiccants, and delay time, the GWMS would fail to meet the design criteria in DCD Tier 2, Section 11.3.1.2. As a result, gaseous effluent releases could exceed the ECLs in 10 CFR Part 20, Appendix B, the dose limits in 10 CFR Part 20, and dose objectives in 10 CFR Part 50, Appendix I. Accordingly, in **RAI 533-4261,**

Question 11.03-15, the staff requested that the applicant include the relevant Tier 1 information derived from the GWMS design description in DCD Tier 2, Section 11.3.1.2. By letter dated April 20, 2010, the applicant responded to the above RAI.

In response to **RAI 533-4261, Question 11.03-15**, the applicant states TS will be prepared to specify the initial types, sizes, and quantities of charcoal and desiccant media based on the GWMS design, and from performance data and/or test reports supplied by equipment vendors in the bid evaluation process. During the equipment fabrication phase, an engineering review is conducted to ensure that the GWMS design meets the TS. Inspections on the type, size, volume, and quality of the media will be conducted for acceptance during the equipment delivery. Procedures will be prepared to load the charcoal adsorbers and desiccant media to insure that the loading meets the GWMS design and the corresponding vendor specifications for the molecular sieve tanks and charcoal beds.

Under “System Purpose and Functions” to DCD Tier 1, Section 2.7.4.2.1, “Design Description,” the applicant added a description of the GWMS design to process radioactive gases using charcoal adsorbers and provide sufficient delay and decay time prior to release of gaseous effluents to ensure compliance with 10 CFR Part 20 and 10 CFR Part 50 when the plant is operational. The applicant also added under “Key Design Features” to DCD Tier 1, Table 2.7.4.2-1 information relating to sufficient delay time and the proper media type, quantity, size, and quality of charcoal in the GWMS design to meet the requirements of 10 CFR Part 20, Appendix B and 10 CFR Part 50, Appendix I. Further, DCD Tier 1, Section 2.7.4.2.1 and Table 2.7.4.2-1 require inspections on the media type, size, volume and quality of charcoal which are verified pre-operational inspections and testing to ensure that the media will meet or exceed the specified design criteria. The staff reviewed the applicant's response and finds it acceptable because the applicant commits to include this information in the next revision of the DCD. **RAI 533-4261, Question 11.03-15** is being tracked as **Confirmatory Item 11.03-1**.

Because the GWMS is not designed to withstand the effects of internal detonations, the staff has determined that ITAAC should be included to confirm that hydrogen and oxygen monitoring instrumentation is included in the GWMS design. Therefore, the staff issued **RAI 5534, Question 11.03-19**, requesting that the applicant provide an ITAAC to address explosive monitoring. **RAI 5534, Question 11.03-19** is being tracked as **Open Item 11.03-2**.

Other Tier 1 information associated with the GWMS is provided on the gaseous radwaste discharge monitor (RMS-RE-072) in DCD Tier 1, Table 2.7.6.6-1, “Process Effluent Radiation Monitoring and Sampling System Equipment Characteristics (Sheet 1 of 2),” Item 1 on the functional arrangement in DCD Tier 1, Table 2.7.6.6-2 (Sheet 1 of 2), and item 2 which requires the GWMS discharge valves to close in response to a GWMS effluent discharge isolation signal in DCD Tier 1, Table 2.7.4.2-1.

11.3.4.9 Technical Specifications

DCD Tier 2, Chapter 16, “Technical Specifications,” TS 5.5.12, “Explosive Gas and Storage Tank Radioactivity Monitoring Program,” provides controls to ensure that in the event of an uncontrolled release of a gas storage tank’s contents, the quantity of radioactivity is less than the amount that would result in a whole body exposure of greater than or equal 0.1 rem to any individual in an unrestricted area in accordance with BTP 11-5, “Postulated Radioactive Release due to Waste Gas System Leak or Failure.” DCD Tier 2, Chapter 16, TS 5.5.1, “Offsite Dose Calculation Manual, ODCM,” and TS 5.5.4, “Radioactive Effluent Controls Program,” provide methods and requirements in controlling releases of radioactive effluents and maintaining public doses ALARA. DCD Tier 2, Chapter 16, TS 5.6.1, "Annual Radiological Environmental Operating Report," and TS 5.6.2, "Radiological Effluent Release Report," specify annual reporting requirements in describing the results of the radiological monitoring program and provide summaries of the quantities of radioactive liquid effluents released in the environment.

As stated in TS 5.5.1, Licensee initiated changes to the ODCM shall be documented and contain the appropriate analyses or evaluations justifying any changes to maintain levels of radioactivity in effluent in compliance with the requirements of 10 CFR 20.1302, 40 CFR Part 190, 10 CFR 50.36a, and 10 CFR Part 50, Appendix I. TS also require the radioactive effluent controls program, which is contained in the ODCM, to include instrumentation to monitor and control liquid effluent discharges; meet limits on effluent concentrations released to unrestricted areas; monitor, sample, and analyze liquid effluents before and during releases; set limitations on annual and quarterly dose commitments to a member of the public; and assess cumulative doses from radioactive liquid effluents. The use of an ODCM is mandated under the operational programs described in DCD Tier 2, Section 13.4, "Operational Program Implementation."

The staff found these requirements acceptable because the implementation of such programs will be addressed in a plant- and site-specific ODCM under COL Information Item 11.5(2) in DCD Tier 2, Section 11.5.5 as described in DCD Tier 2, Table 1.8-2. The staff's evaluation of COL Information Item 11.5(2) is presented in Section 11.5 of this SE.

11.3.4.10 Preoperational Testing

DCD Tier 2, Section 14.2.12, "Individual Test Descriptions," describes individual test abstracts of preoperational and startup tests to verify that the plant systems and components meet design and performance objectives.

The principle test for the GWMS in DCD Tier 2, Section 14.2.12.1.81, "Gaseous Waste Management System Preoperational Test," includes test methods to verify control circuitry including response to normal control, interlock, and alarm signals; operation and performance of the waste gas compressors and waste gas dryer; and routing a test source gas through the charcoal beds. Other associated tests include DCD Tier 2, Section 14.2.12.1.79, "High-Efficiency Particulate Air Filters and Charcoal Adsorbers Preoperational Test," to demonstrate operation of the HEPA filters and charcoal adsorbers including the MCR HVAC system, technical support center (TSC) HVAC system, annulus emergency exhaust system and the containment purge system; and DCD Tier 2, Section 14.2.12.1.84, "Sampling System Preoperational Test," to demonstrate the capability of the sampling system to collect gaseous samples including the PAM system of the containment atmosphere, and the performance of laboratory equipment used for the analysis of effluent samples and determine if radionuclide concentrations comply with the ECLs of 10 CFR Part 20, Appendix B, Table 2, Column 1 for discharge to the environment and verify operation of system valves and control circuitry.

The staff reviewed these tests abstracts and issued the applicant RAIs on the information presented in DCD Tier 2, Section 14.2.12. The staff's evaluation of the applicant's responses and closure of these RAIs is addressed in Section 14.2 of this SE.

11.3.5 Combined License Information Items

Table 11.3-1 provides a list of GWMS related COL item numbers and descriptions from DCD Tier 2, Table 1.8-2:

Table 11.3-1 US-APWR Combined License Information Items

Item No.	Description	DCD Tier 2 Section
11.3(1)	Deleted	
11.3(2)	Deleted	
11.3(3)	The COL applicant is to provide a discussion of the onsite vent stack design parameters and release point specific characteristics.	11.3.2
11.3(4)	Deleted	
11.3(5)	Deleted	
11.3(6)	The COL applicant is to calculate doses to members of the public following the guidance of RG 1.109 (Reference 11.3-19) and RG 1.111 (Reference 11.3-22), and compare the doses due to the gaseous effluents with the numerical design objectives of 10 CFR 50, Appendix I (Reference 11.3-3) and compliance with requirements of 10 CFR 20.1302 (Ref. 11.3-24), 40 CFR 190 (Reference 11.3-25).	11.3.3.1
11.3(7)	Deleted	
11.3(8)	The COL applicant is to perform a site-specific cost benefit analysis to demonstrate compliance with the regulatory requirements.	11.3.1.5
11.3(9)	The COL applicant is to provide P&IDs.	11.3.2

As previously evaluated, the staff determined the above list of COL information items to be complete and adequately describes the actions necessary for the COL applicant or holder.

11.3.6 Conclusions

Except for the open items and confirmatory identified below, the staff concludes that the GWMS, as a permanently installed system, includes the equipment necessary to collect, process, hold for decay, and control releases of radioactive materials in gaseous effluents generated as a result of normal operation including AOOs. The applicant provided sufficient design information to demonstrate that it has met the requirements of 10 CFR 50.34a; 10 CFR 50.36a; 10 CFR Part 50, Appendix A, GDC 60, GDC 61, and GDC 64; and NRC guidance and SRP Section 11.3 acceptance criteria. This conclusion is based on the following:

- The US-APWR design demonstrates compliance with 10 CFR 50.34a, as it relates to the inclusion of sufficient design information and system design features that are necessary for collecting, processing, holding for radioactive decay, controlling, and monitoring safe discharges of gaseous wastes. The design conforms to the guidelines of SRP Section 11.3.

- The US-APWR design demonstrates compliance with the requirements of GDC 61, using the guidelines of RG 1.143, by providing sufficient treatment capacity, retention in charcoal delay beds, and holdup for radioactive decay in ensuring adequate safety under normal operation, AOOs, and postulated accident conditions. This commitment fulfills the requirements of 10 CFR 20.1406 and guidance of RG 4.21 and RG 1.143 in minimizing the contamination of the facility and generation of radioactive wastes, and concerns of IE Bulletin 80-10 in avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled radioactive releases to the environment.

- The US-APWR design meets the requirements of 10 CFR Part 50, Appendix A, GDC 60 with respect to controlling releases of gaseous effluents by monitoring GWMS discharges through the plant vent stack. GWMS releases are monitored by a radiation monitor, which will generate a signal to terminate gaseous releases before discharge concentrations exceed a predetermined radiation monitor setpoint. The COL applicant is required to determine the operational setpoint for its GWMS radiation monitor in a plant and site-specific ODCM under COL Information Item 11.5(2), as described in DCD Tier 2, Table 1.8-2. As part of this commitment, the COL applicant is required to demonstrate, through the ODCM, compliance with 10 CFR 20.1301(e), which incorporates by reference 40 CFR Part 190 for facilities within the nuclear fuel cycle, including nuclear power plants.

- The COL applicant referencing the US-APWR certified design will demonstrate compliance with 10 CFR Part 50, Appendix I, Section II.D design objectives for offsite individual doses and population doses resulting from gaseous effluents by preparing a site-specific cost-benefit analysis using NRC guidance under COL Information Item 11.3(6), as described in DCD Tier 2, Table 1.8-2.

- The US-APWR design demonstrates compliance with 10 CFR Part 50, Appendix A, GDC 3, as it relates to sufficient information and design features necessary for processing and recombining radiolytic decomposition gases and instrumentation in controlling and monitoring potentially explosive gas mixtures in gaseous waste processing equipment.

- The US-APWR design provides sufficient information and design features satisfying the guidance of RG 1.143 for radioactive waste processing systems in establishing the seismic and quality group classifications for system components and structures housing components.

For the following open items, tracked under **RAI 629-4973, Question 11.03-18, Item 2 and RAI 5534, Question 11.03-19,** the staff concludes, using the information presented in the application, that the applicant has not fully demonstrated compliance with NRC regulations and guidance controlling radioactive releases to the environment and associated doses to members of the public. The regulations are contained in 10 CFR Part 20, Appendix B, Table 2, Column 1; 10 CFR 20.1301; 10 CFR 20.1302; 10 CFR Part 50, Appendix I; 10 CFR 50.34a; 40 CFR Part 190 as referenced in 10 CFR 20.1301(e); and 10 CFR Part 50, Appendix A, GDC 3, and the guidance is contained in SRP Section 11.3. For the following confirmatory items, tracked under **RAI 533-4261, Question 11.03-15**; **RAI 535-4287, Question 11.03-16; RAI 535-4287, Question 11.03-17; and RAI 629-4973, Question 11.03-18, Items 1 and 4**, the staff will confirm that these items are incorporated into the next revision of the DCD.

11.4 Solid Waste Management System

11.4.1 Introduction

The SWMS is designed to collect and accumulate spent ion exchange resins and deep bed filtration media, spent filter cartridges, dry active wastes, and mixed wastes generated as a result of normal plant operation including AOOs. Processing and packaging of wastes are by mobile systems and the packaged waste is stored in the A/B and radwaste building until it is shipped offsite to a licensed disposal facility.

For the liquid and gaseous effluents generated during the operation of the SWMS, the associated releases of effluents in the environment and doses to members of the public are addressed by the staff's evaluation of the LWMS and GWMS in Sections 11.2 and 11.3, respectively, of this SE, as the SWMS does not directly discharge effluents into the environment.

11.4.2 Summary of Application

DCD Tier 1: The Tier 1 information associated with this section is found in DCD Tier 1, Section 2.7.4.3, "Solid Waste Management System," summarized here, in part, as follows:

The SWMS is located in the A/B. The portions of the A/B that house the principal SWMS equipment are designed to seismic Category II. The SWMS is a non safety-related system and serves no safety functions. A failure of the SWMS does not compromise safety-related systems or components and does not prevent the safe-shutdown of the plant. The SWMS consists of several subsystems design to handle spent resin and spent carbon, spent filter, sludge and oily waste, and dry active wastes (DAW). The spent resin and spent carbon handling and dewatering subsystem consist of SRST and a modular dewatering station including a control console, fillhead, and dewatering pump. Remote equipment for handling spent filter elements minimizes worker exposure. Sludge and oily wastes are collected in specially designed sumps and are pumped to shipping containers for offsite treatment and/or disposal.   separately collected at the point of generation and is packaged for disposal. The onsite wastes storage area in the A/B is equipped with an overhead crane and an indoor truck bay to load packaged waste for off-site transportation and disposal.

DCD Tier 2: The applicant has provided a system description in DCD Tier 2, Section 11.4 "Solid Waste Management System," summarized here, in part, as follows:

DCD Tier 2, Section 3.2, "Classification of Structures, Systems, and Components," describes the seismic and quality group classification and corresponding codes and standards that apply to the design of SWMS components, piping, and structures housing the system. The SRST and breakpot tank are designed to the seismic criteria of RG 1.143 (Revision 2), "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," and safety classification of RW-IIa; whereas, the fillhead, dewatering vacuum pump and sludge pump is RW-IIb based on the determination of the A1 and A2 quantities specified in 10 CFR Part 71, Appendix A. The SWMS is housed in a reinforced concrete structure to provide adequate shielding and minimize radiation exposures to personnel during operation and maintenance. The thickness of the shield walls of the radioactive waste areas is designed using the design basis source (1 percent failed fuel fraction) in DCD Tier 2, Table 11.1-2 "Design Basis Reactor Coolant Activity," and assumes assumed to be fully loaded with suspended solids and dissolved solids in the shielding analysis. The SWMS design consists of two SRST, components, and subsystems used to de-water or solidify radioactive waste prior to storage or offsite shipment.

If leaks or tank overflows were to occur in rooms containing such equipment or wastes, floor drains capture the resulting spills and route them to appropriate sumps and storage tanks of the liquid waste storage system. Each cubicle containing a SRST is designed to contain the maximum liquid inventory in the event the SRST ruptures. The SRST cubicles are coated with an impermeable epoxy liner (coating) up to the cubicle wall height equivalent to the full tank volume to facilitate decontamination of the facility in the event of a tank leakage and failure. This non-safety related Service Level II epoxy coating used as a design feature, in part, for compliance with 10 CFR 20.1406 is evaluated in Section 11.2 of this SE. Other design features such as early leak detection, drainage and transfer capabilities serve to minimize the release of the radioactive liquid to the groundwater and environment are evaluated in Section 11.4 of this SE.

The SWMS will be subjected to preoperational inspections and testing by the COL applicant to ensure that all subsystems are operationally ready and meet their design basis and performance characteristics, and all automatic interlock controls are fully operational.

DCD Tier 2, Section 11.4 describes the design of the SWMS and its functions in collecting, processing, packaging, storing, and preparing wet and dry solid radwaste for shipment and disposal. The SWMS processes and packages radioactive waste from the LWMS, the CVCS, and the spent fuel pit cooling and purification system (SFPCS). Wet solid radwaste can also be received from the condensate polishing system and the SG blowdown.

The SWMS is divided into five subsystems to handle the following waste types:

- DAW (dry waste)
- Spent filter elements (dry wastes)
- Spent resin (wet waste)
- Spent activated carbon (wet waste)
- Oil and sludge (wet wastes)

DAW includes contaminated clothing, gloves, rags, and shoe coverings; compressible materials such as HVAC filters and non-flammable organic solid materials; and contaminated metallic materials and incompressible solid objects such as contaminated wood, small tools, and equipment or subcomponents. Wet solid radioactive waste mainly consist of spent resin, spent charcoal, sludge, general contaminated plant debris, and spent filter elements. Sludge is stabilized and transported to a disposal facility. Oily waste is collected and sent to a licensed offsite vendor for processing and disposal.

The SWMS design includes a truck bay located next to the packaged waste storage area and provides an enclosed area to bring a shipping container and load packaged radioactive waste onto the truck and for offsite burial or processing in an offsite facility. A permanently installed overhead crane with a span of about 55 ft and lifting capacity of 40 tons is provided to move the packaged waste into and out of the waste storage area, and to load the radioactive waste onto shipping trucks. Radioactive waste is processed and packaged in approved Department of Transportation (DOT) containers acceptable to waste disposal facilities.

DCD Tier 2, Figure 1.2-38, “Auxiliary Building Sectional View A-A,” depicts the general arrangement of the A/B where the SWMS is located. DCD Tier 2, Section 9.4.3, “Auxiliary Building Ventilation System,” presents design information on ventilation systems servicing the A/B where SWMS subsystems are located, as well as systems used to collect gases vented from tanks and vessels. DCD Tier 2, Section 11.2 presents design information on the processing of equipment and floor drains including the collection of liquids from the SWMS.

DCD Tier 2, Table 11.4-1, “Expected Waste Volume Generated Annually by Each “Wet” Solid Waste Source,” identifies the volumes and waste classification of oil and sludge wet wastes generated. DCD Tier 2, Table 11.4-2, “Estimate of Expected Annual “Dry” Solid Wastes and Waste Classification,” identifies the volumes and waste classification of DAW, spent resin, spent filter, spent carbon, and sludge dry wastes generated based on average PWR operating experience. The expected annual solid waste volumes and classifications to be shipped offsite are estimated in DCD Tier 2, Table 11.4-3, “Calculated Shipped Solid Waste Volumes and Classification.” DCD Tier 2, Table 11.4-4, “Solid Waste Management System Component Data Summary,” describes the SWMS components including the capacities, construction materials, applicable codes for the design of the tanks, pumps, and the de-watering mobile unit.

DCD Tier 2, Section 11.4.5, “Malfunction Analysis,” describes the four administrative conditions (steps) to be verified by the operator before each resin transfer operation. The first three steps described are manual operations controlled by plant procedures while the fourth step automatically stops the resin transfer operation if the condition is not met. An operator may interrupt the resin transfer operation at any time and restart the process at the same point in the process after the failure is corrected without adverse consequences. A series of safety interlocks protects the spent resin handling subsystem from component failure and operator error through a series of safety interlocks such as manual start and automatic stop, and the level and temperature alarms which automatically stop the resin transfer operation. DCD Tier 2, Table 11.4-5, “Equipment Malfunction Analysis,” evaluates the major equipment malfunctions considered in the SWMS design.

DCD Tier 2, Section 11.4.7, “Instrumentation Requirements,” states the SWMS is operated and monitored from the radwaste control room in the A/B with the exception of the fillhead operation that is performed from a local control panel. Major system parameters such as SRST level and process flow rate, etc. are indicated and alarmed to provide operational information and performance assessment. Key system alarms such as the SRST high-level alarm are also indicated in the MCR. Alarm instruments and readout locations are identified in DCD Tier 2, Table 11.4-6, “Instrument Indication and Alarm Information Page.” Alarm instruments including back flushing provisions are located in low radiation areas when possible for accessibility and ALARA considerations.

The SWMS process flow diagrams are presented in DCD Tier 2, Figure 11.4-1, “Process Flow Diagram of SWMS Dry Active Waste and Spent Filter Handling Sub-system,” Figure 11.4-2, “Process Flow Diagram of SWMS Spent Resin and Charcoal Handling Sub-System,” and Figure 11.4-3, “Process Flow Diagram of SWMS Oil and Sludge Handling System.”

DCD Tier 2, Section 11.4.1.2, “Design Criteria,” states any liquids and gases generated from the operation of the SWMS are processed by the LWMS (described in DCD Tier 2, Section 11.2) and the plant ventilation system (described in DCD Tier 2, Section 9.4). Any liquids and gases from operation of the SWMS are routed to the LWMS and GWMS for treatment. As a result, the assessment of radiological impacts associated with the expected liquid and gaseous effluents generated during the operation of the plant, including those from SWMS, is addressed in DCD Tier 2, Sections 11.2 and 11.3 for the LWMS and GWMS, respectively. Sections 11.2 and 11.3 of this SE provide the staff's evaluation of liquid and gaseous effluent releases and doses, respectively.

The SWMS design criteria in DCD Tier 2, Section 11.4.1.2 provide the means to package radwaste for compliance with 10 CFR Part 61 and the applicable parts of 10 CFR Parts 60 and 63; collect, process, package, and store radioactive waste for compliance with 10 CFR Part 20; to contain radioactive waste for compliance with 49 CFR Part 171; and process and package radioactive waste for transportation and disposal for compliance with 49 CFR Part 173, Subpart I using the acceptance criteria of SRP Section 11.4 and NRC guidance.

ITAAC: The ITAAC associated with DCD Tier 2, Section 11.4, "Solid Waste Management System," are given in DCD Tier 1, Section 2.7.4.3, "Solid Waste Management System (SWMS)," and Table 2.7.4.3-1, "Solid Waste Management System Inspections, Tests, Analyses, and Acceptance Criteria." DCD Tier 2, Section 14.3.4.7, "ITAAC for Plant Systems," summarizes how ITAAC were developed for DCD Tier 1, Section 2.7.4.3.

TS: There is information pertinent to TS associated with the SWMS in DCD Tier 2, Section 11.4.3.2, "Process Control Program," and DCD Tier 2, Chapter 16, Section 5.5.1, "Offsite Dose Calculation Manual (ODCM)."

10 CFR 20.1406: There is information pertinent to 10 CFR 20.1406 in DCD Tier 2, Sections 11.4.1.4, "Method of Treatment," and 11.4.2.5, "Operation and Personnel Doses."

COL information or action items: (See Section 11.4.5 below).

Technical Report(s): There are no technical reports associated with this area of review.

Topical Report(s): There are no topical reports associated with this area of review.

US-APWR Interface Issues Identified in the DCD: There are no US-APWR interface issues associated with this area of review.

Site Interface Requirements Identified in the DCD: There are no site interface requirements associated with this area of review.

Cross-cutting Requirements (Three Mile Island [TMI], Unresolved Safety Issue [USI]/Generic Safety Issue [GSI], Op Ex): There is a cross-cutting issue for this area of review described in NUREG-0933 and Resolution of Generic Safety Issues: Section 2. Task Action Plan Items (NUREG-0933, Main Report Item C-17: Interim Acceptance Criteria for Solidification Agents for Radioactive Solid Wastes).

RTNSS: There are no RTNSS issues for this area of review.

CDI: This section of the DCD does not contain CDI that is outside the scope of the US-APWR certification.

11.4.3 Regulatory Basis

The relevant requirements of NRC regulations for the radioactive waste system, and the associated acceptance criteria, are given in SRP Section 11.4 of NUREG-0800 and are summarized below. Review interfaces with other SRP sections can be found in NUREG-0800, Section 11.4.

1. 10 CFR 20.1302 and 10 CFR 20.1301(e), as they relate to radioactive materials released in gaseous and liquid effluents to unrestricted areas.

2. 10 CFR 20.1406, as it relates to the design and operational procedures for minimizing contamination, facilitating eventual decommissioning, and minimizing the generation of radioactive wastes.

3. 10 CFR 50.34a, as it relates to providing sufficient information and design features to demonstrate that design objectives for equipment necessary to control releases of radioactive effluents from the SWMS to unrestricted areas are kept as low as reasonably achievable.

4. 10 CFR Part 50, Appendix I, Sections II.A, II.B, II.C, and II.D, as they relate to the numerical guides, design objectives, and limiting conditions for operation to meet the ALARA criterion for equipment installed to process and treat wet and solid radioactive wastes.

