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MFN 09-507 Docket No. 52-010

August 14, 2009

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 348 Related to ESBWR Design Certification Application - Radiation Protection - RAI Number 12.7-5 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) 12.7-5 S01 sent by NRC Letter 348, Reference 1. The response to RAI Number 12.7-5 was previously submitted to the NRC via Reference 2 in response to Reference 3.

GEH response to RAI Number 12.7-5 S01 is addressed in Enclosure 1. Enclosure 2 contains the DCD markups associated with this response.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

References:

1. MFN 09-396, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No. 348 Related to ESBWR Design Certification Application*, June 5, 2009
2. MFN 09-076, Response to Portion of NRC Request for Additional Information Letter Number No. 190 Related to ESBWR Design Certification Application – Radiation Protection - RAI Number 12.7-5, February 4, 2009
3. MFN 08-476, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 190 Related to ESBWR Design Certification Application*, May 14, 2008

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 348 Related to ESBWR Design Certification Application - Radiation Protection - RAI Number 12.7-5 S01
2. Response to Portion of NRC Request for Additional Information Letter No. 348 Related to ESBWR Design Certification Application - Radiation Protection - RAI Number 12.7-5 S01 – DCD Markups

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Enclosure 1

MFN 09-507

Response to Portion of NRC Request for Additional Information Letter No. 348 Related to ESBWR Design Certification Application

Radiation Protection

RAI Number 12.7-5 S01

NRC RAI 12.7-5 S01

After completing their initial review of GEH's response to RAI 12.7-5, the staff held a teleconference with GEH on March 16, 2009 to discuss GEH's response to this RAI and to identify several staff concerns with this response. Those staff concerns that were either not resolved or not discussed during this telecon are listed below:

a. *In part B) of GEH's response, GEH states that "Regulatory objectives that are operational or procedural in nature (item numbers 5, 6a, 8, and 9 above) will be addressed by the COL applicant." In GEH's proposed (Revision 6) modification to DCD Section 12.3.1.5, these four objectives appear as four bullets in subsection 12.3.12.5.2. In the DCD, add a fifth bullet to subsection 12.3.12.5.2 to read:*

   "Establish and perform an onsite contamination monitoring program along the potential pathways from the release sources to the receptor points."

b. *In part C) of GEH's response (p. 5 of 6 and 6 of 6), GEH provided justification for the inclusion of some of the ESBWR design features listed in Table 12.3-18. Modify the proposed ESBWR DCD subsection 12.3.1.5 to include this justification (include the last two paragraphs of part C) in the DCD).*

c. *In part D)(2) of GEH's response, GEH states that, although there will be no lines carrying radioactive waste that will be buried directly in the ground, there is a possibility that other buried piping carrying radioactive or potentially radioactive fluids will be routed outside the Radwaste Tunnels. Potentially radioactive fluids are normally nonradioactive fluids that could become contaminated with radioactive fluids through interfaces with radioactive systems. Some examples of how normally nonradioactive fluids that could become contaminated with radioactive fluids include leakage of radioactive fluids into nonradioactive fluids through leaks in heat exchanger tubes and cross contamination of systems due to valving errors or other operating conditions (NRC Bulletin 80-10, "Contamination of Nonradioactive Systems and Resulting Potential for Unmonitored, Uncontrolled Release to the