5. 40 CFR Part 190 (the EPA generally applicable environmental radiation standards), as implemented under 10 CFR 20.1301(e) and as it relates to controlling doses within EPA generally applicable environmental radiation standards.

6. 10 CFR Part 50, Appendix A, GDC 60, as it relates to the design of the SWMS to control the release of radioactive materials in liquid and gaseous effluents from the SWMS and to handle wet and solid wastes produced during normal plant operation, including AOOs.

7. 10 CFR Part 50, Appendix A, GDC 61, as it relates to the system design for solid radioactive waste systems and the ability of such systems containing radioactivity to assure adequate safety under normal operation including AOOs and suitable shielding for radiation protection.

8. 10 CFR Part 50, Appendix A, GDC 63, as it relates to the ability of solid radioactive waste systems to detect conditions that may result in excessive radiation levels and to initiate appropriate safety actions.

9. 10 CFR 52.47(b)(1), which requires that applications for DC contain the proposed IITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the DC is built, will operate in accordance with the DC and provisions of the Atomic Energy Act and the NRC regulations.

Regulatory guidance adequate to meet the above requirements includes:

1. BTP 11-3 (Revision 3), "Design Guidance for Solid Waste Management Systems Installed in Light-Water Cooled Nuclear Power Plants," dated March 2007.

2. NUREG-0800, SRP Section 11.4, Appendix 11.4-A, including updated guidance from SECY-93-323, “Withdrawal of Proposed Rulemaking to Establish Procedures and Criteria for On-Site Storage of Low-Level Radioactive Waste After January 1, 1996,” and SECY-94-198, “Review of Existing Guidance Concerning the Extended Storage of Low-Level Radioactive Waste,” with respect to long-term onsite storage (e.g., for several years, but within the operational life of the plant).

3. RG 1.143, as it relates to the seismic design, quality group classification of components, general guidelines for design, construction, and testing criteria for radioactive waste systems; and general QA guidelines for radioactive waste management systems.

4. RG 4.21, as it relates to minimizing the contamination of equipment, plant facilities, and environment, and minimizing the generation of radioactive waste during plant operation.

5. GL 89-01, as it relates to the restructuring of the process control program (PCP) and RETS. (Included in NUREG-1301).

6. NUREG-1301, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors,” dated April 1991, as it relates to the development of a plant-specific PCP. Alternatively, a COL applicant may use NEI PCP Template 07-10A (Revision 0, dated March 2009) for the purpose of meeting this regulatory milestone until a plant-specific PCP is prepared, before fuel load, under the requirements of a license condition described in FSAR Tier 2, Section 13.4 of a COL application. The NEI PCP Template 07-10A has been determined to be acceptable by the staff (ML091460627).

7. RIS 2008-32, “Interim Low Level Radioactive Waste Storage at Reactor Sites,” dated December 30, 2008, as it relates to the use of the NRC and industry guidance in addressing limited access to radioactive waste disposal facilities.

8. RG 8.8 (Revision 3), “Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable,” dated June 1978.

9. RG 8.10 (Revision 1-R), “Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable,” dated May 1977.

10. IE Bulletin 80-10, as it relates to methods and procedures used in avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled releases of radioactivity.

11.4.4 Technical Evaluation

The staff reviewed the SWMS in accordance with the guidance of SRP Section 11.4 to determine whether it complies with the requirements of 10 CFR 50.34a; GDC 60, GDC 61, and GDC 63; and the guidance contained in RG 1.143, RG 8.8, and RG 8.10. GDC 60 requires that the SWMS is designed to control releases of liquid and gaseous effluents. GDC 61 requires that the SWMS is designed to ensure adequate safety under normal operations and AOOs, and GDC 63 requires equipment in waste storage areas to detect conditions that may result in excessive radiation levels and initiate appropriate safety actions. 10 CFR 50.34a requires an applicant to provide sufficient design information to demonstrate that the design objectives have been met as they relate to the inclusion of systems and components necessary to process radioactive materials and control releases of radioactive effluents into the environment.

The relevant requirements of GDC 60, GDC 61, and GDC 63 are met by using the regulatory positions contained in RG 1.143, as they relate to the seismic design, quality group classification of components used in the design of the SWMS and structures housing the systems, and provisions used to control leakage and minimize contamination. Other relevant aspects of RG 1.143 address design and construction methods, materials specifications, welding, and inspection and testing standards for SWMS components and piping. RG 8.8 and RG 8.10 address design and operational features to ensure that ambient radiation levels result in occupational exposures that are ALARA. The COL applicant is required to verify the performance of the SWMS as permanently installed systems or in combination with mobile processing equipment in DCD Tier 2, Section 14.3.4.7, "ITAAC for Plant Systems."

The staff reviewed proposed construction standards and methods; system process flow outlines and descriptions; anticipated operational programs, material specifications and potential leakage paths; sources of solid and wet wastes, expected waste volumes and radioactivity levels; flow paths of liquids through subsystems, including potential bypasses; and provisions for monitoring radioactivity levels in process streams and after wastes are containerized for storage or shipment.

The evaluation of the SWMS includes a review of design, design objectives, design criteria, system P&ID, process flow diagrams showing methods of operation, and factors that influence waste treatment (e.g., system interfaces and potential bypasses to nonradioactive systems and radiation monitoring). The review addresses methods used to segregate and treat wastes, estimates of annual waste generation rates and total radioactivity levels and assumptions applied in deriving these estimates, and methods applied to control process flows and reduce releases of liquid and gaseous effluents into the environment, such as with the use of filtration, adsorption, and storage for radioactive decay.

DCD Tier 2, Table 11.4-4, "Solid Waste Management System Component Data Summary," provides a listing of major system components with information on industry codes and standards, volumetric capacities, processing flow rates, and operating conditions such as pressure and temperature, and material grades. DCD Tier 2, Figures 1.2-29, "Auxiliary Building at Elevation -26'-4" - Plan View," 1.2-31, "Auxiliary Building at Elevation 3'-7" - Plan View," and 1.2-38, "Auxiliary Building Sectional View A-A," present the general arrangement of the A/B where the major components of the SWMS are located. DCD Tier 2, Section 9.4.3, "Auxiliary Building Ventilation System," presents design information on the ventilation system servicing the SWMS. DCD Tier 2, Table 12.3-4, "Area Radiation Monitors," provides information such as detector types and exposure rate ranges, areas serviced, and control functions on area radiation monitors, and DCD Tier 2, Table 12.3-45, "Airborne Radioactivity Monitors," lists areas serviced, detector type and activity concentration ranges, calibration isotopes, etc. DCD Tier 2, Figures 12.3-1, "Radiation Zones for Normal Operation/Shutdown (Sheet 14 of 34) Auxiliary Building Sectional View A-A," 12.3-1, "Radiation Zones for Normal Operation/Shutdown (Sheet 17 of 34) Auxiliary Building at Elevation 3'-7"," 12.3-1, "Radiation Zones for Normal Operation/Shutdown (Sheet 21 of 34) Auxiliary Building at Elevation 50'-2"," and 12.3-1, "Radiation Zones for Normal Operation/Shutdown (Sheet 22 of 34) Auxiliary Building at Elevation 76'-5," depict the main floor plans and associated radiation zones associated with the SWMS. DCD Tier 2, Section 11.2 describes design information on the processing equipment and floor drains, including the collection of liquids from the SWMS. DCD Tier 2, Figure 11.5-1h, “Typical Plant Vent Radiation Monitor Schematic,” depicts an overview of the process flow from the SWMS through the GWMS to the point of release via the plant vent stack for gaseous effluents and via the LWMS discharge line for liquid effluents.

The radiological impact associated with the operation of the SWMS is addressed by the staff’s review and evaluation of the LWMS and GWMS since the SWMS does not release liquid and gaseous effluents directly to the environment. The staff’s evaluation in Sections 11.2 and 11.3 of this SE considers liquid and gaseous effluents generated during the processing of solid and wet wastes, and whether the equipment and design features are acceptable and complies with the requirements of 10 CFR 20.1302; 10 CFR Part 20, Appendix B, Table 2, Columns 1 and 2; 10 CFR 20.1406; 10 CFR Part 50, Appendix I; and 10 CFR 20.1301(e) to control doses within the EPA generally applicable environmental radiation standards under 40 CFR Part 190.

The SWMS consists of the solid waste processing and storage systems for treating dry solid wastes, and the radioactive concentrates processing system for the treatment of wet solid wastes. Subsystems provide the equipment and methods for the collection, handling, treatment, and storage of various forms of solid and wet radioactive waste. The SWMS reduces the volume of waste material through compaction, shredding, segregation, and evaporation of water contained in waste streams. The SWMS provides the means for the temporary storage of radioactive materials and packaged wastes prior to shipment to a licensed offsite storage or disposal facility.

Dry solid radioactive wastes typically consist of paper, plastic, cloth, wood, metal parts, concrete, glass, stabilized spent-charcoal and filtration media from the LWMS and GWMS, and other potentially contaminated discarded materials generated during normal, maintenance, and refueling operations. The wastes are collected, segregated, and treated based on radiological, physical, and chemical properties. Solid wastes are initially classified as combustible, compressible, and non-combustible and non-compressible.

Combustible wastes are separated and compressible wastes are compacted to reduce their overall storage or disposal volumes. Other criteria may be used for segregating wastes, such as physical shapes and dimensions, types of materials, and chemical properties, among others. Wastes containing residual amounts of liquids and moisture are stored separately and treated to prevent decomposition of the waste, formation of combustible gas mixtures, and corrosion of containers. Non-combustible and compressible wastes are compacted in storage drums and held in temporary storage. Combustible and non-compressible wastes are either segregated or fragmented and transferred into drums or other types of containers.

The approach to low-level radioactive waste (LLRW) management and storage presumes that LLRW will be disposed of by shipment to an authorized recipient under 10 CFR 20.2001(a)(1). Under this approach, the applicant should demonstrate the capability of the means included in the design to process dry solid and wet wastes so that these wastes meet the classification and characterization definitions in 10 CFR 61.55 and 10 CFR 61.56, respectively.

GDC 60 requires that a plant design include provisions to handle radioactive wastes produced during normal reactor operation including AOOs, and to control releases of radioactive materials to the environment. GDC 60 requires that adequate capacity to hold and store gaseous and liquid radioactive wastes, particularly where unfavorable site environmental conditions may impose unusual operational limitations in releasing effluents. In addition to the provisions described for the SWMS, the holdup capacity for liquid and gaseous effluents is addressed in DCD Tier 2, Sections 11.2 and 11.3 for the LWMS and GWMS, respectively.

GDC 61 and GDC 63 require that radioactive waste systems include features that ensure adequate safety under normal operation and postulated accident conditions, including the means to enable inspection and testing of components important to safety, suitable shielding and ventilation for radiation protection, and means to detect conditions that may result in excessive radiation levels in waste storage locations and initiate appropriate actions. GDC 61 and GDC 63 require that the SWMS include shielding and ventilation design features to protect workers and control releases of gaseous radioactivity in the environment. DCD Tier 2, Sections 11.4.2 and 12.3, "Radiation Protection Design Features," describe design features of the A/B to shield components expected to contain higher levels of radioactivity and display higher radiation exposure rates. Similarly, gaseous phases released from tanks and vessels are captured by the A/B ventilation system and monitored before being released to the environment through the GWMS via the plant vent stack. Finally, the design includes radiation monitors installed on system components and in the A/B to monitor ambient radiation exposure rates and airborne radioactivity levels and alert operators of changing conditions and when to take corrective steps. DCD Tier 2, Section 11.4.5, "Malfunction Analysis," and Table 11.4-5, "Equipment Malfunction Analysis," identify results and actions for malfunctions with spent resin transfer operations; high integrity container (HIC) filling, temperature, and crane operations; SRST leak, temperature, pressure, and level; earthquake damage to the SWMS; and breakpot level.

The staff found the SWMS design features to be acceptable with respect to meeting the guidance in SRP Section 11.4 and RG 1.143, RG 8.8, and RG 8.10, as described in DCD Tier 2, Sections 11.4.2, 9.4.3, and 12.3 on radiation shielding and ventilation to control radiation exposures to workers. Accordingly, GDC 61 and GDC 63 are met in this regard. The staff's evaluation of the A/B ventilation system is presented in Section 9.4.3 of this SE, and the evaluations of the occupational radiation protection program and associated plant design features are presented in Section 12 of this SE. The staff's evaluation of the fire protection system is presented in Section 9.5 of this SE, and the evaluation of the conduct of operation and response to plant emergencies is presented in Section 13 of this SE.

11.4.4.1 Design Considerations

The SWMS in the US-APWR collects, handles, processes, packages, and temporarily stores dry and wet solid waste generated by the plant prior to offsite shipping and disposal resulting from normal operation including AOOs. The SWMS is described in DCD Tier 1, Section 2.7.4.3, "Solid Waste Management System (SWMS)," and DCD Tier 2 Section 11.4, "Solid Waste Management System." The staff reviewed the SWMS description in accordance with the review procedures and acceptance criteria in SRP Section 11.4 as it relates to system design.

10 CFR 50.34a requires the applicant for design approval to submit a general description of the provisions for packaging, storage, and shipment offsite of solid waste containing radioactive materials resulting from treatment of gaseous and liquid effluents and from other sources. GDC 60 requires that the nuclear power unit design include provisions to handle radioactive wastes produced during normal reactor operation including AOOs.

DCD Tier 2, Section 11.4.2, "System Description," provides a description of the equipment and processes used in solid radioactive waste handling and processing. DCD Tier 2, Figures 11.4-1 through 11.4-3 presents process flow diagrams for the SWMS. To ensure compliance with 10 CFR 50.34a, a P&ID of the SWMS is needed to evaluate the system design features to control radioactive effluent releases and review the interfaces with interconnecting systems. Both the DCD Tier 2, Section 11.4.6 and Table 1.8-2 provide a COL information item for the COL applicant to address the site-specific P&ID. Under COL Information Item 11.4(2), the COL applicant is required to provide the P&ID. Because these diagrams require site-specific information which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.4(2) acceptable. From a review of Revision 1 to DCD Tier 2, Section 11.4, the staff found that the SWMS boundaries were not defined and requested the applicant in **RAI 187-2008, Question 11.04-8** to provide this information. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-8**, the applicant states the SWMS boundary starts at specific waste generation streams and ends at the waste storage and truck bay for solid waste shipment. Packaged wastes are transferred to licensed offsite waste processing and disposal facilities. The applicant also stated there is no direct discharge of waste to the environment. In DCD Tier 2, Section 11.4.2, the applicant added a description of the main solid waste streams treated by the SWMS and boundaries of spent resins, spent filters, sludge and mixed wastes, and miscellaneous low concentration wastes. The staff reviewed the applicant's response and found it to be acceptable. The staff also confirmed that Revision 2 to DCD Tier 2, Section 11.4.2 included this information. **RAI 187-2008, Question 11.04-8** is closed.

The SWMS is separated into five subsystems to handle the following types of waste: DAW, spent filter elements, spent resin, spent activated carbon, and oil and sludge. These subsystems provide for the collection, handling, treatment, and storage of the various forms of solid radioactive waste.

The SWMS subsystem for processing and storage of dry active wastes includes a truck bay next to the packaged waste storage area to provide an enclosed area to load packaged waste into a shipping container. A permanently installed overhead crane with a lifting capacity of 40 tons is provided to move packaged waste in the storage area. The staff's evaluation of dry solid wastes and storage capacities is presented in Section 11.4.4.8 of this SE.

The spent filter element handling subsystem provides for remote changing of filter cartridges, dripless transport to the storage area, transfer into and out of filter storage, and the loading of filters into disposal containers.

The spent resin handling and de-watering subsystem is comprised of two cross tied SRST, one for low radioactive resin and one for high radioactive resin, and dewatering station consisting of a control console, a fillhead, and a dewatering pump. When spent resins are to be transferred, the fill head is manually mounted on a HIC. Nitrogen gas is used as the motive force for transferring resin from the SRST to the HIC. The dewatering pump then reduces water content in the HIC to less than 0.5 percent by volume. SRST vents are routed to a breakpot located downstream of the SRST relief valve. In **RAI 187-2008, Question 11.04-7**, the staff requested the applicant to provide the description, specifications, and applicable codes on the breakpot tank; include the breakpot tank in DCD Tier 2, Figure 11.4-2; verify the correct labeling of “breakup pipe” lines routed to the HT and WHT. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-7**, the applicant added specifications, applicable codes, tank shape, orientation, and sizing of the breakpot in DCD Tier 2, Table 11.4-4. In DCD Tier 2, Figure 11.4-2, the applicant corrected various labels by replacing “BREAKUP PIPE” with “BREAKUP TANK,” “HOLDUP TANK” with “GWMS,” and “DRAIN TO WASTE HOLDUP TANK” with “DOWNSTREAM A/B SUMP.” The applicant also revised DCD Tier 2, Section 11.4.4.1.2, “Breakpot Tank,” to describe the breakpot tank design. The staff reviewed the applicant’s response and found it to be acceptable. The staff confirmed that Revision 2 to DCD Tier 2, Sections 11.4.2 and 11.4.4.1.2, and Table 11.4-4 included this information. **RAI 187-2008, Question 11.04-7** is closed.

Processing of spent charcoal is done utilizing the SRST and dewatering equipment in the spent charcoal handling subsystem. However, DCD Tier 2, Section 11.4.2.2.2, “Spent Charcoal Handling,” states, “the spent activated carbon from the LWMS is normally sent directly to disposal containers.” In **RAI 187-2008, Question 11.04-14**, the staff requested the applicant to describe how this direct transfer is performed. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-14**, the applicant stated the activated carbon filter stream can be routed either to the SRST or directly to the HIC via a fillhead by shutting off inlet valves to the SRST and opening up a bypass valve to the HIC. The two SRST provide staging of low radioactive resin/carbon from the LWMS for decay and transfer capability into HIC for offsite disposal. Any standing water in the HIC is removed and/or reduced by the de-watering pump to less than 0.5 percent by volume to meet the requirements of 49 CFR 173, Subpart I. The staff reviewed the applicant's response and found it to be acceptable. **RAI 187-2008, Question 11.04-14** is closed.

DCD Tier 2, Section 11.4.2.2.3, “Oil and Sludge Handling,” employs the use of area sumps, which are designed to separate oil in areas where equipment uses oil for lubrication and decontamination. The separated oils are transferred directly to drums and sent to offsite for processing and disposal. In **RAI 187-2008, Question 11.04-13**, the staff requested the applicant to clarify the pump terminology. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-13**, the applicant stated the “sump pump” described in DCD Tier 2, Section 11.4.4.2.1, “Sludge Pump,” is the same component as the “sludge pump” in DCD Tier 2, Table 11.4-4, and replaced “sump pump” with “sludge pump” in DCD Tier 2, Section 11.4.4.2.1. The staff reviewed the applicant’s response and found it to be acceptable. The staff confirmed that Revision 2 to DCD Tier 2, Section 11.4.4.2.1 included this information. **RAI 187-2008, Question 11.04-13** is closed.

The applicant states no effluent is released from the SWMS. Liquid removed from the spent resin is transferred the WHT for processing in the LWMS. The individual SWMS component vent is processed through the GWMS or the HVAC system. From a review of DCD Tier 2, Figure 11.4-2, the staff requested the applicant in **RAI 187-2008, Question, 11.04-15** to specifically describe the disposition of the gaseous exhaust from the fill head during transfer and dewatering activities. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question, 11.04-15**, the applicant added in DCD Tier 2, Section 11.4.2.2.1, “Spent Resin Handling and De-watering Substation,” to state the gaseous exhaust from the fillhead during transfer and dewatering activities is vented via a vent port connection on the fillhead to the A/B ventilation system. The staff reviewed the applicant’s response and finds it acceptable because provisions to adequately handle gaseous effluents have been provided in the SWMS design. The staff confirmed that Revision 2 to DCD Tier 2, Sections 11.4.2.2.1 included this information. **RAI 187-2008, Question 11.04-15** is closed.

Based on the discussions above, the staff finds that the applicant complies with the requirements of 10 CFR 50.34a and GDC 60 with respect to provisions for handling solid radioactive wastes.

Compliance with GDC 61 requires that the SWMS shall be designed to ensure adequate safety under normal and postulated accident conditions. This criterion specifies that the design of such facilities shall enable inspection and testing of components important to safety and with suitable shielding for radiation protection. RG 1.143 (Revision 2), "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," provides guidance for compliance with GDC 61 related to the design of the SWMS, including provisions for equipment to be used to prevent and contain spillage while pumping, filling, pouring, and overfilling waste containers or system tanks and features to contain the contents of resin storage tanks in the event of subsystem failures.

RG 1.143 provides the applicable design codes, seismic design criteria, QA, safety-classification and natural phenomena and man-induced hazards design criteria for radioactive waste systems. The seismic and quality group classification of the SWMS building and components are discussed in DCD, Tier 2, Section 3.2, "Classification of Structures, Systems, and Components." However, the applicant did not provide safety classifications for the SWMS in accordance with Regulatory Position C.5 to RG 1.143. Consequently, the staff requested the applicant in **RAI 187-2008, Question 11.04-6** to discuss the safety classes in DCD Tier 1, Section 2.7.4, "Radwaste Systems," or DCD Tier 2, Section 11.4 and describe how the Regulatory Position C.5 to RG 1.143 is met. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-6**, the applicant stated the SWMS and LWMS are classified as RW-IIa (High Hazard) and are housed in the A/B. DCD Tier 2, Section 3.7.2.8.4, "A/B," states the A/B is designed as seismic Category II which has more stringent wind, tornado, and flood design requirements than safety classification RW-IIa in RG 1.143. The applicant revised DCD Tier 1, Section 3.7.4.3.1, "Design Description," to state portions of the A/B that house the principal SWMS equipment are designed to seismic Category II, and the SWMS is a non-safety system with non seismic components. The applicant also stated the SWMS component classifications in DCD Tier 2, Section 3.2, Table 3.2-2, item 16, are consistent with Table 1 to RG 1.143. Because the SSC classifications for the SWMS were not identified in DCD Section 11.4, **RAI 188-2007, Question 11.04-6**, was considered closed, but the issue it raised regarding the SSC classifications remained open. As a result, the staff requested that the applicant in **RAI 536-4289, Question 11.04-21**, to provide a discussion of the SWMS components with the safety classifications (RW-IIa, RW-IIb, or RW-IIc) for conformance to RG 1.143, Regulatory Position C.5. By letter dated April 20, 2010, the applicant responded to **RAI 536-4289, Question 11.04-21**.

In response to **RAI 536-4289, Question 11.04-21**, the applicant stated the SWMS components were classified based on their radionuclide inventory determined using the components volume and its source term in DCD Tier 2, Chapter 12, "Radiation Protection." The applicant compared the radionuclide inventory to the A_1l and A_2 quantities in 10 CFR Part 71 using the guidance in RG 1.143. Based on the comparison, the applicant concluded that the SRST and breakpot tank are RW-IIa and the remaining SWMS components are RW-IIc.

The applicant commits to add Table 11.4-7, "Component Classification," to DCD Tier 2, Chapter 11 listing the SWMS components (SRST fillhead, breakpot tank, de-watering vacuum pump, and sludge pump) and the respective safety classifications (RW-IIa or RW-IIc). The staff reviewed the applicant's response and found that the safety classification for the breakpot tank should be RW-IIa rather than RW-IIc as listed in DCD Tier 2, Table 11.4-7 of the response.

Based on the discussions above, the staff finds the SWMS design conforms to the relevant guidance of RG 1.143 and BTP 11-3, as they relate to the seismic design, quality group classification of SWMS components, A/B housing the SWMS, and SWMS design features.

With the exception of the editorial correction related to the breakpot tank safety classification in DCD Tier 2, Table 11.4-7, the staff confirmed that Revision 2 to DCD Tier 1, Section 2.7.4.3.1, "Design Description," included this information under "Seismic and ASME Code Classifications." **RAI 187-2008, Question 11.04-6** is closed, but **RAI 536-4289, Question 11.04-21** is being tracked as **Confirmatory Item 11.04-4**.

DCD Tier 2 Section 11.4.2.2.1, "Spent Resin Handling and De-watering Subsystem," describes design features to prevent and contain spillage of a HIC during transfer activities. The applicant provided flow elements, interlocks, and level and temperature instrumentation to ensure that the proper amount of resin is transferred and to prevent an overflow. The resin transfer is automatically stopped when a high level or high temperature set point is reached or can be manually stopped by an operator. Remote and continuous viewing of container filling and de-watering is provided through the use of a closed captioned television camera (CCTV). In **RAI 187-2008, Question 11.04-16**, the staff requested the applicant to clarify in DCD Tier 2, Section 11.4.2.2.1, whether the CCTV acronym refers to "closed circuit television" rather than "closed captioned television." By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-16**, the applicant commits to revise DCD Tier 1, "Acronyms and Abbreviations," and DCD Tier 2, Section 11.4.2.1 and replace "closed captioned television" with "closed circuit television." Although the staff confirmed that DCD Tier 2, Section 11.4.2.1 included this information, the CCTV acronym and abbreviation was not added to DCD Tier 1, "Acronyms and Abbreviations." **RAI 187-2008, Question 11.04-16** is being tracked as **Confirmatory Item 11.04-1**.

The staff concludes that with the exception of the open and confirmatory items described above, the SWMS meets the requirements of GDC 61 providing assurance that releases of radioactive materials during normal operation and AOOs including adverse conditions on system components, and will not result in radiation doses that exceed the dose limits specified in 10 CFR Part 20.

GDC 63 requires that radioactive waste systems be able to detect conditions that may result in excessive radiation levels in waste storage locations and to initiate appropriate safety actions. The spent resin handling and de-watering subsystem is alarmed as to provide operational information and performance assessment. DCD Tier 2, Section 11.4.7, "Instrumentation Requirements," states the alarm instruments and location of readouts is presented in DCD Tier 2, Table 11.4-6, "Instrument Indication and Alarm Information Page." From review of Table 11.4-6, the staff found that the alarm locations were not identified and requested the applicant in **RAI 187-2008, Question 11.04-17** to provide the location of the alarms and readouts. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-17**, the applicant revised DCD Tier 2, Table 11.4-6 to include the SWMS indication and alarm locations as requested. The staff reviewed the applicant's response and found it to be acceptable because Table 11.4-6 includes alarm locations as stated in DCD section 11.4.7. The staff confirmed that Revision 2 to DCD Tier 2, Table 11.4-6 included this information. **RAI 187-2008, Question 11.04-17** is closed. The staff also finds that the SWMS meets the requirements of GDC 63 with respect to spent resin handling and de-watering subsystem design because instrumentation and alarms have been provided.

DCD Tier 2, Section 11.4.2.5, "Operation and Personnel Doses," describes several SWMS design features to minimize personnel doses to meet compliance with the dose limits specified in 10 CFR Part 20 and the guidance in RG 8.8 during normal operation including AOOs. The SRST are located in individually shielded cubicles in the A/B. These cubicles lined with epoxy coatings are not normally occupied and the entrance is under physical and administrative controls. Cubicle entrances are provided for ease of inspection, ingress, and egress to minimize stay time and radiation doses. The de-watering operation is performed in a shielded and steel-lined cubicle and controlled in a separately shielded cubicle and/or in the radwaste control room. The fillhead is handled remotely and has motors to automatically dislodge from the HIC to minimize contact handling after filling. Ventilation air is designed to flow from areas of low contamination to areas of high contamination. The ventilation air in the dewatering area is controlled and exhausted from the de-watering area to maintain air quality and minimize airborne radioactivity. Radioactive waste is processed and stored in shielded areas except for low activity waste such as contaminated clothing and decontaminated component parts and/or broken tools. Access to the radwaste storage areas is under physical and administrative controls to minimize personnel doses. The staff's evaluations of the occupational radiation protection program and methods used for monitoring and controlling radiation exposures and doses ALARA for compliance with NRC requirements are presented in Section 12 of this SE.

DCD Tier 2, Section 11.4.3.1 "Radioactive Effluent Monitoring," states the SWMS does not have liquid effluents. De-watered effluent and drainage is collected and sent to WHT for processing in the LWMS. The equipment and storage area vents are combined with other HVAC vents and gaseous effluents from the GWMS for processing and discharge by the A/B HVAC system, and then released via the plant vent stack to the environment. Several radiation monitors are associated with the SWMS for routine operation, AOOs, and post-accident monitoring to meet compliance with GDC 13, GDC 60, GDC 63, and GDC 64. Treated gaseous waste is monitored by the gaseous radwaste discharge monitor (RMS-RE-072) before it is released into the plant vent stack. Upon detection of radiation level above the setpoint determined by the COL applicant, a radiation monitor alarm activates in the MCR and radwaste control room and initiates closure of the discharge valve and the HVAC damper. The HVAC duct in the A/B is monitored for radiation with the A/B HVAC radiation monitor (RMS-RE-048B). The plant vent stack is monitored with dual and redundant plant vent radiation gas monitors (RMS-RE-021A/B) after the radioactive gases and the HVAC vents are mixed. Two plant vent extended radiation gas monitors (RMS-RE-80A/B) are provided to operate under post-accident conditions. The process effluent and radiation monitors are evaluated in Section 11.5 of this SE.

11.4.4.1.1 Epoxy Coatings

Since Revision 1 to DCD Tier 2, Section 11.4 was issued, the US-APWR design changed from lining rooms housing SRST with steel to using an impermeable epoxy coating. For DCD Tier 2, Section 11.4, these changes impact Sections 11.4.2, "Design Criteria," 11.4.1.4, "Method of Treatment," 11.4.2.5, "Operation and Personnel Doses," Section 11.4.9, "References," and Table 11.4-5, "Equipment Malfunction Analysis," to meet compliance with 10 CFR 20.1406 and 10 CFR 20.1302; and conformance to BTP 11-3 and RG 4.21 to minimize the potential for contamination of groundwater in the event of a tank failure or overflow. The design changes related to epoxy coatings in DCD Tier 2, Sections 11.2 and 11.4 are described in applicant responses to **RAI 91-1496, Question 12.03-12.04-2** dated October 20, 2008; **RAI 164-1925, Question 11.02-1** dated February 18, 2009; **RAI 185-2031, Question 11.04-1** dated March 11, 2009; **RAI 401-3031, Question 11.04-18** dated July 15, 2009; **RAI 403-3027, Questions 11.02-18 and 11.02-19** dated July 15, 2009; and **RAI 523-4246, Question 11.02-29** dated March 15, 2010, which consolidates the NRC concerns on the epoxy coating system in the US-APWR. The epoxy coating system used for lining cells/cubicles in the LWMS and SRST rooms in the SWMS is evaluated in Section 11.2 of this SE.

11.4.4.2 Cost-Benefit Analysis

DCD Tier 2, Section 11.4.1.5, "Site-Specific Cost-Benefit Analysis," describes the SWMS design for use at any site with flexibility to incorporate site-specific requirements with minor modifications such as preference of technologies, the degree of automated operation, and radioactive waste storage. RG 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors," describes an acceptable method of performing a CBA to demonstrate that the SWMS design includes all items of reasonably demonstrated technology for reducing cumulative population doses from releases of radioactive materials from each reactor to ALARA levels. The applicant states the CBA for the US-APWR design demonstrates that the addition of items of reasonably demonstrated technology will not provide a more favorable cost benefit, but does not include a CBA in DCD Tier 2, Section 11.4.1.5. The COL applicant will provide the site-specific CBA to demonstrate compliance with 10 CFR Part 50, Appendix I, Sections II.A and II.D under COL Information Item 11.4(6), as described in Table 1.8-2, "Compilation of All Combined License Applicant Items for Chapters 1-19 (Sheet 31 of 44)." Although the staff found the inclusion of COL Information Items 11.2(5) and 11.3(8) acceptable, as evaluated in Sections 11.2 and 11.3, respectively, of this SE, the staff acknowledges that the CBA is not required for the SWMS because there are no effluent releases to the environment from the SWMS that result in doses to members of the public in unrestricted areas. Therefore, even though the applicant provides COL Information Item 11.4(6) in both DCD Tier 2, Sections 11.4.8 and Table 1.8-2, its description is not required in DCD Tier 2, Section 11.4.

11.4.4.3 Mobile or Temporary Equipment

DCD Tier 2, Section 11.4.1.6, "Mobile or Temporary Equipment," describes the SWMS design with permanently installed equipment such as tanks and a crane, modular equipment such as the spent resin de-watering subsystem, and mobile equipment. The modular and mobile design intends to ease equipment replacement from advances in treatment technologies and/or broken equipment.

From review of Revision 1 to DCD Tier 2, Section 11.4.1.6, "Mobile or Temporary Equipment," and DCD Tier 2, Table 11.4-4, "Solid Waste Management System Component Data Summary," the staff determined that clarification on flexible hoses and hose connections in the SWMS design was needed. As a result, in **RAI 185-2031, Question 11.04-2**, the staff requested that the applicant address the codes and standards for flexible hoses and hose connections used in conjunction with a mobile radwaste processing system in accordance with Table 1 to RG 1.143 (Revision 2) and provide the COL information item for the modular design and mobile system not included with the permanently installed SWMS equipment. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 185-2031, Question 11.04-2**, the applicant described several design features of the mobile or temporary equipment to meet compliance with 10 CFR 20.1406 and conformance to RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," such as rigid stainless-steel piping design-run to the future mobile area, and special connectors to prevent accidental connection of contaminated fluid to clean piping. The applicant stated no flexible hoses are used up to this point. The connections from these points to the future mobile unit and the design of the future mobile unit are the responsibility of the COL applicant in COL Information Item 11.4(4) evaluated below. The staff finds that the applicant's response is acceptable because the applicant states rigid stainless-steel piping is design-run to the future mobile area, but not flexible hoses. **RAI 185-2031, Question 11.04-2** is closed.

DCD Tier 2, Section 11.4.1.6 requires the COL applicant conform to ANSI/ANS-40.37-1993 for solid radioactive waste processing with the mobile system or temporary equipment, and to take responsibility for the mobile system or temporary equipment in COL Information Items 11.4(4) and 11.4(5). From review of DCD Tier 2, Section 11.4.1.6, the staff determined that information regarding conformance to ANSI/ANS-40.37-1993, revision of COL Information Item 11.4(4), and tests on the future mobile unit were needed. As a result, in **RAI 534-4256, Question 11.04-19**, the staff requested that the applicant justify use of ANSI/ANS-40.37-1993 as it was withdrawn by the ANSI/ANS; describe in DCD Tier 2, Sections 11.2 and 11.4, the procedural outline that will be used to control and contain leakage produced during normal operation including and AOOs from operation of the future mobile unit for compliance with 10 CFR 20.1406 and conformance to IE Bulletin 80-10 previously included in COL Information Item 11.4(4) in Revision 1 to DCD Tier 2, Section 11.4, but was removed in Revision 2 to DCD Tier 2, Section 11.4; describe the tests such as pressure testing, hydrostatic testing, etc. performed to ensure that flexible connections used between the permanently installed equipment and the future mobile unit described in DCD Tier 2, Sections 11.2 and 11.4 to verify that the SWMS design specifications are met; and describe how the future mobile unit design and COL Information Item 11.4(4) adopts these control measures and provisions, conforms to RG 1.143, and complies with 10 CFR 50.34a and 10 CFR 20.1406 in DCD Tier 2, Sections 11.2 and 11.4. By letter dated April 20, 2010, the applicant responded to the above RAI.

In response to **RAI 534-4256, Question 11.04-19**, the applicant stated Section 5.3.14.1, "Dewatering Equipment," of ANSI/ANS-40.37-2009 contains the same requirements as the 1993 version of the ANSI/ANS standard except with new information on overflow prevention and the US-APWR design addresses overflow prevention by hi- and hi-hi level controls, alarms, visual verification and operator actions, The applicant commits to revise DCD Tier 2, Sections 11.4.1.4, 11.4.1.6, and 11.4.9, and conform to ANSI/ANS-40.37-2009 or its equivalent requirements at the time of use. The applicant described the dewatering equipment in the US-APWR as an intermediate step to remove standing water in HIC forwarded to a WHT for reprocessing in the LWMS to remove radioactive contamination, and is not released into the effluents to unrestricted areas.

The applicant also commits to revise DCD Tier 2, Sections 11.2 and 11.4 to address the requirements in IE Bulletin 80-10 for the future mobile and temporary liquid radioactive waste processing equipment and its interconnection to plant systems; revise DCD Tier 2, Sections 11.2.1.6, 11.2.5, 11.4.4.5, 11.4.8, and 11.4.9 to acknowledge IE Bulletin 80-10; revise COL Information Item 11.4(4) requiring the COL applicant to prepare a plan to develop and use operating procedures for the future mobile units in accordance with IE Bulletin 80-10 in order to control and contain leakage produced during normal operation including AOOs. Because operating procedures acknowledging IE Bulletin 80-10 for mobile units require site-specific information which is outside the scope of the requested design certification, the staff finds the inclusion of COL Information Item 11.4(4) acceptable.

The applicant also states the flexible hoses for the dewatering equipment and the future mobile unit is hydrotested to at least 1.5 times the system design pressure and held for 30 minutes without leakage or bloating to verify the integrity of the hose and assembled end-fittings prior to use. Section 6.4.5, “Flexible Hoses and Hose Connections,” of ANSI/ANS-40.37-2009 describes the operating guidance for mobile units should include guidance for hose specifications, configuration, and maintenance. The mobile or temporary equipment and its connections to permanently installed equipment will be subjected to hydrostatic testing using the guidance in BTP 11-3 and RG 1.143.

The staff reviewed the applicant's response and finds it acceptable because the applicant commits to revise the DCD to include this information. **RAI 534-4256, Question 11.04-19** is being tracked as **Confirmatory Item 11.04-2.** In response to **RAI 91-1496, Question 12.03-12.04-2**, evaluated in Section 12.3 of this SE, the applicant provided the design features used to minimize contamination for compliance with 10 CFR 20.1406 and conformance to RG 4.21. The applicant commits to add COL Information Item 11.4(9) to ensure that mobile and temporary solid radioactive waste processing (i.e., mobile de-watering system) equipment, structures and component operations and testing and its interconnection to plant systems meets the requirements in 10 CFR 50.34a and 10 CFR 20.1406, and the guidance in RG 1.143. The applicant also commits to add COL Information Item 12.1(8) in DCD Tier 2, Chapter 12, “Radiation Protection,” evaluated in Section 12 of this SE, requiring the applicant to develop operational procedures limiting leakage and the spread of contamination using the guidance in RG 4.21 for the operation and handling of all SSCs which could be potential sources of contamination within the plant. Because mobile and temporary solid radioactive waste processing requires site-specific information which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.4(9) acceptable.

Based on the discussion above, the staff finds that the SWMS design specifications and features used for solid waste processing with the mobile system or temporary equipment acceptable.

11.4.4.4 Compliance with Effluent Concentration Limits and Doses to Members of the Public

Under 10 CFR Part 20, Appendix B, and 10 CFR Part 50, Appendix I, applicants are responsible for addressing requirements in controlling radioactive effluent releases in unrestricted areas and doses to a hypothetical maximally exposed member of the public and populations living near the proposed nuclear power plant. The requirements for liquid and gaseous effluent releases are in 10 CFR Part 20, Appendix B, Table 2, Columns 1 and 2, respectively. 10 CFR Part 50, Appendix I, Sections II.A, II.B, and II.C contain the requirements for doses to maximally exposed individuals from liquid and gaseous effluents. The requirements for a CBA in justifying installed processing and treatment systems for liquid and gaseous wastes are specified in Section II.D of Appendix I to 10 CFR Part 50. The LWMS and GWMS control the liquid and gaseous effluent releases, respectively, generated by the SWMS. Accordingly, compliance with the requirements of 10 CFR Part 20, Appendix B, and 10 CFR Part 50, Appendix I, for the SWMS is subsumed in DCD Tier 2, Section 11.2 for the LWMS and in DCD Tier 2, Section 11.3 for the GWMS. Sections 11.2 and 11.3 of this SE present the staff’s evaluation on the applicant's submittal of the respective DCD Tier 2 sections related to the RWMS for compliance with 10 CFR Parts 20 and 50.

11.4.4.5 Process Control Program

DCD Tier 2, Section 11.4.3.2, "Process Control Program," states the PCP which contains site-specific requirements needs to be consistent with the guidance in NEI PCP Template 07-10A (Revision 0), "Generic FSAR Template Guidance for Process Control Program (PCP)." The PCP will be developed to meet the requirements in 10 CFR Part 71 and conform to the guidance in NUREG-1301, NUREG-0133, and RG 1.109, RG 1.111, or RG 1.113. Implementation of the PCP using the NEI PCP Template 07-10A ensures that radioactive waste once treated and packaged for shipment and disposal will meet the NRC and DOT shipping regulations and acceptance criteria of the disposal site.

The development of a PCP is addressed under SECY-05-0197, RG 1.206, and SRP Section 11.4. A COL applicant referencing the US-APWR certified design will develop a plant-specific PCP which identifies the operating procedures (i.e., boundary conditions for a set of process parameters, such as settling time, drain time, drying time, etc.) for processing wet wastes and parallel sets of conditions in processing and preparing dry solid wastes. DCD Tier 2, Section 11.4.1.2, "Design Criteria," states the SWMS is designed to package radioactive wastes in accordance with 10 CFR Part 61 and the applicable portions of 10 CFR Parts 60 and 63; shipping containers will meet the requirements in 49 CFR Part 171; and solid wastes are processed and packaged for transportation and disposal in accordance with 49 CFR Part 173, Subpart I. In addition to the waste classification and characterization requirements in 10 CFR Part 61, wastes shipped for disposal must conform with the requirements in 10 CFR 20.2007 in demonstrating compliance with other applicable Federal, State, and local regulations governing the presence of any other toxic or hazardous properties in radioactive wastes, such as mixed wastes. Similarly, transactions of wastes shipped for disposal or to commercial waste processors must be recorded, and under 10 CFR 20.2108, such records must be maintained until the NRC terminates the license. DCD Tier 2, Section 11.4.1.2 states the SWMS is designed to meet the requirements of 10 CFR 20.1301(e); 10 CFR 20.2006; 10 CFR 20.2007; and 10 CFR 20.2108.

NEI 07-10A was determined to be acceptable by the staff (ML091460627) for the purpose of meeting the regulatory milestone to develop a plant-specific PCP with the format and content of the PCP, as described in NUREG-0133, until a plant-specific PCP is prepared before fuel load under the requirements of a license condition in FSAR Section 13.4, "Operational Program Implementation," of a COL application. Under COL Information Item 11.4(3), the COL applicant is responsible for preparing a plan for the plant-specific PCP to describe the process and effluent monitoring and sampling program. Because the PCP is an operational program and requires plant-specific information that is beyond the scope of the requested DC, the staff finds inclusion of COL Information Item 11.4(3) acceptable.

11.4.4.6 Task Action Plan

NUREG-0933, Section 2, "Resolution of Generic Safety Issues," includes a task action plan which identifies items covering a wide variety of subjects, and includes Task Action Plan item C-17, "Interim Acceptance Criteria for Solidification Agents for Radioactive Solid Waste." In addressing Task Action Plan, Item C-17, DCD Tier 2, Section 11.4 describes design features of the SWMS to collect, process, and package wet and dry solid wastes before shipment to disposal sites or offsite waste processors. As a result, the COL applicant is responsible for the implementation of a plant-specific PCP presenting operating procedures and TS for the classification, treatment, and disposal of radioactive wastes in accordance with regulatory requirements of the NRC, DOT, and State and local agencies. The parameters and criteria, used to process, treat, store, and ship wastes will be included in a plant-specific PCP and implementing procedures. The guidance on the development of a plant-specific PCP is contained in GL 89-01 and NUREG-1301. The commitment to develop a PCP is identified under COL Information Item 11.4(3) in DCD Tier 2, Section 11.4 and Table 1.8-2. In fulfilling this commitment as described in the SRP Section 11.4, the COL applicant has two options: 1) prepare a plant-specific PCP using the NRC criteria and guidance; or 2) adopt by reference NEI Generic FSAR Template Guidance for PCP 07-10A (Revision 0) in meeting this regulatory milestone. Either option is acceptable in complying with Task Action Plan Item C-17.

11.4.4.7 Radioactive Waste Storage and Shipment

DCD Tier 2, Section 11.4.1.2, “Design Criteria,” Section 11.4.1.4, “Method of Treatment,” and Section 11.4.3.3, “Packaged Waste Storage and Shipment,” describe the SWMS design as having sufficient onsite storage to hold processed waste in accordance with ANSI/ANS-55.1-1992, “Solid Radioactive Waste Processing System for Light-Water-Cooled Reactor Plants.” Section 4.1, “Process Design,” of ANSI/ANS-55.1-1992 states, the “radioactive waste solidification system shall provide for the temporary storage of up to 30 days of anticipated normal waste generation for packaged waste awaiting transport.”

DCD Tier 2, Sections 11.4.2.1, “Dry Solid Waste,” and 11.4.2.2, “Wet Solid Waste,” discuss a margin of 40 percent included in the design of the total generation and storage of dry and solid wastes, respectively, to account for higher than normal operation rate of waste generation during some AOOs such as a refueling condition. DCD Tier 2, Tables 11.4-2, “Estimate of Expected Annual “Dry” Solid Wastes and Waste Classification,” and 11.4-1, “Expected Waste Volume Generated Annually by Each “Wet” Solid Waste Source,” present the volumes of dry and wet solid wastes, respectively, expected to be generated annually from operating experience and industry practices from similar PWR plants, but provided insufficient information on expected volumes of dry and solid wastes generated from AOOs such as a refueling condition. As a result, in **RAI 185-2031, Question 11.04-4**, the staff requested that the applicant provide the basis for the 40 percent design margin on the total generation and storage of dry and wet solid wastes, and describe the design and/or operational features used to satisfy this design margin. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 185-2031, Question 11.04-4**, the applicant described the solid waste storage area as divided into high activity waste (Class B/C waste) and low activity waste (Class A waste) storage areas. The high activity waste storage area is designed with about 570 ft^2 of space with an actual storage area, after crane clearance around 400 ft^2, for up to 12 HIC (each with a diameter of 62 inches and assuming 4 inches clearance between HIC without stacking between HIC). The applicant anticipates the waste will occupy about 6 to 8 HIC of spent resin for the high activity storage area depending on activity levels. Using an average of 7 containers, the design margin of about 40 percent is determined. The low activity storage waste area is designed with a space about 1,600 ft^2 with an actual storage area about 1,000 ft^2. The applicant assumes sufficient waste is generated during refueling operation to fill a B-25 box, 12 drums, and 2 HIC to occupy an area of less 600 ft^2 allowing for separation spaces for crane access.

The annual projected solid waste generated over one year during normal operation including and AOOs is presented in DCD Tier 2, Table 11.4-3, “Calculated Shipped Solid Waste Volumes and Classification,” which describes the annual projected solid waste generated during normal operation and AOOs. DCD Tier 2, Section 11.4.2.3, “Packaging, Storage, and Shipping,” assumes volumes of 100 ft^3 for Class B or C wastes and 174 ft^3 for Class A waste to estimate the number of containers and potential shipments. DCD Section 11.4.2.3, "Packaging, Storage, and Shipping," states packaging and shipment of solid waste for disposal complies with 10 CFR 20, Appendix G, and 49 CFR Part 173, Subpart I. For 30 days of operation, the applicant estimates about 3 containers of Class B waste and 20 containers of Class A waste will be generated. Because the applicant has provided the basis for the 40 percent design margin on the total generation and storage of dry and wet solid wastes, the staff finds the applicant's response acceptable.

When additional storage capability is desired, under COL Information Item 11.4(1), the DCD requires that the COL applicant identify plant-specific needs and provide a discussion of onsite storage of LLRW in accordance with ANSI/ANS-55.1-1992. COL Information Item 11.4(1) also provides that it is the COL applicant's responsibility to determine the number of shipments to support plant operations, long-term radioactive waste, and onsite storage information. Because an assessment of onsite storage needs and the number of shipments needed to support plant operations, long-term radioactive waste, and onsite storage information, all require plant-specific information that is beyond the scope of the requested DC, therefore, the staff finds inclusion of COL Information Item 11.4(1) acceptable.

The operation for the packaging of spent resin, spent charcoal, and spent filters are performed remotely and controlled from the radwaste control room and/or local control console for filter replacement and spent resin dewatering. Shielding and ventilation is provided for the filling and dewatering area to ensure airborne radioactivity is controlled in accordance with ALARA principles. Waste is classified as A, B, C or greater than Class C in accordance with 10 CFR 61.55 and 10 CFR 61.56. Each container of processed waste is classified using a site-specific 10 CFR Part 61 waste form in the plant-specific PCP. Packaged waste is sampled and analyzed. During the filling operation, the waste is also monitored for radioactivity to ensure it meets the disposal requirements for the licensed land disposal facility. DCD Tier 2, Section 11.4.2.3 states the filled waste containers are normally shipped promptly after they are filled or staged in the shielded waste storage area if a shipment cannot be promptly arranged, or if a single shipment is not cost-effective. Waste containers can be retrieved from the waste storage area for a shipment and are loaded inside the truck bay area in the A/B to minimize radiation doses. DCD Tier 2, Section 11.4.2.3 describes preparation of waste manifests on the waste type and chemical and radiological characteristics based on sampling and analysis, and states packaged wastes comply with the requirements of in 10 CFR 61.55 and are verified before shipment offsite for treatment and/or disposal. DCD Tier 2, Table 11.4-1 provides estimated volumes of oily waste and sludge generated during normal operation and maintenance. The estimated volumes of 35 ft^3/yr for oily and 50 ft^3/yr for sludge wastes based on plant operating experience, noted in DCD Tier 2, Table 11.4-1 as being slightly radioactive, are pumped directly into drums where sorbent is added to stabilize the liquid for shipment to an approved facility for treatment and disposal.

DCD Tier 2, Section 11.4.3.3, "Packaged Waste Storage and Shipment," states packaged waste is stored in the radioactive waste storage area inside a shielded area in the A/B. The SWMS is designed to use DOT-approved containers accepted by waste disposal facilities. A movable wall which separates the low activity storage from the high-level storage area is used to shield HIC. The HIC and drums are moved between the high and low activity storage areas and into the truck bay area through a notch in the movable wall. DCD Tier 2, Figure 11.5-2c, "Location of Radiation Monitors at Plant (Power Block at Elevation 3'-7")," depicts the temporary onsite storage of processed waste in the A/B next to the truck bay. For the purpose of estimating 30 days of onsite storage space, HIC with 100 ft^3 usable volumes, 55-gallon drums, and B-25 boxes are used to calculate the storage requirements. The staff finds that these standard waste volumes of DOT-approved containers are acceptable for estimating onsite storage space.

Based on the applicant's projected LLRW generation rates and an evaluation of physical space of the facility, the staff determined the US-APWR design has sufficient temporary onsite storage capacity for up to 30 days of anticipated normal waste generation in accordance with ANSI/ANS-55.1-1992. The need for storage space capacity beyond that which is built into the certified design is left to the determination of the COL applicant, based on implementation of a plant-specific LLRW management plan and plant-specific PCP, part of which requires the COL applicant to address storage capacity. The design of a new building or modifications to existing storage provisions should conform to the guidelines of BTP 11-3 and SRP Section 11.4, Appendix 11.4-A, and the requirements of 10 CFR Part 20 in protecting members of the public and plant workers. The COL applicant may store LLRW at one of its existing operating reactor sites or commercially procure the necessary storage space such as through a waste processor.

The NRC has issued technical and regulatory guidance on the storage of LLRW. In GL 81-038, "Storage of Low Level Radioactive Wastes at Power Reactor Sites," the NRC provides guidance to licensees on the addition of onsite LLRW storage facilities. Appendix 11.4-A, "Design Guidance for Temporary Storage of Low-Level Radioactive Waste," to SRP Section 11.4 and RIS 2008-32, "Interim Low Level Radioactive Waste Storage at Reactor Sites," provides guidance on waste storage at reactor sites. Appendix 11.4-A addresses the guidance of GL 80-009, "Low Level Radioactive Waste Disposal," on LLRW disposal; GL 81-038 discusses the storage of LLRW at reactor sites; and GL 81-039, "NRC Volume Reduction Policy," presents the NRC's LLRW volume reduction policy. IE Circular 80-18, "10 CFR 50.59 Safety Evaluations for Changes to Radioactive Waste Treatment Systems," presents criteria in considering changes made to radioactive waste treatment systems under the requirements of 10 CFR 50.59 for license holders. Collectively, the guidance addresses technical issues in considering the duration of the intended storage, types and forms of LLRW, selection and expected long-term integrity of storage containers, and amounts of radioactive materials contained in LLRW in ensuring public health and safety, minimizing doses to operating personnel, and protection of the environment.

In considering the design and construction of an onsite LLRW storage facility or modifications to existing storage capacity, the COL applicant is expected to follow the requirements of the change process that will be outlined in the US-APWR DC rule (similar to the process included in 10 CFR 50.59), as it relates to facility modifications, changes in SSCs that could affect performance, and compliance with the requirements in 10 CFR Parts 20 and 50, and changes in methods described in the DCD and operating procedures.

The staff recognizes that the need for additional onsite storage capacity for LLRW is a site-specific consideration that depends, in part, on whether the State or a regional LLRW compact has provided a facility for long-term storage or disposal. The availability of offsite LLRW storage space is beyond the control of the DCD and COL applicant. Consequently, when offsite storage or disposal capacity is not available, the COL applicant should submit to the NRC the details of arrangements about long-term onsite storage or disposal of LLRW. The COL applicant should evaluate the need for any additional LLRW storage capability and design features of such a facility under the requirements of the change process that are outlined in the US-APWR DC rule and the guidance in SRP Section 11.4, RIS 2008-32, RG 1.143, RG 4.21, RG 8.8, and RG 8.10. The staff will review and evaluate proposals for additional site-specific LLRW storage against these guidelines. Based on the discussion above, the staff finds the SWMS design and provisions for waste classification, LLRW onsite storage, shipment, and disposal, as it relates to radioactive waste acceptable. **RAI 185-2031, Question 11.04-4** is closed.

11.4.4.8 Minimization of Contamination

DCD Tier 2, Section 11.4.1.2, "Design Criteria," describes SWMS design features to meet compliance with 10 CFR 20.1406. These design features include housing SRST in individual cubicles coated with an impermeable epoxy liner (coating) up to the cubicle wall height equivalent to the full tank volume; early leak detection; drainage, and transfer capabilities to minimize the release of the radioactive liquid to the groundwater and environment; and double isolation valves and special fittings (e.g., one check valve and one isolation valve) to minimize the potential for cross contamination of non-radioactive systems (e.g., PMW, nitrogen, and service air systems) and preclude uncontrolled and unmonitored releases of radiation to the environment; routing of any liquids and gases from the operation of the LWMS and GWMS, respectively, for treatment; pumping of liquid from the dewatering operations of spent resin and spent carbon, equipment and piping flushes and decontamination, and local area drainage to the WHT or liquid waste collected in the A/B sump tanks to the LWMS for processing; routing of gases from the spent resin transfer and filling operations and gases from the SRST to the HT for processing by the GWMS.

DCD Tier 2, Section 12.3 addresses compliance with 10 CFR 20.1406, as it relates to facility design, including the SWMS, and operational procedures for minimizing the contamination of the facility and the generation of radioactive waste. DCD Tier 2, Section 12.3 discusses programmatic aspects and design features of SSCs intended to minimize contamination and prevent unintended releases and early detection of unintended contamination. The SWMS generates radioactive wastes from the associated operation of the SWMS collection system and processing subsystems. Such radioactive wastes could potentially cross-contaminate nonradioactive systems, result in the contamination of nearby facilities and equipment, and potentially result in unmonitored and uncontrolled radioactive releases to the environment. Because compliance with IE Bulletin 80-10 was not addressed in DCD Tier 2, Section 11.4, in **RAI 629-4973, Question 11.03-18, Item 4**, the staff requested that the applicant identify the design criterion (i.e., compliance with IE Bulletin 80-10, as it relates to the SWMS) as considered in DCD Tier 2, Section 11.4.1.2, "Design Criteria," on interconnections between SWMS and other plant systems to preclude contamination of non-radioactive systems and minimize uncontrolled and unmonitored releases of radiation to the environment. By letter dated September 24, 2010, the applicant responded to the above RAI.

In response to **RAI 629-4973, Question 11.03-18, Item 4**, the applicant commits to revise DCD Tier 2, Section 11.4.1.2, to identify the requirements of IE Bulletin 80-10 in the SWMS design criteria. The staff finds the applicant's response acceptable because the applicant commits to revise the DCD to include this information. The portion of **RAI 629-4973, Question 11.03-18, Item 4,** related to the SWMS, is being tracked as **Confirmatory Item 11.03-5**.

11.4.4.9 DCD Tier 1 Information

DCD Tier 1, Section 2.7.4.3, "Solid Waste Management Systems (SWMS)," describes the SWMS as a non safety-related system designed to collect, process, package, and store radioactive waste generated during normal operation including AOOs. DCD Tier 1, Table 2.7.4.3-1 describes the ITAAC for the SWMS. The ITAAC for the RWMS in DCD Tier 2, Section 14.3.4.7, "ITAAC for Plant Systems," identified in DCD Tier 2, Table 14.3-6, "Plant Systems

(Sheet 1 of 3)," includes verifying the performance of the SWMS as permanently installed systems or in combination with mobile processing equipment.

DCD Tier 1, Section 2.7.4.3.1, "Design Description," states the SWMS is located in the A/B and has several subsystems which are designed to handle wastes mainly comprised of spent resin, spent carbon, spent filter, sludge and oily waste, and DAW such as contaminated clothing, tools, and maintenance materials. The spent resin and spent carbon handling and dewatering subsystem consists of cross-connected SRST so that a failure or maintenance of one component does not impair system or plant operation and a modular dewatering station with a control console, fillhead, and dewatering pump. Spent filter elements are handled remotely to minimize worker exposure. Sludge and oily wastes are collected in sumps and are pumped to shipping containers for offsite treatment and/or disposal. DAW is collected at the point of generation and packaged for disposal. The onsite waste storage area located in the A/B is equipped with an overhead crane and an indoor truck bay to load packaged waste for offsite transportation and disposal. Spent resins from various plant sources are collected in the SRST and provide staging for decay and transfer into disposal containers for offsite disposal. The spent charcoal handling subsystem shares use of the SRST and the resin dewatering equipment. Packaging operations for the spent resin, spent charcoal, and spent filter are remotely controlled for filter replacement and spent resin dewatering. The SWMS is not designed to process any mixed wastes which contain both hazardous chemical and radioactive wastes. Lubricants and solvents are collected in the area sump tanks which provide staging and gravitational oil separation for transfer into disposable drums. The SWMS is a non safety-related system and has no important alarms, displays, controls, or interlocks required for safety functions related to the SWMS. The principal SWMS non-seismic equipment components are located in portions of the A/B designed to seismic Category II requirements. DCD Tier 1, Section 2.7.4.3 provides ITAAC to confirm proper construction and implementation of the SWMS design. ITAAC to confirm compliance to functional arrangements of the system, and pressure boundary integrity testing have been included in this section. The staff reviewed the proposed ITAAC and found that they are an acceptable means to verify the system will perform as stated in DCD Tier 1, Section 2.7.4.3.

Other Tier 1 information associated with the SWMS is provided on the gaseous radwaste discharge monitor (RMS-RE-072) and the plant vent radiation gas monitors (RMS-RE-021A, RMS-RE-021B, RMS-RE-80A, RMS-RE-80B) described in DCD Tier 1, Sections 2.7.6.6, "Process Effluent Radiation Monitoring and Sampling System," and 2.7.6.7, "Process and Post-accident Sampling System (PSS)," and DCD Tier 1, Tables 2.7.6.6-1, 2.7.6.6-2, and 2.7.4.2-1. The process effluent and radiation monitors are evaluated in Section 11.5 of this SE.

The staff reviewed the descriptions, arrangement, design features, environmental qualification, performance requirements, and information provided in DCD Tier 1, Section 2.7.4.3 to confirm completeness and consistency with the plant design basis as described in DCD Tier 2, Section 11.4. The staff determined that the Tier 1 information is complete, consistent, and accurate. Based on the discussion above, the staff finds that the SWMS complies with the requirements of 10 CFR 52.47(b)(1).

11.4.4.10 Technical Specifications

DCD Tier 2, Chapter 16, "Technical Specifications," describes the TS associated with the RWMS. DCD Tier 2, Chapter 16, Section 5.6.2, "Radioactive Effluent Release Report," require the annual report include a summary of the quantities of the radioactive liquid and gaseous effluents and solid waste released from the unit. Section 5.6.2 also requires that the information included in the annual summary be consistent with the objectives outlined in the PCP and complies with the requirements of 10 CFR 50.36a and 10 CFR Part 50, Appendix I. The use of a PCP is under the operational programs described in DCD Tier 2, Section 13.4, "Operational Program Implementation," evaluated in Section 13.4 of this SE. The staff finds the TS requirements acceptable as the implementation of such programs will be addressed in the plant-specific PCP under COL Information Item 11.4(3) evaluated previously.

11.4.4.11 Preoperational Testing

From review of Revision 1 to DCD Tier 2 Sections 11.4.6, "Testing and Inspection Requirements," and 14.2.12.1.82, "Solid Waste Management System Preoperational Test," the staff found information on tests was missing. As a result, in **RAI 185-2031, Question 11.04-3**, the staff requested that the applicant provide the preoperational test and startup testing requirements associated with the nitrogen supply and mobile systems of the SWMS. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 185-2031, Question 11.04-3**, the applicant stated B.4 "Required support systems are available" under "Prerequisites" in DCD Tier 2, Section 14.2.12.1.82, "Solid Waste Management System Preoperational Test," contains the test information which includes the nitrogen supply from the compressed gas system. The applicant revised C.4 under "Test Method" to add "The test source gas is routed through the SWMS to verify performance" and also D.2 under "Acceptance Criteria" to add "The nitrogen supply gas demonstrates conformance with design flows and process capabilities."

DCD Tier 2, Section 14.2.12.1.82 describes the tests to be conducted on identified plant systems and components in confirming performance of the SWMS and its subsystems. For the SWMS, this test will verify manual and automatic system controls, interlocks, alarms and indications; demonstrate the ability of SRST to receive spent resin from the LWMS, CVCS, SFPCS, SG blowdown system, and the condensate polisher ion exchange columns; demonstrate the ability of the SWMS to handle dry active waste, spent filter elements, spent resin, spent activated carbon, and oil and sludge described in DCD Section 11.4.2, "Design Criteria," and the test source gas. The staff reviewed the applicant's response and finds it acceptable because the test method and acceptance criteria for the SWMS preoperational test were addressed. Additionally, the staff confirmed that Revision 2 to DCD Tier 2, Section 14.2.12.1.82 included this information. **RAI 185-2031, Question 11.04-3** is closed. The preoperational testing to verify that the SWMS will perform as stated in DCD Tier 2, Section 11.4, "Verification Programs," is evaluated in Section 14.2 of this SE.

11.4.5 Combined License Information Items

From review of Revision 1 to DCD Tier 2, Section 11.4, the staff could not find explicit statements directing the COL applicant to take responsibility of COL Information Items 11.4(4) related to mobile/portable SWMS connections; 11.4(7) related to compaction equipment and adoption of contract services for specialized waste services; and 11.4(8) related to P&IDs. As a result, in **RAI 185-2031, Question 11.04-5**, the staff requested that the applicant include a statement in the relevant DCD Tier 2 sections for the COL applicant to take responsibility of these COL information items. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 185-2031, Question 11.04-5**, the applicant revised DCD Tier 2, Section 11.4.4.5, "Mobile De-Watering System," to state the COL applicant is responsible for identifying the mobile/portable SWMS connections that are considered nonradioactive but later may become radioactive through contact or contamination with radioactive systems and for preparing the related operating procedures in COL Information Items 11.4(4) and 11.4(7) as revised; DCD Tier 2, Section 11.4.2.3, "Packaging, Storage, and Shipping," to state the COL applicant is responsible for providing information on the adoption of compaction equipment under COL Information Item 11.4(7); and DCD Tier 2, Section 11.4.2.2.1, "Spent Resin Handling and De-watering Subsystem," to state the COL applicant is responsible for including P&IDs under COL Information Item 11.4(8). The applicant also revised COL Information Item 11.4(7) in response to **RAI 187-2008, Question 11.04-11**, evaluated later in this section, to clarify that the SWMS design does not include solid waste processing facility such as the de-watering system and compactor for reducing waste volume.

The staff found the applicant's response acceptable and confirmed that Revision 2 to DCD Tier 2, Section 11.4 included this information. The implementation of these COL information items will be addressed in a plant-specific PCP and related operational programs. **RAI 185-2031, Question 11.04-5** is closed.

Revision 1 to DCD Tier 2, Section 11.4.2.1.1, "Dry active wastes," states, "The COL applicant is to include descriptions of wastes other than normally accumulated non-radioactive wastes such as activated carbon from GWMS charcoal beds, solid wastes coming from component (steam generator, reactor vessel, etc.) replacement activities, and other unusual cases." From review of Revision 1 to DCD Tier 2, Section 11.4.2.1.1, the staff determined that this information should be a COL information item. As a result, in **RAI 187-2008, Question 11.04-9**, the staff requested that the applicant justify why this information was not included as a COL information item. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-9**, the applicant stated the DAW reference to the waste descriptions will be described in COL Information Item 11.4(3) on the site-specific PCP. Because the PCP requires site-specific information which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.4(3) acceptable. The applicant revised DCD Tier 2, Section 11.4.2.1.1 to clarify that the waste descriptions other than normally accumulated non-radioactive wastes will be described by the COL applicant in the PCP and implemented in accordance with the milestones. The staff found the applicant's response acceptable and confirmed that Revision 2 to DCD Tier 2, Section 11.4.2.1.1 included this information. **RAI 187-2008, Question 11.04-9** is closed.

From review of COL Information Item 11.4(5), the staff determined that clarification on this COL information item was needed. As a result, in **RAI 187-2008, Question 11.04-10**, the staff requested that the applicant clarify what the COL applicant is expected to provide in COL Information Item 11.4(5). By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-10**, the applicant revised COL Information Item 11.4(5) to clarify that the applicant may choose to use offsite laundry services for processing contaminated clothing or bring in a mobile compaction unit to reduce volume prior to disposal of contaminated clothing. The staff found the applicant's response acceptable and confirmed that COL Information Item 11.4(5) in Revision 2 to DCD Section 11.4.8 included this information. **RAI 187-2008, Question 11.04-10** is closed.

From review of COL Information Item 11.4(7), the staff determined that clarification on this COL information item was needed. As a result, in **RAI 187-2008, Question 11.04-11**, the staff requested that the applicant give the COL applicant more specific guidance on what information is required regarding the solid waste processing facility which the COL applicant may choose to adopt in COL Information Item 11.4(7). By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-11**, the applicant revised COL Information Item 11.4(7) to clarify that the SWMS design does not include a solid waste processing facility (e.g., de-watering system, compactor for reducing waste volume), but may choose to add this equipment or adopt contract services from specialized services. The applicant also revised DCD Tier 2, Section 11.4.2.3, "Packaging, Storage, and Shipping," to state the COL applicant is required to provide information on the adoption of compaction equipment in COL Information Item 11.4(7). Because the addition of compaction equipment or adoption of contract services requires site-specific information which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.4(7) acceptable. The staff found the applicant's response acceptable and confirmed that COL Information Item 11.4(7) in Revision 2 to DCD Section 11.4.8 included this information. **RAI 187-2008, Question 11.04-11** is closed.

Revision 1 to DCD Tier 2, Section 11.4.2.4, "Effluent Controls," states, "The spent resin filling and dewatering operations have level control setpoints. The ranges, setpoints, and references for these instruments are to be developed in the detailed design phase and are not provided in this DCD." From review of Revision 1 to DCD Tier 2, Section 11.4.2.4, the staff determined that additional information on this statement was needed. As a result, in **RAI 187-2008, Question 11.04-12**, the staff requested that the applicant justify why this information was not included as a COL information item. By letter dated March 11, 2009, the applicant responded to the above RAI.

In response to **RAI 187-2008, Question 11.04-12**, the applicant stated the details on the level instrument control range setpoints and references for the HIC filling and de-watering operations will be determined in the detailed design. The applicant also stated the site-specific mobile de-watering subsystem in COL Information Item 11.4(7) is typically comprised of one HIC, a de-watering fillhead station, a pump, a control console, and a CCTV to monitor tank level operation. The staff reviewed the additional information and found that the described design details were not included in the DCD. The staff closed **RAI 187-2008, Question 11.04-12** and, in follow-up **RAI 536-4289, Question 11.04-20**, requested that the applicant include these design details which are the responsibility of the COL applicant in DCD Tier 2, Section 11.4.2.4. By letter dated April 20, 2010, the applicant responded to the above RAI.

In response to **RAI 536-4289, Question 11.04-20**, the applicant commits to revise DCD Tier 2, Sections 11.4.2.2.1 and 11.4.2.4 and add design details and clarification regarding the separate level switch location above the high level to prevent overfilling of the HIC and permanent level stick installed inside the container for continuous monitoring of the liquid level in the HIC on the control panel which are manually stopped by an operator via CCTV observations. The staff finds the applicant's response acceptable because the applicant commits to revise the DCD to include this information. **RAI 536-4289, Question 11.04-20** is being tracked as **Confirmatory Item 11.04-3**.

Table 11.4-1 to Section 11.4 of this SE provides a list of SWMS related COL information items and descriptions from DCD Tier 2, Table 1.8-2, "Compilation of All Combined License Applicant Items for Chapters 1-19 (Sheet 31 and 32 of 44)."

Table 11.3-2 US-APWR Combined License Information Items

Item No.	Description	DCD Tier 2 Section
11.4(1)	The current design meets the waste storage requirements in accordance with ANSI/ANS-55.1. When the COL applicant desires additional storage capability beyond that which is discussed in this Tier 2 document, the COL applicant will identify plant-specific needs for on-site waste storage and provide a discussion of on-site storage of low-level waste.	11.4.2.3
11.4(2)	Deleted	
11.4(3)	The COL applicant is to prepare a plan for the process control program describing the process and effluent monitoring and sampling program. The plan should include the proposed implementation milestones.	11.4.2.1.1 11.4.3.2
11.4(4)	The COL applicant is to describe mobile/portable SWMS connections that are considered non-radioactive but later may become radioactive through contact or contamination with radioactive systems (i.e., a non-radioactive system becomes contaminated due to leakage, valving errors, or other operating conditions in the radioactive systems), and operational procedures of the mobile/portable SWMS connections.	11.4.4.5
11.4(5)	The current design provides collection and packaging of potentially contaminated clothing for offsite shipment and/or disposal. Depending on site-specific requirements, the COL applicant can send the wastes to an offsite laundry facility processing and/or bring in a mobile compaction unit for volume reduction. The laundry services, including contracted services and/or a temporary mobile compaction subsystem, are COL items.	11.4.1.3
11.4(6)	The COL applicant is required to perform a site-specific cost benefit analysis to demonstrate compliance with the regulatory requirements.	11.4.1.5
11.4(7)	The SWMS design does not include solid waste processing facility (e.g. de-watering system, compactor for reducing waste volume) but provides the flexibility for the site-specific utilities to add compaction equipment or to adopt contract services from specialized facilities. This is the responsibility of the COL applicant.	11.4.2.3 11.4.4.5
11.4(8)	The COL applicant is to provide P&IDs.	11.4.2.2.1
11.4(9)	The COL applicant is responsible for ensuring that mobile and temporary solid radwaste processing and its interconnection to plant systems conforms to regulatory requirements and guidance such as 10 CFR 50.34a, 10 CFR 20.1406, and RG 1.143.	11.4.1.6

As previously evaluated, the staff determined that the above list of COL information items to be complete, and concludes that they adequately describe the actions necessary for the COL applicant.

11.4.6 Conclusions

Except for the confirmatory items identified below, the staff concludes that the SWMS, as a permanently installed system, includes the equipment necessary to collect, hold, process, package, and store wet and dry solid wastes and control releases of radioactive materials associated with the operation of the SWMS. The applicant provided sufficient design information to demonstrate that it has met the requirements of 10 CFR 50.34a; GDC 60, GDC 61, and GDC 63 of 10 CFR Part 50, Appendix A; and NRC guidance and acceptance criteria. This conclusion is based on the following:

- The US-APWR design demonstrates compliance with 10 CFR 50.34a, as it relates to the inclusion of sufficient design information and system design features that are necessary for collecting, holding, processing, handling, packaging, and safe storage of wet and dry solid radioactive wastes. The design conforms to the guidelines of BTP 11-3 and SRP Section 11.4, Appendix 11.4-A. The US-APWR demonstrates compliance with the requirements of GDC 61 by meeting the guidelines of RG 1.143 in providing sufficient wet and solid waste processing capacities and storage space to ensure adequate safety under normal operation, AOOs, and postulated accident conditions.

- The design of the US-APWR implements a plant-specific PCP, as an operational program, described in FSAR Tier 2, Sections 11.4.3 and 13.4, for the processing of LLRW. The PCP addresses plant-specific operating procedures and acceptance criteria as they relate to the treatment and processing of radioactive wastes such that waste products generated by the SWMS will meet the classification and characterization definitions in 10 CFR 61.55 and 10 CFR 61.56, respectively. The implementation of a PCP is specified under COL Information Item 11.4(3), as described in DCD Tier 2, Table 1.8-2.

- The design of the US-APWR radioactive waste storage area in the A/B includes provisions for 30 days of onsite storage of processed solid and wet wastes, exclusive of dry wastes classified as Class A wastes under 10 CFR 61.55. The approach to LLRW management presumes that LLRW will be disposed of by shipment to an authorized recipient under 10 CFR 20.2001(a)(1). Under that approach, the applicant should demonstrate the capability of the means included in the design to process dry solid and wet wastes so that these wastes meet the classification and characterization definitions in 10 CFR 61.55 and 10 CFR 61.56, respectively. The need for LLRW storage space beyond that of the design capacity of the radioactive waste storage areas is the responsibility of the COL applicant under the implementation of a plant-specific waste management plan and updated PCP.

- The US-APWR design meets the requirements of 10 CFR Part 50, Appendix A, GDC 60 with respect to controlling releases of radioactive liquid and gaseous effluents generated during the operation of the SWMS as part of the operation of the LWMS, GWMS, and PERMS, as described in DCD Tier 2, Sections 11.2, 11.3, and 11.5. All LWMS and GWMS releases are monitored by radiation monitors, which will generate signals to terminate releases or alert plant operators before discharges exceed a predetermined instrumentation set point. The COL applicant is responsible for determining the operational set-points for its LWMS and GWMS radiation monitors in a plant-specific ODCM under COL Information Item 11.5(2), as described in DCD Tier 2, Table 1.8-2.

- The US-APWR design meets the requirements of 10 CFR 20.1302 by ensuring that annual average concentrations of radioactive materials contained in liquid and gaseous wastes generated during the operation of the SWMS will be controlled and released as part of the operations of the LWMS and GWMS. The operations of the LWMS and GWMS are controlled such that releases of liquid and gaseous effluents in unrestricted areas will not exceed the limits specified in 10 CFR Part 20, Appendix B, Table 2, Columns 1 and 2 and dose limits for members of the public in 10 CFR 20.1301, as described in DCD Tier 2, Sections 11.2 and 11.3. As part of this commitment, the COL applicant will be responsible for demonstrating, through the plant-specific ODCM, compliance with 10 CFR 20.1301(e), which incorporates by reference 40 CFR Part 190 for facilities within the nuclear fuel cycle, including nuclear power plants.

- The US-APWR design complies with the design objectives of 10 CFR Part 50, Appendix I, Sections II.A, II.B, II.C, and II.D in ensuring that releases of liquid and gaseous effluents generated during the operation of the SWMS will not exceed the numerical criteria and design objectives of 10 CFR Part 50, Appendix I and are ALARA. The COL applicant is responsible for determining the operational set-points for their LWMS and GWMS radiation monitors in a plant-specific ODCM under COL Information Item 11.5(2), as described in DCD Tier 2, Table 1.8-2.

- A COL applicant referencing the US-APWR certified design will demonstrate compliance with 10 CFR 50, Appendix I, Section II.D design objectives for offsite individual doses and population doses resulting from liquid and gaseous effluents generated during the operation of the SWMS as part of a site-specific CBA conducted for the LWMS and GWMS under COL Information Items 11.2(5) and 11.3(8), as described in DCD Tier 2, Table 1.8-2.

- The US-APWR design provides sufficient information and design features satisfying the guidance of RG 1.143 for SWMS processing systems in establishing the seismic and quality group classifications for system components and structures housing components.

For the following confirmatory items, tracked under tracked under **RAI 187-2008, Question 11.04-16; RAI 534-4256, Question 11.04-19; RAI 536-4289, Question 11.04-20, RAI 536-4289, Question 11.04-21;** and the portion of **RAI 629-4973, Question 11.03-18, Item 4,** related to PERMS, the staff concludes, with the information presented in the application, that the applicant has not fully demonstrated compliance with NRC regulations and guidance in describing design specifications related to solid waste processing with mobile systems or temporary equipment for conformance to ANSI/ANS-40.37-2009 or its equivalent requirements; design information on the level instrument control range setpoints and references for the HIC filling and de-watering operations; and design features that would minimize the contamination of the facility and environment, prevent the cross contamination of nonradioactive systems, and avoid unmonitored and uncontrolled radioactive releases to the environment. The staff will confirm these confirmatory items in the next revision of the DCD. The regulations are contained in 10 CFR 50.34a and 10 CFR 20.1406 and the guidance is contained in RG 4.21, RG 1.143, SRP Section 11.4, and IE Bulletin 80-10.

11.5 Process Effluent Radiation Monitoring and Sampling Systems

11.5.1 Introduction

PERMS are used to monitor liquid and gaseous process streams and effluent releases from RWMS during normal operation, AOOs, and post-accident conditions. The systems include radiation monitors to detect and measure radioactivity and radiation levels and to provide indication of radioactive release rates or concentration levels in process and effluent streams. The PERMS include sampling systems to extract samples from process or effluent streams and to provide the means to collect samples on filtration and in adsorbent media. The PERMS provide the means to establish alarm set points for the purpose of indicating when excessive radioactivity levels are present, track and record rates of radioactivity releases, and initiate protective isolation actions, such as terminating or diverting process or effluent flows. Typically, the system consists of skid-mounted radiation monitoring equipment and permanently installed sampling lines with the equipment being located at points to measure radioactivity or collect samples that are representative of process flows and effluent releases. Samples collected on filtration and in adsorbent media are evaluated by laboratory analyses in confirming measurement results recorded by radiation monitors and determining radioactivity levels associated with radionuclides that are not readily detected by radiation monitoring devices. The system includes local instrumentation readout panels and alarm functions in addition to those located in control rooms. The PERMS does not generate additional sources of radioactive materials associated with its operation given that it is used only to control and monitor liquid and gaseous process streams and effluents discharged to the environment. Fluid samples collected from process and effluent streams are returned to their origins and are not discharged locally.

11.5.2 Summary of Application

DCD Tier 1: The applicant provided a system description in DCD Tier 1, Section 2.7.6.6, “Process Effluent Radiation Monitoring and Sampling System," summarized here, in part, as follows:

The PERMS provides the capability to sample, measure, control, and record the radioactivity levels of selected process streams within the plant and effluent streams released into the environment; actuate alarms and control releases of radioactivity; provide data to keep worker exposures ALARA; and provide process data to support plant operation in accordance with the NRC regulations. The PERMS monitors are located in the R/B, A/B, and T/B. DCD Tier 1, Table 2.7.6.6-1, “Process Effluent Radiation Monitoring and Sampling System Equipment Characteristics,” provides the design characteristics of PERMS components on safety related, seismic, Class 1E division, and harsh environment classifications and qualifications. The safety-related MCR gas, iodine, and particulate effluent radiation monitors are classified as Class 1E while the remaining PERMS monitors are non-safety related. The safety-related function of the MCR monitors is to automatically activate signals to start the MCR isolation and an alarm in the MCR requiring operator actions when detection of radioactivity levels exceeds predetermined setpoints. PERMS monitors are provided for the reactor containment atmosphere, spaces containing components for recirculation of loss-of coolant accident (LOCA) fluids, effluent discharge paths, and the plant environs for radioactivity released during normal operation, AOOs, and post-accident conditions. DCD Tier 1, Table 2.7.6.6-2, “Process Effluent Radiation Monitoring and Sampling System Inspections, Tests, Analyses, and Acceptance

Criteria," identifies the ITAAC for the PERMS. Detailed descriptions on the PERMS design and operation features are provided in DCD Tier 2, Section 11.5.

DCD Tier 2: The applicant has provided a description in DCD Tier 2, Section 11.5, "Process and Effluent Radiation Monitoring and Sampling Systems," summarized here, in part, as follows:

DCD Tier 2, Section 11.5 describes the PERMS design to monitor, control, record and sample, liquid and gaseous effluent and noble gas releases, and in-plant radiation and airborne radioactivity during normal operation, AOOs, and post-accident conditions. The PERMS monitors which provide non-safety related and safety related functions in the US-APWR include:

- Process gas and particulate monitors
    - Non-safety related containment radiation monitors (RMS-RE-040) located in the R/B to measure the radiation level in the gas stream from containment atmosphere and meet the RCS leakage rate technical basis in DCD Tier 2, Chapter 16, "Technical Specifications," TS 3.4.13 and TS B 3.4.13 to detect 0.5 gpm within 1 hour of response time using a realistic concentration in the RCS.
    - Non-safety related containment low volume purge radiation gas monitor (RMS-RE-023) located in the R/B to measure the radiation level in the containment air purges.
    - Non-safety related containment exhaust radiation gas monitor (RMS-RE-022) located in the R/B to measure the radiation level of the containment exhaust system.
    - Non-safety related main steam line radiation monitors (RMS-RE-065A/B, RMS-RE-066A/B, RMS-RE-067A/B, RMS-RE-068A/B, RMS-RE-087, RMS-RE-088, RMS-RE-089, RMS-RE-090) located in the R/B to measure the concentration levels of radioactive materials in the main steam line from the SG.
    - Non-safety related gaseous radwaste discharge monitor (RMS-RE-072) located in the R/B to measure the in-line concentration of radioactive material from the charcoal adsorber in the GWMS before reaching the plant vent.
    - Safety-related MCR outside air intake radiation monitors (RMS-RE-084A/B, RMS-RE-085A/B, RMS-RE-083A/B) located in the R/B to measure the radioactivity levels in the gas stream, iodine, and particulates into the MCR.
    - Non-safety related TSC outside air intake radiation monitors (RMS-RE-100, RMS-RE-101, RMS-RE-102) located in the A/B to measure the radioactivity levels in the gas stream, iodine, and particulates into the TSC.
- Process liquid monitors
    - Non-safety related component cooling water (CCW) radiation monitors (RMS-RE-056A, RMS-RE-056B) located in the R/B to measure the radiation level in the CCW for leakage within the heat exchange equipment.

- Non-safety related auxiliary steam condensate water radiation monitor (RMS-RE-057) located in the A/B to measure the concentration of radioactive material in the auxiliary steam system condensate from components such as the boric acid evaporator in the CVCS.

- Non-safety related primary coolant radiation monitor (RMS-RE-070) located in the R/B to measure the concentration of radioactive material in the CVCS line from the RCS during normal operation, AOOs, and design basis accidents.

- Non-safety related T/B floor drain radiation monitor (RMS-RE-058) located in the T/B to measure radioactivity collected in the T/B floor drain from the steam turbine area.

- Non-safety related SG blowdown water radiation monitor (RMS-RE-055) located in the R/B to measure the radiation level in the SG blowdown water after it is cooled and before it enters the flash tank for primary-to secondary system leakage.

- Non-safety related SG blowdown return water radiation monitor (RMS-RE-036) located in the R/B to measure the radiation level in the SG blowdown water after it is treated and before it is returned into the condensate storage tank for primary-to-secondary system leakage due to a SG tube leak.

• Effluent gas monitors

  - Non-safety related plant vent radiation gas monitors (RMS-RE-021A/B, RMS-RE-080A/B) located in the R/B to collect radioactive iodine, particulate, and tritium released through the plant vent stack.

  - Non-safety related condenser vacuum pump exhaust line radiation monitors (RMS-RE-043A/B, RMS-RE-081A/B) located in the T/B to measure the radiation level in non-condensable gases from the main condenser vented by vacuum pumps to the atmosphere and meet the RCS leakage rate technical basis in DCD Tier 2, Chapter 16, TS 3.4.17 and TS B 3.4.17 to detect 30 gpd primary-to-secondary leakage in the RCS in accordance with the NEI 97-06, "Steam Generator Program Guidelines," and EPRI, "Pressurized Water Reactor Steam Generator Examination Guidelines."

  - Non-safety related gland seal system (GSS) exhaust fan discharge line radiation monitors (RMS-RE-044A/B, RMS-RE-082A/B) located in the T/B measure the radiation level in non-condensable gases discharged from the gland steam condenser exhaust fan for primary-to-secondary system leakage due to a SG tube leak.

• Effluent liquid monitors

  - Non-safety related liquid radwaste discharge radiation monitor (RMS-RE-035) located in the A/B to monitor the in-line liquid discharge stream before it reaches the discharge header for discharge to the environment.

  - Non-safety related essential service water (ESW) radiation monitoring and sampling system (RMS-RE-074A/B, RMS-RE-074C/D) located in the R/B to measure the radiation level in the ESW for leakage within the heat exchange equipment.

  - Non-safety related GSS exhaust fan discharge line radiation monitors (RMS-RE-044A/B, RMS-RE-082A/B) located in the T/B for primary-to-secondary system leakage due to a SG tube leak.

- Samplers

  - Plant vent sampler to collect radioactive iodine, tritium, and particulate released through the plant vent stack.

  - Containment sampler to collect radioactive iodine, tritium, and particulate in the containment.

The PERMS provides the means to terminate and isolate process flows and effluent releases upon detecting elevated levels of radioactivity. The PERMS are comprised of distributed sets of radiation monitors each with detectors, radiation processor, and shielded sample collectors (in-line radiation monitors have no sample collectors) to collect liquid and gaseous samples from process and effluent streams and minimize the effects from background radiation and equipment. Grab samples are taken for chemical and radiological analyses to confirm isotopic compositions and radiation levels as described in DCD Tier 2, Section 9.3.2, "Process and Post-Accident Sampling Systems."

DCD Tier 2, Section 11.5.1, "Design Basis," presents the design basis and design criteria of the system. DCD Tier 2, Section 11.5.2, "System Descriptions" presents information on the process gas and particulate radiation monitors, process liquid radiation monitors, effluent gas and liquid radiation monitors, and samplers; determination of alarm setpoints, addresses compliance with NRC regulations as it relates to effluent releases and development of site-specific procedures, ODCM, REMP, CBA, and the PERMS range; DCD Tier 2, Section 11.5.3, "Effluent Monitoring and Sampling," presents the radiological monitoring and sampling instruments and design; and DCD Tier 2, Section 11.5.4, "Process Monitoring and Sampling," addresses compliance with the NRC regulations as it relates to process monitoring and sampling.

DCD Tier 2, Tables 11.5-1, "Process Gas and Particulate Monitors," through 11.5.4, "Effluent Liquid Monitors," identify operational design characteristics such as detector type, monitor range, calibration isotope, check source, and subsystems that include automatic control functions in terminating or diverting process flows and effluent releases required for plant safety and/or radiation protection. DCD Tier 2, Table 11.5-5 provides information on samplers to collect radioactive iodines, particulates, tritium, and halogens in process and effluent streams. DCD Tier 2, Figures 11.5-1a, "Typical Containment Atmosphere Radiation Monitor Schematic," through 11.5-1j, "Typical Gland Steam Radiation Monitor Schematic," show general process configurations and schematics of the PERMS monitors. Plant locations of radiation monitors are depicted in DCD Tier 2, Figures 11.5.2-a, "Location of Radiation Monitors at Plant (Power Block at Elevation -26'-4")," through 11.5.2k, "Location of Radiation Monitors at Plant (Power Block Section A-A)." Section 9.3.2 of this SE addresses the adequacy of the sampling locations and station descriptions for chemical and radiological analysis during normal operations, AOOs, and post-accident conditions. PERMS monitors which have post-accident monitoring functions are evaluated in Section 7.5 of this SE.

Except for specific subsystems, failure of the PERMS does not compromise safety-related systems or components and does not prevent the safe shutdown of the plant. DCD Tier 2, Section 3.2, "Classification of Structures, Systems, and Components," describes the seismic and quality group classification and corresponding codes and standards that apply to structures housing the PERMS. In addition, DCD Tier 2, Section 3.10, "Seismic and Dynamic Qualification of Mechanical and Electrical Equipment," addresses the seismic qualification of mechanical and electrical equipment, and DCD Tier 2, Section 3.11, "Environmental Qualification of Mechanical and Electrical Equipment," addresses environmental qualification of mechanical and electrical equipment. These topics are evaluated in Section 3 of this SE. The radiation monitoring system section of the PCMS, as it relates to the PERMS, provides non-safety area and process radiation monitoring to generate displays and alarms, are not required for safety is described in DCD Tier 2, Section 7.7, "Control Systems Not Required for Safety."

The associated NRC TMI-related items in monitoring radioactive effluents under accident conditions, as they relate to the post-accident monitoring system, are addressed in DCD Tier 2, Sections 7.1.1.5, "Information Systems Important to Safety," 7.5, "Information Systems Important to Safety," and 9.3.2, "Process and Post-Accident Sampling Systems."

DCD Tier 2, Sections 11.5.3, "Effluent Monitoring and Sampling," 11.5.4, "Process Monitoring and Sampling," and 9.3.2, "Process and Post-Accident Sampling Systems," describe manual provisions in the US-APWR design to sample effluent streams and radiation levels to verify the performance and accuracy of the PERMS monitors during normal operations, AOOs, and post-accident conditions.

Preoperational testing of the PERMS is conducted by the COL applicant. The development of operational programs and procedures is the responsibility of the COL applicant under COL Information Items 11.5(1) through 11.5(5) in DCD Tier 2, Section 11.5.5, "Combined License Information," as described in DCD Tier 2, Table 1.8-2, "Compilation of All Combined License Applicant Items for Chapters 1-19." The applicant states the PERMS is designed to meet compliance with 10 CFR 20.1301; 10 CFR 20.1302; 10 CFR 20.1406; 10 CFR Part 50, Appendix A, GDC 60, 63, and 64; 10 CFR Part 50, Appendix I; 10 CFR 50.34a; 10 CFR 50.36a; 10 CFR 52.47(b)(1); and 40 CFR Part 190 using the acceptance criteria of SRP Section 11.5 and associated NRC guidance. For NRC TMI-related requirements, the applicant states the PERMS design conforms to 10 CFR 50.34(f)(2)(xvii) and 10 CFR 50.34(f)(2)(xxvii) for monitoring in-plant radiation and airborne radioactivity.

ITAAC: The ITAAC associated with DCD Tier 2, Section 11.5, "Process and Effluent Radiation Monitoring and Sampling Systems," are given in DCD Tier 1, Section 2.7.6.6, "Process Effluent Radiation Monitoring and Sampling System," and Tables 2.7.6.6-1, "Process Effluent Radiation Monitoring and Sampling System Equipment Characteristics (Sheets 1 and 2)," and 2.7.6.6-2, "Process Effluent Radiation Monitoring and Sampling System Inspections, Tests, Analyses, and Acceptance Criteria (Sheets 1 and 2)." DCD Tier 2, Section 14.3.4.7, "ITAAC for Plant Systems," summarizes how ITAAC were developed for DCD Tier 1, Section 2.7.6.6.

TS: There is information pertinent to TS associated with the PERMS in DCD Tier 2, Sections 11.5.2.9, "Offsite Dose Calculation Manual," 11.5.2.10, "Radiological Environmental Monitoring Program," 11.5.3, "Effluent Monitoring and Sampling," and 11.5.4, "Process Monitoring and Sampling," and DCD Tier 2, Chapter 16, Sections 3.3.3, "Post Accident Monitoring (PAM) Instrumentation," 5.5.9, "Steam Generator (SG) Program," 5.5.1, "Offsite Dose Calculation Manual (ODCM)," 5.5.4, "Radioactive Effluent Controls Program," 5.5.12, "Explosive Gas and

Storage Tank Radioactivity Monitoring Program," 5.6.1, "Annual Radiological Environmental Operating Report," and 5.6.2, "Radiological Effluent Release Report," TS 3.4.13 and TS B 3.4.13, "RCS Operational LEAKAGE,"TS 3.4.15 and TS B 3.4.15, "RCS Leakage Detection Instrumentation," TS 3.4.17 and TS B 3.4.17, "Steam Generator (SG) Tube Integrity."

10 CFR 20.1406: There is information pertinent to 10 CFR 20.1406 in DCD Tier 2, Section 11.5.1.2, "Design Criteria."

COL information or action items: (See Section 11.5.5 below)

Technical Report(s): There is a technical report associated with this area of review. Technical Report MUAP-07004 [Proprietary] (revision 4), Technical Report MUAP-07004 [Non-Proprietary] (revision 4), "Safety I&C System Description and Design Process," dated March 2010, referenced in DCD Tier 2, Section 7.1, "Introduction," demonstrates conformance of the instrumentation and control (I&C) systems to Institute of Electrical and Electronics Engineers (IEEE) Standard (Std.) 603-1991.

Topical Report(s): There are no topical reports associated with this area of review.

US-APWR Interface Issues Identified in the DCD: There are no US-APWR interface issues associated with this area of review.

Site Interface Requirements Identified in the DCD: There are no site interface requirements associated with this area of review.

Cross-cutting Requirements (Three Mile Island [TMI], Unresolved Safety Issue [USI]/Generic Safety Issue [GSI], Op Ex): The associated TMI-related items in monitoring radioactive effluents under accident conditions, as they relate to the post-accident monitoring system, are addressed in Sections 7.1, "Introduction," 7.5, "Information Systems Important to Safety," and 9.3.2, "Process and Post-Accident Sampling Systems," of this SE.

RTNSS: There are no RTNSS issues for this area of review.

CDI: This section of the DCD does not contain CDI since it is outside the scope of the US-APWR certification.

11.5.3 Regulatory Basis

The relevant requirements of the Commission regulations for the process and effluent radiological monitoring and sampling systems, and the associated acceptance criteria, are given in SRP Section 11.5 and are summarized below. Review interfaces with other SRP sections can be found in SRP Section 11.5.

1. 10 CFR 20.1302 and 10 CFR 20.1301(e), as they relate to monitoring radioactivity in plant radiological effluents to unrestricted areas. These criteria apply to all effluent releases resulting from operation during normal plant operations and AOOs.

2. 10 CFR 50.34a, as it relates to equipment design and procedures used to control releases of radioactive material to the environment within the numerical guides provided in Appendix I to 10 CFR Part 50.

3. 10 CFR 50.36a, as it relates to operating procedures and equipment installed in radioactive waste management systems pursuant to 10 CFR 50.34a to ensure that releases of radioactive materials to unrestricted areas are kept ALARA.

4. 10 CFR Part 50, Appendix I, as it relates to numerical guides and design objectives to meet the requirements of 10 CFR 50.34a and 10 CFR 50.36a, which specify that radioactive effluents released to unrestricted areas and doses to members of the public be kept ALARA.

5. 10 CFR 20.1406, as it relates to the design and operational procedures in minimizing contamination of the facility, facilitating eventual decommissioning, and minimizing the generation of radioactive waste.

6. 10 CFR 50, Appendix A, GDC 13, as it relates to in part that instrumentation be provided to monitor variables and systems over their anticipated ranges for accident conditions, as appropriate, to assure adequate safety.

6. 10 CFR Part 50, Appendix A, GDC 60, as it relates to controlling effluent releases from the LWMS, GWMS, and SWMS and designing these systems to handle radioactive materials produced during normal reactor operation including AOOs.

7. 10 CFR Part 50, Appendix A, GDC 63 and GDC 64, as they relate to the designs of the LWMS, GWMS, and SWMS, and capabilities to monitor and control radiation levels and radioactivity in effluents, as well as radioactive leakages and spills, during normal operations, including AOOs, and from postulated accidents, and initiate appropriate safety actions.

8. Requirements specified in 10 CFR 50.34(f)(2)(xvii) and 10 CFR 50.34(f)(2)(xxvii) for monitoring gaseous effluents from all potential accident release points, consistent with the requirements of 10 CFR Part 50, Appendix A, GDC 63 and GDC 64. These requirements correspond to the NRC TMI Action Plan Items II.F.1 and III.D.3.3, respectively.

9. IEEE Std. 603-1991, “Standard Criteria for Safety Systems for Nuclear Power Generating Stations,” as it relates to compliance with 10 CFR 50.55a(h)(3) which stipulates DCs are to meet the requirements for safety systems in IEEE Std. 603-1991.

Regulatory guidance adequate to meet the above requirements includes:

1. RG 1.21, “Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste,” as it relates to guidance for the design, implementation, and QA of effluent monitoring and sampling systems.

2. RG 1.33, “Quality Assurance Program Requirements (Operation),” as it relates to QA for the operation of equipment that is part of the PERMS.

3. RG 1.97, “Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants,” as it relates to accident monitoring instrumentation and performance of radiation monitoring systems. Additional guidance on the application of RG 1.97 is provided in SRP Section 7, BTP 7-10, “Guidance on Application of Regulatory Guide 1.97,” NUREG-0800.

4. RG 4.15, “Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination) - Effluent Streams and the Environment,” as it relates to the design, implementation, and QA of effluent monitoring and sampling systems.

5. RG 4.21, “Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning,” as it relates to minimizing the contamination of equipment, plant facilities, and environment, and minimizing the generation of radioactive waste during plant operation.

6. Radiological Assessment BTP (Revision 1, dated November 1979), as it relates to the conduct of environmental monitoring, in Appendix A to NUREG-1301.

7. NUREG-0133, “Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants,” dated October 1978, as it relates to the format and contents of an ODCM.

8. SECY-05-0197, “Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria,” dated October 28, 2005, as it relates to descriptions of operational programs and exclusion of ITAAC for operational programs.

9. ANSI/HPS N13.1-1999, “Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts for Nuclear Facilities,” as it relates to sampling and monitoring of airborne releases from stacks.

10. ANSI N42.18-2004, “Specification and Performance of On-site Instrumentation for Continuously Monitoring Radioactivity in Effluents, 2004,” as it relates to the performance of radiation monitoring equipment.

11. NUREG-0800, SRP Section 11.5, Appendix 11.5-A, “Design Guidance for Radiological Effluent Monitors Providing Signals for Initiating Termination of Flow or Other Modification of Effluent Stream Properties,” as it relates to the design of automatic control functions.

12. IE Bulletin 80-10, “Contamination of Nonradioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment,” dated May 6, 1980, as it relates to methods and procedures used in avoiding the cross-contamination of non-radioactive systems and unmonitored and uncontrolled releases of radioactivity.

13. GL 89-01, “Implementation of Programmatic and Procedural Controls for Radiological Effluent Technical Specifications” (Supplement No. 1, dated November 14, 1990), as it relates to the restructuring of the ODCM and RETS (included in NUREG-1301).

14. NUREG-1301, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors,” dated April 1991, as it relates to the development of a plant-specific ODCM. Alternatively, a COL applicant may use NEI ODCM Template 07-09A (Revision 0) to meet this regulatory milestone until a site-specific ODCM is prepared, before fuel load, under the requirements of a license condition described in FSAR Section 13.4 of COL applications. The NEI ODCM Template 07-09A has been determined to be acceptable by the staff (ML083530745).

15.

16. EPRI, “PWR Primary-To-Secondary Leak Guidelines-Revision 2” Technical Report-104788-R2 (2000), as it relates to industry-developed approach for calculating and monitoring primary-to-secondary leak rates.

17. IN 2005-24, “Nonconservatism in Leakage Detection Sensitivity” (dated August 3, 2005), as it relates to reactor coolant activity assumptions for containment radiation gas channel monitors.

11.5.4 Technical Evaluation

GDC 60, GDC 63, and GDC 64 are met by using the regulatory positions in RG 1.143, as they relate to the seismic design and quality group classification of structures housing the PERMS. Other applicable NRC guidance includes RG 1.21, RG 1.33, RG 4.15, RG 1.97, and RG 1.143 (interfaces with the LWMS and GWMS), and NUREG-0133 and NUREG-1301 on the development of an ODCM. Relevant industry guidance includes ANSI/HPS 13.1-1999 and ANSI N42.18-2004. With respect to compliance with the TMI-related items, NUREG-0718, NUREG-0737, RG 1.97, and BTP 7-10 provide supplemental information and guidance in meeting the requirements identified under 10 CFR 50.34(f)(2)(xvii) and 10 CFR 50.34(f)(2)(xxvii). Compliance with the requirements of 10 CFR 20.1406 is met by using the guidance of RG 1.143, RG 4.21, and IE Bulletin 80-10.

The PERMS are used to sample and monitor liquid and gaseous process streams and effluents during normal operation, AOOs, and post-accident conditions. The PERMS alerts control room operators of abnormal levels of radioactivity in process streams and liquid and gaseous effluents, and provide signals that initiate automatic safety functions, isolate process streams, and terminate effluent discharges if predetermined radioactivity levels or release rates exceed established alarm setpoints. The PERMS generates signals to initiate the operation of certain safety-related equipment to control radioactive releases under normal and abnormal operations and accident conditions. The PERMS provides the means to collect samples from process and effluent streams for radiological analyses to assess compliance with the NRC regulations.

The staff review of the PERMS included evaluation of the design basis, design objectives, and design criteria; types of radiation detection methods and instrumentation used; related sampling equipment and collection media; redundancy and independence of subsystems; instrumentation measurement ranges, calibration and sensitivity; programs and methods used in establishing alarm set-points for activating alarms or terminating process flows and effluent releases; and diversity of equipment used for normal operation, AOOs, and postulated accidents.

11.5.4.1 Design Considerations

From review of Revision 1 to DCD Tier 2, Section 11.5.1.2, “Design Criteria,” the staff determined that a clarification regarding safety controls was needed. As a result, the staff asked the applicant in **RAI 130-1715, Question 11.05-1**, whether the DCD statement that the monitoring and sampling systems activate appropriate safety controls referred to controls for the MCR isolation being initiated by the MCR outside air intake radiation monitors. By letter dated January 30, 2009, the applicant responded to the above RAI.

In response to **RAI 130-1715, Question 11.05-1**, the applicant stated the MCR outside air intake radiation monitors are the only safety-related radiation monitors which implement the safety actions of GDC 63. GDC 63 requires that the appropriate systems are provided in fuel storage and radioactive waste systems and associated handling areas to detect conditions that may result in loss of residual heat removal capability and excessive radiation levels and to initiate appropriate safety actions. Automatic safety controls are performed by the PERMS in the fuel storage, radioactive waste systems and associated handling areas, and the MCR while manual safety controls are associated with the fuel storage and handling areas:

- The inline non-safety related gaseous radwaste discharge monitor (RMS-RE-072) measures the radioactivity in gaseous effluent before it reaches the plant vent. When radioactivity levels exceed the predetermined setpoint, the discharge valve automatically closes to isolate the gaseous discharge from the vent, terminates the gaseous discharge operation, and activates an alarm in the MCR and A/B radwaste control room for operator actions. The gas stream is then recycled for additional processing. The gaseous radwaste discharge monitor is described in DCD Tier 2, Section 11.5.2.2.5 and Table 11.5-1.

- The inline non-safety related liquid radwaste discharge monitor (RMS-RE-035) measures the radioactivity in liquid effluent in the discharge stream before it reaches the discharge header. The discharge valve is under supervisory control and required approval to open the valve for discharge. When radioactivity levels exceed the predetermined setpoint, the discharge valve automatically closes to isolate the liquid discharge and activates an alarm in the MCR. The liquid stream is then recycled for additional processing. The liquid radwaste discharge monitor is described in DCD Tier 2, Section 11.5.2.5.1 and Table 11.5-4.

- The inline non-safety related fuel handling area HVAC radiation gas monitor (RMS-RE-049) measures the airborne radioactivity level in the exhaust air inside the fuel storage area contained in the HVAC duct. When airborne radioactivity levels exceed the predetermined setpoint, an alarm is activated in the MCR, and the supply and exhaust duct isolation dampers of the affected high airborne radioactivity area are manually closed. The fuel handling area HVAC radiation gas monitor is described in DCD Tier 2, Sections 9.4.3.2.1 and 12.3.4.2.8.1, and Table 12.3-5 evaluated in Sections 9.4 and 12.3, respectively, of this SE.

- The inline safety-related MCR outside air intake radiation monitors (RMS-RE-083A/B, RMS-RE-084A/B, RMS-RE-085A/B) measures airborne radioactivity levels of particulate, gas, and iodine (compose one radiation monitor set) in the supply air are part of the I&C design of the engineered safety feature (ESF) systems. When airborne radioactivity levels exceed the predetermined setpoint, a signal is automatically activated to start the MCR isolation, and an alarm is activated for operator actions. The MCR outside air intake radiation monitors are described in DCD Tier 2, Sections 7 and 11.5.2.2.6, Table 11.5-1, and Figure 11.5-1e.

The applicant also stated the dose evaluation for the fuel handling accident at the spent fuel pit was performed assuming MCR isolation due to the safety-related MCR outside air intake radiation monitors, and confirms that the dose limit is not exceeded (for additional information of the dose evaluation see **RAI 26-410, Questions 06.04-1 and 06.04-2**, evaluated in Section 6.4 of this SE). Based on the discussion above, the staff finds that the description of safety controls for the radiation monitors in the fuel storage, radioactive waste systems and associated handling areas, and the MCR acceptable. **RAI 130-1715, Question 11.05-1** is closed.

The criteria for I&C systems are described in 10 CFR 50.55a(h), which incorporates IEEE Std. 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," and the correction sheet dated January 30, 1995During the review of DCD Tier 2, Section 11.5.2.2.6, "Main Control Room Outside Air Intake Radiation Monitors (RMS-RE-084A, RMS-RE-084B, RMS-RE-085A, RMS-RE-085B, RMS-RE-083A, RMS-RE-083B)," the staff determined that the conformance to the requirements in IEEE Std. 603-1991 was not adequately addressed in the section. As a result, in **RAI 130-1715, Question 11.05-2**, the staff requested that the applicant discuss how the safety-related MCR outside air intake radiation monitors conform to IEEE Std. 603-1991. By letter dated January 30, 2009, the applicant responded to the above RAI.

In response to **RAI 130-1715, Question 11.05-2**, the applicant stated the PERMS are part of the safety-related I&C systems. The GDC applicable for these systems are described in DCD Tier 2, Chapter 7, "Instrumentation and Controls." The MCR outside air intake radiation monitors are described in DCD Tier 2, Section 7.3, "Engineered Safety Feature Systems." DCD Tier 2, Table 7.1-2 identifies IEEE Std. 603-1991 as applied to the design of the ESF actuation system which encompasses the safety-related MCR outside air intake radiation monitors in the regulatory requirements applicability matrix. Technical Report MUAP-07004 (Revision 3), referenced in DCD Tier 2, Section 7.1, "Introduction," describes conformance of the I&C systems to IEEE Std. 603-1991. The applicant also revised DCD Tier 2, Section, 11.5.2.2.6 identifying the MCR outside air intake radiation monitors as being part of the ESF systems as described in DCD Tier 2, Section 7.3, "Engineered Safety Feature Systems," for conformance of the ESF systems I&C design including the MCR outside air intake radiation monitors to the requirements of IEEE Std. 603-1991. Additionally, the staff confirmed that Revision 2 to DCD Tier 2, Sections 11.5.2.2.6 and 11.5.6 included this information. The staff finds the applicant's response acceptable because the applicant appropriately revised , the description of the safety-related MCR outside air intake radiation monitors in DCD Tier 2, Section 11.5 and referenced IEEE Std. 603-1991. **RAI 130-1715, Question 11.05-2** is closed.

GDC 1 requires SSCs important to safety to be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. SRP Section 7.7 addresses the use of digital systems and states to minimize the potential for control system failures that could challenge safety systems, control system software should be developed using a structured process similar to that applied to safety system software. The staff determined that information regarding the standards and processes by which safety-related monitoring instruments are selected to ensure quality such as in EPRI Technical Report-106439, "Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications," was needed. As a result, in **RAI 130-1715, Question 11.05-3**, the staff requested that the applicant describe how EPRI Technical Report-106439 was considered in the selection of digital equipment to ensure adequate quality if commercial equipment is used. By letter dated January 30, 2009, the applicant responded to the above RAI.

In response to **RAI 130-1715, Question 11.05-3**, the applicant stated because the safety-related MCR outside air intake radiation monitors are purchased as Class 1E components and are not commercially dedicated, EPRI Technical Report-106439 does not apply. The non-safety PERMS monitors are designed in accordance with ANSI N42.18-2004, and are part of the plant control and monitoring system (PCMS). The applicant also stated because the non-safety related PERMS monitors are also qualified in accordance with RG 1.143, Section IV, the software for the PCMS is developed using a structured process comparable to the safety related software for the protection and safety monitoring system. The quality program for the PCMS described in DCD Tier 2, Section 7.7 and evaluated in Section 7.7 of this SE. The staff finds the applicant's response acceptable because the safety-related MCR outside air intake radiation monitors are not commercially dedicated and therefore not applicable to EPRI Technical Report-106439, and because the non-safety related monitors are designed for conformance to ANSI N42.18-2004 and qualified in accordance to RG 1.143, Section IV. **RAI 130-1715, Question 11.05-3** is closed.

GDC 13 requires instrumentation to monitor variables and systems over their anticipated ranges for normal operation, AOOs, and for accident conditions as appropriate to assure adequate safety. In **RAI 130-1715, Question 11.05-4**, the staff requested the applicant to describe how the instrumentation design and/or environmental control systems are available to protect radiation monitoring instrumentation from the effects of environmental stressors such as freezing conditions, high temperatures, electromagnetic interference, high humidity, seismic/vibration conditions, and high radiation. By letter dated January 30, 2009, the applicant responded to the above RAI.

In response to **RAI 130-1715, Question 11.05-3**, the applicant stated the safety-related MCR outside air intake radiation monitors, designated as Class 1E components, are required to function during normal operation, AOOs, and post-accident conditions. The staff finds that the applicant's response acceptable because the safety-related MCR outside air intake radiation monitors are environmentally qualified as described in the US-APWR Equipment Environmental Qualification Program in DCD Tier 2, Section 3.11, "Environmental Qualification of Mechanical and Electrical Equipment," and are located in a mild environment as described in DCD Tier 2, Table 3D-2, "US-APWR Environmental Qualification Equipment List." **RAI 130-1715, Question 11.05-4** is closed.

From review of Revision 1 to DCD Tier 2, Section 11.5.2.2.4, the staff determined that information on the main steam line monitors (high sensitivity monitors (RMS-RE-065A/B, RMS-RE-066A/B, RMS-RE-067A/B, RMS-RE-068A/B) and main steam line accident monitors (RMS-RE-087 to 090)) in regards to environmental factors was needed. DCD Tier 2, Section 11.5.1.2, "Design Criteria," states the PERMS are designed to meet the applicable requirements in ANSI N42.18-2004, "Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents." ANSI N42.18-2004 provides recommendations on the selection and performance of effluent radiation monitoring instrumentation from factors influencing monitor response and operability such as temperature, humidity, electronic, and ambient radiation effects. As a result, in **RAI 249-1978, Question 11.05-9**, the staff requested that the applicant describe the design features for the main steam line accident and high sensitivity main steam line (N-16 ch) monitors using the recommendations in ANSI N42.18-2004. By letter dated March 31, 2009, the applicant responded to the above RAI.

In response to **RAI 249-1978, Question 11.05-9**, the applicant described the design features considered to minimize high temperature and humidity effects on the response of main steam line monitors installed on main steam lines which continuously measure radioactivity concentration from the SG, cross talk due to high-energy gamma radiation on the response of main steam line monitors located near one another, and ambient radiation effects from direct or scattered radiation during LOCA conditions on main steam line monitors located near containment penetrations. These design features consist of placing the main steam line radiation monitor detectors and other instruments away from the main steam lines, room ventilation where radiation monitors are located, and shielding radiation detectors except from the gamma radiation of the main steam line being monitored.

The staff reviewed the applicant's response and finds it acceptable because the environmental factors described in ANSI N42.18-2004 were addressed. **RAI 249-1978, Question 11.05-9** is closed. However, since these PERMS design features were not included in the DCD, in follow up **RAI 400-3032, Question 11.05-16** the staff requested that the applicant include this information in the DCD. By letter dated July 15, 2009, the applicant responded to the above RAI.

In response to **RAI 400-3032, Question 11.05-16**, the applicant revised DCD Tier 2, Section 11.5.2.2.4 by adding the design features to minimize the effects on the response of the high sensitivity main steam line radiation and main steam line accident monitors from environmental factors. The staff also confirmed that Revision 2 to DCD Tier 2, Section 11.5.2.2.4 included this information. Based on the discussion above, the staff found the applicant's description of the main steam line accident and high sensitivity main steam line (N-16 ch) monitors acceptable. **RAI 400-3032, Question 11.05-16** is closed.

From review of Revision 1 to DCD Tier 2, Table 11.5-1, the staff determined that design information on the location, calibration isotopes, and check source requirements was incomplete or inconsistent for some PERMS monitors. As a result, in **RAI 249-1978, Question 11.05-10**, the staff requested that the applicant provide design information regarding the location, calibration isotopes, and check source requirements on the main steam line accident (RMS-RE-087, RMS-RE-088, RMS-RE-089, RMS-RE-090) and high sensitivity main steam line (N-16 ch) monitors (RMS-RE-065A/B, RMS-RE-066A/B, RMS-RE-067A/B, and RMS-RE-068A/B). By letter dated March 31, 2009, the applicant responded to the above RAI.

In response to **RAI 249-1978, Question 11.05-10**, the applicant added DCD Tier 2, Figure 11.5-2k to include location information on the main steam line accident and high sensitivity main steam line (N-16 ch) monitors as indicated in DCD Tier 2, Figure 11.5-2i, "Location of Radiation Monitors at Plant (Power Block at Elevation 101'-0")," and Table 11.5-1,"Process Gas and Particulate Monitors." DCD Tier 2, Figure 11.5-2e, "Location of Radiation Monitors at Plant (Power Block at Elevation 25'-3")," and Table 11.5-1 were also revised to depict the SG blowdown return water monitor (RMS-RE-036) and GA Drawing Number 11.5-2e.

The staff reviewed DCD Tier 2, Figure 11.5-2k, "Location of Radiation Monitors at Plant (Power Block Section A-A)," showing the location on the main steam line accident and high sensitivity main steam line (N-16 ch) monitors and Table 11.5-1 identifying GA Drawing Number 11.5-2e for the SG blowdown return water monitor (RMS-RE-036) and finds it acceptable because it includes all of the design information that was missing from the previous version of the DCD. The staff also confirmed that Revision 2 to DCD Tier 2, Figure 11.5-e, and Table 11.5-1 included this information. Therefore, **RAI 249-1978, Question 11.05-10** is closed.

The applicant's response on check source requirements for the main steam line accident monitors and calibration isotope information for the high sensitivity main steam line (N-16 ch) monitors omitted important information. As a result, in **RAI 400-3032, Question 11.05-17**, the staff requested that the applicant revise DCD Tier 2, Table 11.5-1 to include information on how the function of the main steam line accident monitors is verified; describe how performance monitoring checks are conducted and trended in accordance with Section 4.3.3, "Maintenance/Surveillance Requirements," of EPRI, "PWR Primary-To-Secondary Leak Guidelines-Revision 2," Technical Report-104788-R2 (2000); address the potential energy response dependence for detectors that will be installed when using another isotope of lower energy to calibrate the N-16 channel on the high sensitivity main steam line (N-16 ch) monitors; and provide the isotope used to calibrate the high sensitivity main steam line (N-16 ch) monitors such as the reference source or other qualified source described in Section 4.3.2.4, "N-16 Monitors," of EPRI TR-104788-R2 (2000). By letter dated July 15, 2009, the applicant responded to the above RAI.

Section 4.3.2.4 of EPRI Technical Report-104788-R2 (2000) discusses energy dependence for calibration of the N-16 channel using lower energy isotopes can be determined for sodium iodide (NaI) or cesium iodide (CsI) detectors. Since either NaI or CsI detectors may be used in high sensitivity main steam line (N-16 ch) monitors, the specific gamma source (Cs-137 or Co-60) to calibrate these detectors could not be identified. Accordingly, in the response to RAI 400-3032, Question 11.05-17, the applicant revised DCD Tier 2, Table 11.5-1 by adding Note 1 to stipulate the calibration source and qualification process is provided by vendor recommendations consistent with the guidance in Section 4.3.2.4 of EPRI Technical Report-104788-R2 (2000). The applicant also revised Table 11.5-1 to add Note 2 to indicate how proper functioning of the main steam line accident monitors is verified. The applicant will use detectors which include a radiation source called a "live zero source" to produce an output signal below the lower limit of the measurement range. The output signal is monitored in the signal processor and alarms indicating detector failure when the output level is lower than the setpoint. Performance monitoring checks and trending are continuously performed by the "live zero source" method.

The staff reviewed the applicant's response to select an appropriate isotope to calibrate the NaI or CsI detectors in the high sensitivity main steam line (N-16 ch) monitors in accordance with Section 4.3.2.4 of EPRI Technical Report-104788-R2 (2000), and perform and trend monitoring checks in accordance with Section 4.3.3 of EPRI Technical Report-104788-R2 (2000) and found it acceptable because it conformed to EPRI Technical Report-104788-R2 (2000). Because the implementation of these commitments requires plant and site-specific information, the staff finds the inclusion of COL Information Items 11.5(1), 11.5(4), and 11.5(5) acceptable. Additionally, the staff confirmed that Revision 2 to DCD Tier 2, Table 11.5-1 included this information. **RAI 400-3032, Question 11.05-17** is closed.

11.5.4.2 Site-Specific Cost-Benefit Analysis

Similarly to DCD Tier 2, Sections 11.2.1.5, 11.3.1.5, and 11.4.1.5, DCD Tier 2, Section 11.5.2.11, "Site-Specific Cost-Benefit Analysis," states the cost-benefit numerical analysis as required by 10 CFR 50, Appendix I, Section II, Paragraph D demonstrates that the addition of items of reasonably demonstrated technology will not provide a favorable cost benefit, but does not include a CBA. Under COL Information Item 11.5(6), the COL applicant will perform a site-specific CBA to demonstrate compliance with NRC regulations. Although the staff found the inclusion of COL Information Items 11.2(5) and 11.3(8) acceptable, as evaluated in Sections 11.2 and 11.3, respectively, of this SE, the staff acknowledges that the CBA is not required for the PERMS because there are no effluent releases to the environment from the PERMS that result in doses to members of the public in unrestricted areas. Therefore, even though the applicant provides COL Information Item 11.5(6) in both DCD Tier 2, Sections 11.5.5 and Table 1.8-2, its description is not required in DCD Tier 2, Section 11.5. However, the CBA is required for the LWMS and GWMS by the COL applicant, as evaluated in Sections 11.2.4.2 and 11.3.4.2 of this SE, respectively.

11.5.4.3 Offsite Dose Calculation Manual

From review of Revision 1 to DCD Tier 2, Section 11.5, the staff determined that clarification on several COL information items for the PERMS in DCD Tier 2, Section 11.5.5 was needed. As a result, in **RAI 249-1978, Question 11.05-11**, the staff requested that the applicant clarify COL Information Items 11.5(1), 11.5(4), and 11.5(5); identify where these COL information items are described in DCD Tier 2, Section 11.5; and instruct the COL applicant to perform these COL information items in the discussion of the relevant DCD Tier 2 sections. By letter dated March 31, 2009, the applicant responded to the above RAI.

In response to **RAI 249-1978, Question 11.05-11**, the COL applicant is required to provide site-specific information related to the PERMS using the guidance in RGs 1.21, 1.33, and 4.15 to satisfy COL Information Item 11.5(1) in DCD Tier 2, Section 11.5. The second part of COL Information Item 11.5(1) requires the applicant to comply with the dose objectives in 10 CFR Part 50, Appendix I discussed in DCD Tier 2, Section 11.5.2.9, "Offsite Dose Calculation Manual." Under COL Information Items 11.5(4) and 11.5(5), the COL applicant is responsible for developing the site-specific procedures related to radiation monitoring instruments and radioanalytical methods and sampling in DCD Tier 2, Sections 11.5.2.6, "Reliability and Quality Assurance," and 11.5.2.8, "Compliance with Effluent Release Requirements," respectively. The staff finds the applicant's response acceptable because the implementation of COL Information Items 11.5(1), 11.5(4), and 11.5(5) will be addressed in a plant- and site-specific ODCM and related operational programs in FSAR Section 13.4. Additionally, the staff confirmed that Revision 2 to DCD Tier 2, Section 11.5 included the revised information. **RAI 249-1978, Question 11.05-11** is closed.

DCD Tier 2, Section 11.5.2.9, "Offsite Dose Calculation Manual," states the COL applicant will prepare an ODCM that contains a description of the methodology and parameters used for calculation of offsite doses for gaseous and liquid effluents to comply with NRC regulations. The ODCM will follow the guidance in NUREG-0133, RG 1.109, RG 1.111, or RG 1.113, and will include a discussion on how the NUREGs, RGs, or alternative methods are implemented. Under COL Information Item 11.5(2), the COL applicant will follow the NEI 07-09A (Revision 0), "Generic FSAR Template Guidance for Offsite Dose Calculation Manual (ODCM) Program Description," as an alternate to providing the ODCM at the time of application. The milestones for the development and implementation of the ODCM are addressed in COL Information Item 13.4(1) evaluated in Section 13.4 of this SE.

NEI 07-09A presents the functional elements of an ODCM that, if met, would demonstrate compliance with 10 CFR 50.34a, 10 CFR 50.36a, and 10 CFR 50, Appendix I. NEI 07-09A identifies monitoring criteria, liquid and gaseous radiological effluent controls, monitoring instrumentation, methods for deriving lower limits of detection and detection sensitivities, methods for establishing instrumentation alarm setpoints, dose limits for members of the public, requirements for process and effluent sampling in various plant systems, requirements limiting effluent releases, surveillance requirements, methods for calculating effluent release rates and doses, radiological environmental monitoring, QA and QC program, information to be contained in annual radiological effluent release reports, reporting requirements to the NRC, process for initiating and documenting changes to the ODCM and supporting procedures, and record keeping. NEI 07-09A was previously reviewed and found to be acceptable by the staff (ML083530745).

NEI 07-09A also addresses the standard radiological effluent controls (SREC) and the REMP. The description to implement the administrative and operational programs for the SREC, ODCM, and REMP were found to be consistent with the requirements of GL 89-01, and the guidance of NUREG-1301, NUREG-0133, RG 1.21, RG 1.33, RG 4.1, RG 4.8, RG 4.15, and the Radiological Assessment BTP in NUREG-1301, Appendix A.

The staff reviewed the applicant's submittal against the requirements of 10 CFR Part 50, as it relates to a program that provides the means to calculate offsite doses to the public resulting from gaseous and liquid effluents, and found it acceptable. Both, the DCD Tier 2, Section 11.5.5 and Table 1.8-2 provides a COL information item for the COL applicant to address the ODCM. Under COL Information Item 11.5(2), the COL applicant is required to prepare the ODCM following NEI 07-09A as an alternative to providing the ODCM at the time of application. Because the ODCM requires plant- and site-specific information which is outside the scope of the requested DC, the staff finds the inclusion of COL Information Item 11.5(2) acceptable.

11.5.4.4 Radiological Environmental Monitoring Program

DCD Tier 2, Section 11.5.2.10 "Radiological Environmental Monitoring Program," states the COL applicant will develop the REMP. Under COL Information Item 11.5(3), the COL applicant commits to follow NEI 07-09A, as described in Section 11.5.4.3 of this SE which includes the REMP and other programs, as an alternative to providing descriptions of the these programs at the time of application. The plant and site-specific REMP will consider local land use and census data to identify all potential radiation exposure pathways, and take into account associated radioactive materials present in liquid and gaseous effluents and direct external radiation from SSCs. The milestones for the development and implementation of the REMP are addressed in COL Information Item 13.4(1) evaluated in Section 13.4 of this SE.

The REMP describes the process and methods for monitoring, sampling, and analyzing environmental samples representative of expected radionuclide distributions and concentrations in environmental media and associated exposure pathways. The REMP also identifies the types, numbers, and sampling locations, and sampling and analytical frequencies of environmental samples. The REMP follows the guidance in GL 89-01, NUREG-1301, NUREG-0133, and the Radiological Assessment BTP in NUREG-1301, Appendix A.

The staff reviewed the applicant's submittal against the requirements of 10 CFR Part 50, as it relates to a program that provides the means to monitor and quantify radiation and radioactivity levels in the environs of the plant associated with gaseous and liquid effluent releases and the direct external radiation from contained sources of radioactive materials in tanks and equipment and in buildings, and found it acceptable. Both, the DCD Tier 2, Section 11.5.5 and Table 1.8-2 provides a COL information item for the COL applicant to develop the REMP. Under COL Information Item 11.5(3), the COL applicant is required to develop the REMP following the guidance in NUREG-1301, NUREG-0133, and NEI 07-09A as an alternative to providing the REMP at the time of application. Because the REMP requires plant- and site-specific information which is outside the scope of the requested design certification, the staff finds the inclusion of COL Information Item 11.5(3) acceptable.

11.5.4.5 Task Action Plan

NUREG-0933, Section 2, "Resolution of Generic Safety Issues," includes a task action plan which identifies items covering a wide variety of subjects and includes Task Action Plan Item B-67, "Effluent and Process Monitoring Instrumentation." In addressing Task Action Plan, Subtask 1 of Item B-67 for normal plant operation and AOO effluents, DCD Tier 2, Section 11.5 conforms to the acceptance criteria and guidance of SRP Section 11.5. The associated NRC TMI-related items in monitoring radioactive effluents under accident conditions are covered in the applications sections in DCD Tier 2, Chapter 7, "Instrumentation and Controls," and Chapter 9, "Auxiliary Systems." The staff's evaluations of these DCD Tier 2 sections are addressed in the respective sections of this SE.

In addressing Task Action Plan, Subtask 2 of Item B-67, the whole body doses at the EAB associated with a GWMS leak or component failure is addressed in DCD Tier 2, Sections 11.3.3.2.1 and 11.3.3.2.2. The assumptions and analysis of the radiological consequence associated with a waste gas surge tank leak evaluated in Section 11.3 of this SE was determined to be in conformance with the acceptance criteria and guidance in SRP Section 11.3 and BTP 11-5 for systems designed to preclude the accumulations of oxygen and hydrogen explosive gas mixtures and detonations within the GWMS, and complies with the requirements of 10 CFR Parts 20 and 50.

In addressing Task Action Plan, Subtask 3 of Item B-67, the radiological consequence associated with the failure of a liquid waste tank is addressed in DCD Tier 2, Section 11.2.3.2. The analysis considers the potential impacts from a release of radioactive materials on the nearest potable water supply located in an unrestricted area. The assumptions, analysis, and approach of the radiological consequence associated with a liquid tank failure evaluated in Section 11.2.4.8 of this SE was determined to be in conformance with the acceptance criteria and guidance in SRP Section 11.2 and BTP 11-6, and complies with the requirements of 10 CFR Part 20 and 10 CFR Part 50.

In addressing Task Action Plan, Subtask 4 of Item B-67, DCD Tier 2, Section 11.4 describes the installation and use of permanently installed solid and wet processing subsystems. This approach evaluated in Section 11.4 of this SE conforms to the acceptance criteria and guidance in SRP Section 11.4.

11.5.4.6 Minimization of Contamination

DCD Tier 2, Section 11.5.1.2, “Design Criteria,” states the PERMS provide operational data to minimize the potential for the contamination of the facility and of the environment, and the generation of radioactive waste in accordance with 10 CFR 20.1406. Liquid and gaseous processes and streams that are radioactive or have the potential of becoming radioactive from cross-contamination are monitored by the PERMS. Grab and representative sampling of process fluids with the various sampling subsystems to monitor overall plant condition and systems is described in DCD Tier 2, Section 9.3.2, “Process and Post-Accident Systems,” and evaluated in Section 9.3.2 of this SE.

Design features for the PERMS to meet compliance with 10 CFR 20.1406 include a piping tap for purging and cleaning of the safety and non-safety related process gas and particulate radiation monitors, non-safety related process liquid radiation monitors, and the non-safety related liquid and gaseous effluent radiation monitors. Any leakage outside the containment in the post-accident sampling system (PASS) is collected in the R/B sump tank. In the primary sampling systems of the PASS, liquid leakage is collected in a sink and drained to the WHT for processing through the LWMS. The purged liquid is returned to the low pressure end of its own system. Purged gas for collection of representative grab samples of containment atmosphere during normal operation are returned back to containment. Residual liquid condensation collected in the gas sample vessel is returned to the HT. In the secondary sampling systems used for controlling water quality, the sample line and sink drain are drained to the T/B floor sump for processing through the LWMS. Based on the discussion above, the staff found the applicant’s description of PERMS design features to meet compliance with the requirements with 10 CFR 20.1406 acceptable.

Under COL Information Item 12.1(8), evaluated in Section 12.3 of this SE, the COL applicant is required to develop operational procedures limiting leakage and the spread of contamination using the guidance of RG 4.21 for the operation and handling of all SSCs which could be potential sources of contamination within the plant.

RG 1.206, Section C.I.11.3 describes the minimum information that should be provided by applicant's to address system design features and operational procedures to ensure that interconnections between plant systems and mobile processing equipment avoids contamination of nonradioactive systems and uncontrolled releases of radioactivity in the environment in accordance with IE Bulletin 80-10 and RG 1.143, in part, to meet compliance with 10 CFR 20.1406. Further, RG 1.206, Section C.I.11.5.2, "System Description," states for continuous process and effluent radiation monitors, the applicant should provide monitoring systems and procedures for detection of radioactivity in nonradioactive systems to prevent unmonitored and uncontrolled releases of radioactive material to the environment." From review of DCD Tier 2, Section 11.5, the staff determined that the guidance in RG 1.206 was not addressed. As a result, in **RAI 629-4973, Question 11.03-18**, **Item 4** the staff requested that the applicant identify compliance with IE Bulletin 80-10 in the PERMS design. By letter dated September 24, 2010, the applicant responded to above RAI. The staff reviewed the applicant's response and found that it did not acknowledge the requirements of IE Bulletin 80-10 in the PERMS design. Conformance to IE Bulletin 80-10 should be acknowledged in DCD Tier 2, Section 11.5 but was not. **RAI 629-4973, Question 11.03-18, Item 4,** as it relates to acknowledgement of IE Bulletin 80-10 in the PERMS design, is being tracked as **Open Item 11.05-1**.

11.5.4.7 Tier 1 Information

DCD Tier 1, Section 2.7.6.6, "Process Effluent Radiation Monitoring and Sampling System," provides PERMS design features to monitor liquid and gaseous effluent releases to unrestricted areas during normal plant operations, AOOs, and post-accident conditions; monitor containment atmosphere, airborne radioactivity, spaces containing components for recirculation of LOCA fluids, effluent discharge paths, and the plant environs during normal plant operations, AOOs, and post-accident conditions; provide radiation monitoring equipment for liquid and gaseous effluents from plant systems for annual release reports, ensure plant systems operate as designed and installed, and measure radiation levels and quantities of noble gases, radioactive iodine and particulates in gaseous effluents from all release points; control gaseous and effluent releases to ensure doses to unrestricted areas from liquid and gaseous effluents are ALARA; provide operational data to minimize and/or prevent contamination of the facility and environment; and monitor radioactive waste systems to detect conditions that may result in excessive radiation levels. The MCR (RMS-RE-084A/B, RMS-RE-085A/B, RMS-RE-083A/B) and containment radiation particulate (RMS-RE-040) monitors in DCD Tier 1, Table 2.7.6.6-1, "Process Effluent Radiation Monitoring and Sampling System Equipment Characteristics (Sheets 1 and 2)," are designed to satisfy seismic Category I requirements. The MCR monitors are the only PERMS monitors that are powered from their respective Class 1E divisions and physically separated from the other divisions by a structural barrier which also serves as a fire barrier. There are no PERMS monitors identified in DCD Tier 1, Table 2.7.6.6-1 that need to withstand harsh environments.

DCD Tier 1, Table 2.7.6.6-2, "Process Effluent Radiation Monitoring and Sampling System Inspections, Tests, Analyses, and Acceptance Criteria (Sheets 1 and 2)," describes the ITAAC for the PERMS. Table 2.7.6.6-2 requires inspection of the as-built PERMS monitors in DCD Tier 1, Section 2.7.6.6.1; inspection, type test, and/or analysis of seismic Category 1 radiation monitors and verification of these radiation monitors in a seismic Category I structure; and inspection for retrievability of data and alarms in the MCR. The ITAAC for the liquid and gaseous radwaste discharge radiation monitors in DCD Tier 1, Sections 2.7.4.1.1 and 2.7.4.2.1, and DCD Tier 2, Table 11.5-1 requires the respective LWMS and GWMS discharge valves to close in response to an effluent discharge isolation signal. In response to **RAI 523-4246, Question 11.02-32** and **RAI 533-4261, Question 11.03-15**, evaluated in Sections 11.2 and 11.3 of this SE, the applicant revised DCD Tier 1, Sections 2.7.4.1.1 and 2.7.4.2.1 to address compliance with 10 CFR Part 20, Appendix B and 10 CFR Part 50, Appendix I as ITAAC design features for the LWMS and GWMS. Other Tier 1 information associated with the PERMS is provided in DCD Tier 1, Section 2.7.6.7, “Process and Post-Accident Sampling System,” evaluated in Section 9.3 of this SE. The ITAAC for the PERMS in DCD Tier 2, Section 14.3.4.7, “ITAAC for Plant Systems,” and Table 14.3-6, “Plant Systems,” includes verifying the performance of the PERMS as permanently installed systems or in combination with portable skid-mounted equipment (the GWMS does not have provisions for mobile or temporary equipment).

10 CFR 52.47(b)(1) requires that a DC application contain the ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, that a plant that incorporates the DC is built and will operate in accordance with the DC and the provisions of the Atomic Energy Act, and NRC regulations. From review of Tier 1 information related to SG tube leakage detection instrumentation, the staff found ITAAC information to verify compliance with the PERMS design criteria was missing. As a result, in **RAI 249-1978, Question 11.05-7**, the staff requested that the applicant address the sensitivity, response time, and alarm limit in the ITAAC for the SG tube leakage detection instrumentation. By letter dated March 31, 2009, the applicant responded to the above RAI.

In response to **RAI 249-1978, Question 11.05-7**, the applicant referred to their response in **RAI 249-1978, Question 11.05-6** evaluated in Section 11.5.4.8 of this SE. The applicant stated three types of radiation monitors to detect SG tube leakage, with ranges in DCD Tier 2, Tables 11.5-1, “Process Gas and Particulate Monitors,” through 11.5-3, “Effluent Gas Monitors,” provide the capability to detect SG tube leakage of an amount to conform to the NEI 97-06 and EPRI guidelines, and the ITAAC is identified in DCD Tier 1, Tables 2.7.6.6-1 and 2.7.6.6-2. The staff reviewed the applicant's response to **RAI 249-1978, Question 11.05-7** and found that information on the sensitivity, response time, and alarm limit for the SG tube leak detection instrumentation was not described in DCD Tier 1, Tables 2.7.6.6-1 and 2.7.6.6-2. As a result, the staff closed **RAI 249-1978, Question 11.05-7** and, in follow-up **RAI 400-3032, Question 11.05-14**, requested that the applicant provide the ITAAC in Tier 1 information to address the sensitivity, response time, and alarm limit of the SG tube leak detection instrumentation. By letter dated July 15, 2009, the applicant responded to the above RAI.

In response to **RAI 400-3032, Question 11.05-14**, the applicant stated the Tier 1 information includes ITAAC to verify the as-built monitors are consistent with the functional arrangement and design description in DCD Tier 1, Section 2.7.6.6 and Table 2.7.6.6-1, and other non-Class 1E radiation monitors. The applicant considers the numeric values for sensitivity, response time and alarm limits for SG tube leakage detection instrumentation below the level of detail for Tier 1 information.

Because comprehensive testing is conducted in the preoperational testing of RCS leakage detection instrumentation including SG tube leakage detection instrumentation (for additional information on SG leakage detection instrumentation, see also **RAI 400-3032, Question 11.05-**

15), and the capability to adequately measure SG tube leakage and maintain leakage within acceptable limits is assured during plant operation by the requirements in DCD Tier 2, Chapter 16, "Technical Specifications," TS 3.4.13, "RCS Operational Leakage," and Section 5.5.9, "Steam Generator (SG) Program," the staff finds the applicant's description of Tier 1 information on ITAAC for the non-safety PERMS monitors (SG blowdown water radiation monitor, high sensitivity main steam line monitors, and condenser vacuum pump exhaust line radiation monitors), acceptable. **RAI 400-3032, Question 11.05-14** is closed.

11.5.4.8 Technical Specifications

DCD Tier 2, Chapter 16 describes the TS associated with the RWMS. DCD Tier 2, Chapter 16, TS 5.5.1, "Offsite Dose Calculation Manual (ODCM)," and TS 5.5.4, "Radioactive Effluent Controls Program," provides directions in managing releases of radioactive effluents and the control and handling of concentrated wastes for disposal. TS 5.5.12, "Explosive Gas and Storage Tank Radioactivity Monitoring Program," specifies the quantity of radioactivity contained in gas storage tanks and in unprotected outdoor liquid storage tanks in accordance with BTP 11-5 and BTP 11-6, respectively. TS 5.5.12 requires concentration limits and surveillances of hydrogen and oxygen in the GWMS whether or not the system is designed to withstand a hydrogen explosion; ensures the quantity of radioactivity in each gas storage tank is less than the amount that would result in a whole body exposure of ≥0.1 rem to any individual in an unrestricted area in the event of a tank failure; and ensures the quantity of radioactivity in all outdoor liquid tanks not surrounded by liners, dikes, or walls capable of holding the tank contents and that do not have tank overflows and surrounding area drains connected to the LWMS is less than ECLs in 10 CFR Part 20, Appendix B, Table 2, Column 2 at the nearest potable water supply and the nearest surface water supply in an unrestricted area in the event of a tank failure.

TS 5.6.1, "Annual Radiological Environmental Operating Report," and TS 5.6.2, "Radiological Effluent Release Report," specifies annual reporting requirements in describing the results of the radiological monitoring program and provide summaries of the quantities of radioactive liquid effluents released into the environment. In TS 5.5.1, COL initiated changes to the ODCM shall be documented with sufficient information by analyses or evaluations and meet compliance with 10 CFR 20.1302; 40 CFR Part 190; 10 CFR 50.36a; and 10 CFR Part 50, Appendix I. TS 5.5.4, "Radioactive Effluent Control Program," contained in the ODCM includes alarm setpoints for effluent monitors; monitoring, sampling, and analysis of liquid and gaseous effluents to meet compliance with 10 CFR 20.1302; determination of cumulative and projected pubic dose limits from liquid and gaseous effluents and noble gases to meet compliance with 10 CFR Part 50, Appendix I; and annual public dose limits to meet compliance with 40 CFR Part 190. The use of an ODCM is under the operational programs described in DCD Tier 2, Section 13.4, "Operational Program Implementation." The implementation of such programs will be addressed in a plant and site-specific ODCM under COL Information Items 11.5(2) and 11.5(3) in DCD Tier 2, Section 11.5.5, "Combined License Information," as described in DCD Tier 2, Table 1.8-2, "Compilation of All Combined License Applicant Items for Chapters 1-19 (Sheet 32 of 44)."

From review of Revision 1 to DCD Tier 2, Sections 11.5.2.1 and 5.2.5.4.1.2, and Chapter 16 TS 3.4.13 and TS B 3.4.15, the staff determined that information on the RCS leakage rate technical basis for the containment particulate (RMS-RE-040) and gaseous (RMS-RE-041) radiation monitor sensitivities was needed. The technical basis for RCS leakage detection instrumentation and RG 1.45 (Revision 1) establish radiation monitor sensitivity requirements for a leakage detection increase of 1 gpm within 1 hour using a realistic primary coolant concentration. While DCD Tier 2, Section 5.2.5.4.1.2, "Containment Airborne Particulate Radioactivity Monitor," specifies containment radiation monitor sensitivities for RCS leakage detection instrumentation and DCD Tier 2, Section 11.5.2.2, "Process Gas and Particulate Monitors Component Description," and Table 11.5-1 presents PERMS range information, they do not describe the methodology to demonstrate that the PERMS monitors selected by the COL applicant for RCS leakage detection instrumentation are capable of satisfying the technical basis using a realistic radioactive concentration in the RCS. As a result, in **RAI 249-1978, Question 11.05-5**, the staff requested that the applicant revise DCD Tier 2, Table 11.5-1 to reflect the minimum required sensitivities for the containment particulate and gaseous radiation monitors necessary to satisfy the required RCS leakage rate technical basis; and describe in DCD Tier 2, Section 11.5.2.2 the methodology, assumptions, and basis to demonstrate that the PERMS monitors selected by the COL applicant are capable of satisfying the technical basis for RCS leakage detection instrumentation using a realistic radioactive concentration in the RCS. By letter dated March 31, 2009, the applicant responded to the above RAI.

In response to **RAI 249-1978, Question 11.05-5**, the applicant stated the containment radiation gas monitor will be deleted from the TS leakage detection methods as this radiation monitor does not have enough leakage detection capability assuming no failed fuel exists (for additional information on containment radiation gas monitor, see **RAI 164-1967, Question 05.02.05-2**, evaluated in Section 5.2 of this SE), but the containment radiation particulate monitor will remain as a diverse detection method.

The staff reviewed the applicant's response and finds deletion of the containment radiation gas monitor from the TS leakage detection methods in DCD Tier 2, Chapter 16 acceptable because the NRC Information Notice 2005-24 (August 2005), "Nonconservatism in Leakage Detection Sensitivity," describes operating experience on the response time of 1 gpm within 1 hour for a gaseous radiation monitor may be a non-conservative estimate based on the assumption of non-realistic radioactive concentration in the RCS. Further, RG 1.45 (Revision 1) states the gaseous radiation monitor is no longer required in the TS for RCS leakage detection. Additionally, the staff confirmed that Revision 2 to DCD Chapter 16 deleted the containment radiation gas monitor from the TS leakage detection methods. **RAI 249-1978, Question 11.05-5** is closed.

From review of DCD Tier 2, Section 5.2.5.4.1.2, "Containment Airborne Particulate Radioactivity Monitor," the staff determined that the containment particulate radiation monitor sensitivity necessary to satisfy the RCS leakage rate technical basis for leakage detection of less than 0.5 gpm within 1 hour of detector response time under corrosion and activation products was not addressed. As a result, in **RAI 400-3032, Question 11.05-12**, the staff requested that the applicant submit a detailed evaluation to demonstrate that the containment particulate radiation monitor range provides the capability to detect leakage of less than 0.5 gpm within 1 hour of detector response time using a realistic radioactive concentration in the RCS or describe the program and procedure that will be used to satisfy the RCS leakage rate technical basis and RG 1.45 (Revision 1); and update reference to RG 1.45 (Revision 1) in DCD Tier 2, Sections 5.2.5.4.1.2 and 5.2.7, and Table 1.9.1-1. By letter dated July 15, 2009, the applicant responded to the above RAI.

Under 10 CFR 2.390, the applicant submitted the methodology in response to **RAI 400-3032, Question 11.05-12**, to demonstrate that the containment particulate radiation monitor range is capable of satisfying the technical basis for RCS leakage detection instrumentation using a realistic radioactive concentration in the RCS. The applicant revised DCD Tier 2, Section 11.5.2.2.1, "Containment Radiation Monitors," stating the containment particulate radiation monitor has the capability of detecting less than 0.5 gpd leakage within 1 hour of response time. The staff reviewed the applicant's methodology and performed confirmatory calculations of time-dependent radioactivity concentrations of RCS leakage into containment to verify the RCS leakage detection capability of the containment particulate radiation monitor, but could not confirm the flashing rate value. As a result, the staff closed **RAI 400-3032, Question 11.05-12** and issued follow-up **RAI 522-4247, Question 11.05-18**, evaluated below and later in this section, requesting that the applicant provide the basis of this value and describe conformance of the PERMS monitors with the guidance in RG 1.45 (Revision 1) and recommendations in ANSI N42.18-2004, "Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents." to satisfy the RCS leakage rate technical basis..

By letter dated March 8, 2010, the applicant provided the basis under 10 CFR 2.390 on the flashing rate value in response to **RAI 522-4247, Question 11.05-18**. The staff reviewed the basis and confirmed that the flashing rate value was within the stated PERMS range for RCS leakage detection instrumentation. The staff also calculated the expected release factor for flashing sprays caused from overheating process equipment using the methodology in NUREG/CR-6410, "Nuclear Fuel Cycle Facility Accident Analysis Handbook," based on an energy balance on the system. Additionally, the staff confirmed the applicant's flashing rate value and finds the selection of a lower (more conservative) flashing rate value acceptable. Therefore, the staff finds flashing rate value as it relates to the RCS leakage rate technical basis for the PERMS monitors acceptable. This item regarding the flashing rate value in **RAI 522-4247, Question 11.05-18** is closed**.** The remaining items regarding conformance of the PERMS monitors to RG 1.45 (Revision 1) and ANSI N42.18-2004 in **RAI 522-4247, Question 11.05-18** are evaluated later in this section.

NEI 97-06, "Steam Generator Program Guidelines," and EPRI guidelines referenced in DCD Tier 2, Section 5.4.2 and TS B 3.4.17.1, establish radiation monitor sensitivity requirements for a leakage detection capability of 30 gpd. From review of Revision 1 to DCD Tier 2, Sections 11.5.2.1 and 5.4.2, and DCD Tier 2, Chapter 16, Section 5.5.9 and TS B 3.4.17.1, the staff determined that information on primary-to-secondary leakage radiation monitor sensitivities to satisfy the leakage rate detection sensitivity technical basis was needed. While DCD Tier 2, Section 11.5.2.2 and Table 11.5-1 present PERMS range information, they do not describe the methodology to demonstrate that the radiation monitors selected by the COL applicant for primary-to-secondary leakage detection instrumentation are capable of satisfying the technical basis using a realistic radioactive concentration in the RCS. As a result, in **RAI 249-1978, Question 11.05-6**, the staff requested that the applicant identify in DCD Tier 2, Table 11.5-1 those PERMS monitors that will satisfy the primary-to-secondary leakage detection requirement in NEI 97-06 and the minimum required radiation monitor sensitivities necessary to satisfy the required leakage rate technical basis; and describe in DCD Tier 2, Section 11.5.2.2, the methodology, assumptions, and basis to demonstrate that the PERMS monitors selected by the COL applicant are capable of satisfying the technical basis for primary-to-secondary leakage detection instrumentation using a realistic radioactive concentration in the RCS. By letter dated March 31, 2009, the applicant responded to the above RAI.

The applicant's response to **RAI 249-1978, Question 11.05-6**, raised additional issues regarding the description of "other monitors" and "other isotopes," primary-to-secondary leakage rate technical basis, and design information that should be included in the DCD. Therefore, the staff closed **RAI 249-1978, Question 11.05-6** and, in follow-up **RAI 400-3032, Question 11.05-13**, requested that the applicant provide this information as discussed and evaluated below.

In response to **RAI 249-1978, Question 11.05-6**, by letter dated April 13, 2009, the applicant stated three types of non-safety radiation monitors in DCD Tier 2, Section 5.2.5.3, "Detection of Identified Leakage," are used to detect primary-to-secondary leakage and compare leakage rates calculated by "other monitors" to ensure the validity of the method. Because "other monitors" was not sufficiently described, the staff closed this item in **RAI 249-1978, Question 11.05-6** and, in follow-up **RAI 400-3032, Question 11.05-13**, requested that the applicant identify "other monitors" and discusses how they are used to calculate primary-to-secondary leakage rate and validate the methods.

In response to **RAI 400-3032, Question 11.05-13**, by letter dated July 16, 2009, the applicant described three types of PERMS monitors are used to detect primary-to-secondary leakage in the US-APWR:

- SG blowdown water radiation monitor (RMS-RE-055).
- High sensitivity main steam line monitors (RMS-RE-065A/B, RMS-RE-066A/B, RMS-RE-067A/B, RMS-RE-068A/B).
- Condenser vacuum pump exhaust line radiation monitors (RMS-RE-043A/B) (primary PERMS monitors used to detect the primary-to-secondary leakage rate in the US-APWR design).

The staff finds the applicant's response on this item acceptable because "other monitors" are described, and the applicant committed to revise the DCD to include this information. The staff confirmed that Revision 2 to the DCD included this information. Therefore, this item regarding the description of "other monitors" in **RAI 400-3032, Question 11.05-13** is closed.

In response to **RAI 249-1978, Question 11.05-6**, by letter dated April 13, 2009, the applicant stated the primary-to-secondary leakage rate can be estimated by comparing the fission gas activity such as Xe-133 in the condenser exhaust gas to the fission gas activity in the RCS and when fission gas concentrations are low in the RCS, "other isotopes" such as Ar-41 can be used taking into consideration the effect of their shorter half-lives. The applicant also stated radiochemical grab sampling will be used to verify the performance of radiation monitors and alarms, confirm leakage rate estimates, and provide early detection of levels or changes in radioactivity in the secondary system that are below the sensitivity of the radiation monitors. Because "other isotopes" was not sufficiently described and the method to estimate primary-to-secondary leakage rate with these "other isotopes" was not addressed, the staff closed this item in **RAI 249-1978, Question 11.05-6** and, in follow-up **RAI 400-3032, Question 11.05-13**, requested that the applicant identify "other isotopes" and describe how they are used to estimate the primary-to-secondary leakage rate in the condenser exhaust gas when fission gas concentrations are low in the RCS given that the Ar-41 composition in air is very small (<1 percent), and revise DCD Tier 2, Section 11.5.2.4.2, "Condenser Vacuum Pump Exhaust Line Radiation Monitors (RMS-RE-043A, RMS-RE-043B, RMS-RE-081A and RMS-RE-081B)," to include this information. By letter dated July 15, 2009, the applicant responded to the above RAI.

In response to **RAI 400-3032, Question 11.05-13**, the applicant provided "other isotopes" such as the long-lived noble gas isotopes with relative abundance in the RCS given in the EPRI guideline which can be used in the primary-to-secondary leak rate analysis for the condenser vacuum pump exhaust line radiation monitor measurements. The EPRI guideline also provides "other isotopes" found in secondary coolant from primary-to-secondary leakage.

The staff finds the applicant's response on this item acceptable because the EPRI guideline lists these noble gas isotopes which can be used in the primary-to-secondary leak rate analysis, and the applicant committed to revise the DCD to include this information. The staff confirmed that Revision 2 to the DCD included the description of the methodology for estimating the primary-to-secondary leakage rate by comparing the fission gas activity such as Xe-133 in the condenser exhaust gas to the fission gas activity in the RCS and "other isotopes" such as Ar-41 when fission gas concentrations are low in the RCS, and the ability of the condenser vacuum pump exhaust line radiation monitors range having the capability of detecting 30 gpd leakage using the methodology in the EPRI guideline. Therefore, this item regarding the description of "other isotopes" in **RAI 400-3032, Question 11.05-13** is closed.

In response to **RAI 249-1978, Question 11.05-6**, by letter dated April 13, 2009, the applicant stated the PERMS ranges in DCD Tier 2, Tables 11.5-1 through 11.5-3 are sufficient to provide the capability to detect 30 gpd primary-to-secondary leakage and conform to the NEI 97-06 and EPRI guidelines, and no specific sensitivity requirement needs to be stated in DCD Tier 2, Tables 11.5-1 through 11.5-3. Because the methodology to demonstrate that the PERMS monitors selected by the COL applicant are capable of satisfying the technical basis for primary-to-secondary leakage detection instrumentation using a realistic radioactive concentration in the RCS was not addressed, the staff closed this item in **RAI 249-1978, Question 11.05-6** and, in follow-up **RAI 400-3032, Question 11.05-13**, requested that the applicant submit a detailed evaluation demonstrating that the lower range of the primary-to-secondary radiation monitor is sufficient to provide the capability to detect 30 gpd primary-to-secondary leakage using a realistic radioactive concentration in the RCS, or describe the program and procedure that will be used to satisfy the primary-to-secondary leakage rate technical basis and conform with the NEI 97-06 and EPRI guidelines.

Under 10 CFR 2.390, the applicant submitted the methodology in response to **RAI 400-3032, Question 11.05-13**, by letter dated July 16, 2009, to demonstrate that the PERMS monitors selected by the COL applicant are capable of satisfying the technical basis for primary-to-secondary leakage detection instrumentation using a realistic radioactive concentration in the RCS.

The staff reviewed the applicant's methodology to estimate the primary-to-secondary leak rate using the SG blowdown water radiation monitor which considers an activity balance of the system relating the change in activity concentration in the SG as the difference between the activity entering and the activity leaving around the leaking SG. The staff finds this methodology as described in Sections 5.2, "Leak Rate Calculations Via Condenser Off-Gas Analysis," and 5.3, "Leak Rate Calculations Via Blowdown Analysis," of EPRI PWR Primary-to-Secondary Leak Guidelines-Revision 3 (dated December 2004) guideline, acceptable. The staff calculated the Ar-41 concentration in the condenser off-gas sample, transit time, and noble gas activity concentration in the primary coolant. The staff's results verified the lower range of the condenser vacuum pump exhaust line radiation monitors is sufficient to detect 30 gpd primary-to-secondary leakage using a realistic radioactive concentration in the RCS.

Based on the discussion and evaluation above, the staff finds that the applicant's description on the primary-to-secondary leakage radiation monitors sensitivity to satisfy the leakage rate detection sensitivity technical basis acceptable and conforms to NEI 97-06 and EPRI guideline. All items in **RAI 400-3032, Question 11.05-13** are closed.

From review of DCD Tier 2, Section 11.5.2.2.1; DCD Tier 1, Sections 2.4.7 and 2.7.6.6, and Tables 2.4.7-1 and 2.7.6.6-1; and the applicant's response to **RAI 400-3032, Question 11.05-12**, by letter dated July 16, 2009, the staff determined that additional information to describe the ability of the PERMS monitors to detect RCS leakage of less than 0.5 gpm within 1 hour of response time using a realistic concentration in the RCS was needed. The RCS leakage rate technical basis in TS 3.4.13 and TS B 3.4.15 requires the sensitivity to detect 1 gpm within 1 hour of response time using a realistic concentration in the RCS. RG 1.45 (Revision 1) and ANSI N42.18-2004 provide guidance and recommendations, respectively, on the overall response time, representativeness of sampling locations, sample line losses, types of radiation detection instrumentation for expected radionuclide distributions or chosen surrogate radionuclide, instrumentation and sampling system types (i.e., fixed or moving filter paper), and characterization of plant locations for RCS leakage detection instrumentation. As a result, in **RAI 522-4247, Question 11.05-18**, the staff requested that the applicant describe how the PERMS monitors conform to RG 1.45 (Revision 1) and ANSI N42.18-2004; add RG 1.45 (Revision 1) to the PERMS design criteria in DCD Tier 2, Section 11.5.1.2; identify DCD Tier 2, Section 11.5 with Section 5.2.5 to also conform with RG 1.45 (Revision 1) in DCD Tier 2, Table 1.9.1-1; and update reference to RG 1.45 (Revision 1) in DCD Tier 2, Section 11.5.6.

By letter dated March 8, 2010, the applicant provided a markup to DCD Tier 2, Section 11.5.1.2, "Design Criteria," 11.5.2.1, "Process and Effluent Radiological Monitoring and Sampling System," 11.5.2.2.1, "Containment Radiation Monitors (RMS-RE-041 and RMS-RE-040)," 11.5.6, "References," and Table 1.9.1-1 (Sheet 4 of 15) to address the guidance in RG 1.45 (Revision 1) and recommendations in ANSI N42.18-2004 on the PERMS monitors. The applicant commits to add design criteria providing capabilities to detect, monitor, quantify, and identify leakage into the containment from the RCS for conformance to RG 1.45 (Revision 1) and ANSI N42.18-2004 in DCD Tier 2, Section 11.5.1.2; specify that the PERMS design conforms to RG 1.45 (Revision 1) to minimize the effect of local ambient radiation and the selection of sampling point locations to assure representative sample DCD Tier 2, Section 11.5.2.1; reference RG 1.45 (Revision 1) in DCD Tier 2, Section 11.5.6; and revise Table 1.9.1-1 to include conformance to RG 1.45 (Revision 1) in DCD Tier 2, Sections 5.2.5 and 11.5. The staff reviewed the markup and finds the applicant's commitment to revise the DCD acceptable because conformance to RG 1.45 (Revision 1) and ANSI N42.18-2004 satisfies, in part, the RCS leakage rate technical basis for the PERMS monitors. The above items regarding conformance of the PERMS monitors to RG 1.45 (Revision 1) and ANSI N42.18-2004, as described in the response to **RAI 522-4247, Question 11.05-18,** are being tracked as **Confirmatory Item 11.05-2**.

11.5.4.9 Preoperational Testing

DCD Tier 2, Section 14.2.12, "Individual Test Descriptions," describes individual test abstracts of preoperational and startup tests to verify that the plant systems and components meet design and performance objectives.

The tests associated with the PERMS are described in DCD Tier 2, Section 14.2.12.1.78, "Process and Effluent Radiological Monitoring System, Area Radiation Monitoring System and Airborne Radioactivity Monitoring System Preoperational Test," to demonstrate operation of the PERMS in DCD Tier 2, Section 11.5, and the area radiation monitoring system and airborne radioactivity monitoring system in DCD Tier 2, Section 12.3.4, "Area Radiation and Airborne Radioactivity Monitoring Instrumentation," including the normal-range and post-accident radiation monitors located in the plant vent stack; DCD Tier 2, Section 14.2.12.1.80, "Liquid Waste Management System Preoperational Test," to verify control circuitry and operation of system pumps and valves; LWMS operation and performance characteristics to comply with the ECLs of 10 CFR Part 20, Appendix B, Table 2, Column 2 for discharge to the environment and response to normal control, alarms, and indications; DCD Tier 2, Section 14.2.12.1.81, “Gaseous Waste Management System Preoperational Test,” to demonstrate operation of the waste gas compressors, charcoal bed, waste gas dryer, and GWMS components and associated control and interlock circuitry, and the performance of the waste gas compressor, charcoal delay bed, and waste gas dryer; DCD Tier 2, Section 14.2.12.1.84, “Sampling System Preoperational Test,” to demonstrate the capability of the sampling system to collect gaseous samples including post-accident monitoring system of the containment atmosphere, and the performance of laboratory equipment used for the analysis of effluent samples and determine if radionuclide concentrations comply with the ECLs of 10 CFR Part 20, Appendix B, Table 2, Column 1 for discharge to the environment, and verify operation of system valves and control circuitry; and DCD Tier 2, Section 14.2.12.2.4.13, “Process and Effluent Radiation Monitoring System Test,” to demonstrate the operation of the PERMS monitors using acceptable standards, adjust control systems, establish baseline activities, and perform independent laboratory or other analyses to verify that the PERMS is correctly responding.

The principle test for the PERMS in DCD Tier 2, Section 14.2.12.1.78 following completion of prerequisites on component testing and instrument calibration, test instrumentation calibration, and availability of suitable check sources includes verification on each monitor for operation; setpoint, control logic, annunciation (e.g. high alarm of spent fuel pool area radiation monitor), and power failure alarms; and uncertainty and determination of setpoint. The staff reviewed these tests abstracts and issued RAIs on the information presented in DCD Tier 2, Section 14.2.12, “Individual Test Descriptions.”

10 CFR 50.34(b)(6)(iii) requires that applicants for standard plant design approval must provide plans for preoperational testing and initial operations. DCD Tier 2, Section 14.2, “Acceptance Criteria,” states the DC applicant can meet the requirements by conforming to the criteria in RG 1.68 (Revision 3), “Initial Test Programs for Water-Cooled Nuclear Power Plants.” From the review of Revision 1 to DCD Tier 2, Chapter 14, “Verification Programs,” the staff found insufficient test information related to SG tube leakage detection for compliance with the design criteria. As a result, in **RAI 249-1978, Question 11.05-8**, the staff requested that the applicant identify the tests performed to demonstrate that the SG tube leakage detection radiation monitors satisfy the technical basis leakage rate detection criteria. By letter dated March 31, 2009, the applicant responded to the above RAI.

In response to **RAI 249-1978, Question 11.05-8**, the applicant referred to their response in **RAI 249-1978, Question 11.05-6** previously evaluated in Section 11.5 of this SE. The applicant stated three types of radiation monitors to detect SG tube leakage with the PERMS ranges in DCD Tier 2, Tables 11.5-1 through 11.5-3 provide the capability to detect SG tube leakage of an amount to conform with the NEI 97-06 and EPRI guidelines, and the preoperational test is described in DCD Tier 2, Section 14.2.12.1.78, “Process and Effluent Radiological Monitoring System, Area Radiation Monitoring System and Airborne Radioactivity Monitoring System Preoperational Test.” Because information on the sensitivity, response time, and alarm limit for the SG tube leak detection instrumentation was not described in DCD Tier 2, Section 14.2.12.1.78, the staff closed **RAI 249-1978, Question 11.05-8** and, in follow-up **RAI 400-3032, Question 11.05-15**, requested that the applicant provide the preoperational tests in Tier 2 information to demonstrate that the sensitivity, response time, and alarm limit of the SG tube leak detection instrumentation conforms with the NEI 97-06 and EPRI guidelines. By letter dated July 15, 2009, the applicant responded to the above RAI.

In response to **RAI 400-3032, Question 11.05-15**, the applicant states the preoperational testing of the RCS and SG tube leakage detection instrumentation was expanded and clarified in response to **RAI 371-2617, Question 14.02-117** evaluated in Section 14.2 of this SE. The applicant commits to revise DCD Tier 2, Section 14.2.12.1.115, “RCPB Leak Detection Systems Test,” to add a cross-reference table on the RCS leakage detection instrumentation tests in DCD Tier 2, Section 14.2.12.1.78. The cross-reference table also includes the PERMS monitors used to measure primary-to-secondary leakage. The applicant also commits to revise DCD Tier 2, Section 14.2.12.1.115 to add C “Test Method,” 1.a to require preoperational testing of the SG blowdown water radiation monitor, high-sensitivity main steam line monitors, and the condenser vacuum pump exhaust line radiation monitors, and verification of calibration, alarm functions, and alarm setpoints with the numeric values specified as part of the detailed design. The staff finds the applicant’s description regarding preoperational testing and initial operations for the PERMS monitors and commitment to revise the DCD to include this information, acceptable. **RAI 400-3032, Question 11.05-15** is being tracked as **Confirmatory Item 11.05-1**.

11.5.5 Combined License Information Items

Table 11.5-1 to Section 11.5 of this SE provides a list of PERMS related COL information items and descriptions from DCD Tier 2, Table 1.8-2, "Compilation of All Combined License Applicant Items for Chapters 1-19 (Sheet 32 and 33 of 44)."

Table 11.5-1 US-APWR Combined License Information Items

Item No.	Description	DCD Tier 2 Section
11.5(1)	The COL applicant is responsible for the additional site-specific aspects of the process and effluent monitoring and sampling system beyond the standard design, in accordance with RG 1.21, RG 1.33 and RG 4.15 (Reference 11.5-12, 11.5-17, 11.5-14). Furthermore, the COL applicant is responsible for assuring the fulfillment of the guidelines issued in 10 CFR 50, Appendix I (Reference 11.5-3) regarding the offsite doses released through gaseous and liquid effluent streams.	11.5
11.5(2)	The COL applicant is to prepare an ODCM to provide specific administrative controls and liquid and gaseous effluent source terms to limit the releases to site-specific requirements containing a description of the methods and parameters that drive to arrive radiation instrumentation alarm setpoint. The COL applicant is to commit to follow the NEI generic template 07-09A (Reference 11.5-30) as an alternative to providing the ODCM at the time of application.	11.5.2.9
11.5(3)	The COL applicant is to develop a radiological and environmental monitoring program taking into consideration local land use and census data in identifying all potential radiation exposure pathways. The program shall take into account associated radioactive materials present in liquid and gaseous effluents and direct external radiation from SSCs. The COL applicant is to follow the guidance outlined in NUREG-1301(Reference 11.5-21), and NUREG-0133 (Reference 11.5-18) when developing the radiological effluent monitoring program. The COL applicant is to commit to follow the NEI generic template 07-09A (Reference 11.5-30) as an alternative to providing the radiological effluent monitoring program at the time of application.	11.5.2.10
11.5(4)	The COL applicant is to develop procedures which are of inspection, decontamination, and replacement related to radiation monitoring instruments.	11.5.2.8
11.5(5)	The COL applicant is to provide analytical procedures and sensitivity for selected radioanalytical methods and type of sampling media for site-specific matter.	11.5.2.8
11.5(6)	The COL applicant is to perform a site-specific cost benefit analysis to demonstrate compliance with the regulatory requirements.	11.5.2.11

As previously evaluated, the staff concludes the above list of COL information items to be complete and adequately describes the actions necessary for the COL applicant.

11.5.6 Conclusions

For the following confirmatory items, tracked under **RAI 400-3032, Question 11.05-15**, and **RAI 522-4247, Question 11.05-18** the staff will confirm that these items are incorporated into the next revision of the DCD.

Except for the open item identified below, the staff concludes that the PERMS includes the necessary equipment to measure and control releases of radioactive materials in plant process streams and liquid and gaseous effluents; alert control room operators of abnormal levels of radioactivity in process streams and liquid and gaseous effluents; and provide signals that initiate automatic safety functions, isolate process streams, and terminate effluent discharges if predetermined radioactivity levels or release rates exceed alarm set points. Based on this evaluation, the staff determined that the PERMS is in compliance with the requirements of 10 CFR Part 50, Appendix A, GDC 60, GDC 63, and GDC 64; 10 CFR 50.34a; 10 CFR 50.36a; 10 CFR Part 50, Appendix I; 10 CFR 20.1301; and 10 CFR 20.1302; and the NRC guidance and SRP acceptance criteria. This conclusion is based on the following:

- The US-APWR demonstrates compliance with 10 CFR 50.34a and 10 CFR Part 50, Appendix A, GDC 60, GDC 63, and GDC 64 by providing the means to monitor and control liquid and gaseous effluent releases. The PERMS design conforms to the guidelines of SRP Section 11.5. The instrumentation of the PERMS monitors combined effluent releases from the plant vent stack. The PERMS monitors exhausts and process streams for the R/B, A/B, AC/B, T/B, containment, fuel building, radioactive waste systems, and associated handling areas. The PERMS monitors liquid effluent releases through a sole discharge line and gaseous effluent releases to the environment via the plant vent stack.

- Airborne radioactivity is monitored inside the exhaust air duct form the fuel handling area, penetration and safeguard component area, R/B controlled area, A/B controlled area, and sampling/laboratory area (AC/B controlled area), and the containment low volume purge exhaust filtration unit which exhausts through the plant vent stack to comply with the requirements of 10 CFR 50, Appendix A, GDC 63 and GDC 64.

- The US-APWR provides the means, in accordance with 10 CFR Part 50, Appendix A, GDC 64 to monitor systems required for normal operation, AOOs, and post-accident conditions. The PERMS provide signals and initiate termination functions for radioactive particulate concentrations in containment; radioactive air concentrations released from the GWMS, plant vent, and condenser vacuum pump exhaust line; radioactive gas, iodine, particulate concentrations in the MCR and TSC outside air intakes; and radioactive liquid concentrations in the CCW, auxiliary steam condensate water, and SG blowdown water.

- The US-APWR identifies the implementation of a plant and site-specific ODCM as an operational program described in DCD Tier 2, Sections 11.5.2 and 13.4 in controlling and monitoring radioactive liquid and gaseous effluent releases, and for implementing SREC and a REMP. The ODCM addresses plant and site-specific operating procedures and acceptance criteria, as they relate to the means of controlling radioactive effluent releases and conducting radiological surveys in the environs of operating nuclear power plants. The COL applicant is responsible for the implementation of a plant and site-specific ODCM under COL Information Item 11.5(2) as described in DCD Tier 2, Table 1.8-2. The ODCM should conform to the guidance of GL 89-01 and NUREG-1301 for PWR plants; NUREG-0133; RG 1.21, RG 1.33, RG 4.1, RG 4.8, and RG 4.15; and the guidance from Radiological Assessment BTP in NUREG-1301. As part of this commitment, the COL applicant is responsible for demonstrating, through the ODCM, compliance with 10 CFR 20.1301(e) which incorporates by reference 40 CFR Part 190 for facilities within the nuclear fuel cycle including nuclear power plants.

- The PERMS in the US-APWR, operating in conjunction with the LWMS, GWMS, and SWMS used to control and monitor radioactive effluent releases was determined to provide the means to comply with the dose requirements of 10 CFR 20.1301 and 10 CFR 20.1302 by ensuring that annual average concentrations of radioactive materials in liquid and gaseous effluents released into unrestricted areas will not exceed the ECLs specified in 10 CFR Part 20, Appendix B, Table 2, Columns 1 and 2.

- The PERMS in the US-APWR, in conjunction with the operations of the LWMS, GWMS, and SWMS, complies with 10 CFR Part 50, Appendix I, Sections II.A, II.B, and II.C in ensuring that offsite individual doses resulting from liquid and gaseous effluent releases are ALARA and will not exceed the numerical guides and design objectives in 10 CFR Part 50, Appendix I, and complies with 10 CFR 50.34a and 10 CFR 50.36a. Compliance with 10 CFR Part 50, Appendix I, Section II.D, as it relates to the conduct of CBA in reducing population doses, is addressed in Sections 11.2, 11.3, and 11.4 of this SE for the LWMS, GWMS, and SWMS, respectively.

- The US-APWR conforms to the quality group classifications used for system components, and the seismic design applied to structures housing PERMS subsystems using the guidance in RG 1.143.

- The US-APWR provides the plans for preoperational testing and initial operations of the PERMS including the RCS and SG leakage detection instrumentation to comply with the requirements in 10 CFR 50.34(b)(6)(iii), and the ITAAC to comply with the requirements of 10 CFR 52.47(b)(1).

- The PERMS in the US-APWR provides the safety controls for radiation monitors in the fuel storage, radioactive waste systems and associated handling areas, and the MCR to comply with the requirements of 10 CFR Part 50, Appendix A, GDC 63. The safety-related radiation PERMS monitors conform to IEEE Std. 603-1991 to comply with the requirements of 10 CFR Part 50, Appendix A, GDC 13.

For the following open item, tracked under **RAI 629-4973, Question 11.03-18, Item 4,** the staff concludes, using the information presented in the application, that the applicant has not provided sufficient information in describing the provisions to avoid unmonitored and uncontrolled radioactive releases to the environment. The relevant regulation is contained in 10 CFR 20.1406 and the NRC guidance contained in RG 4.21, RG 1.143, SRP Section 11.5, and IE Bulletin 80-10.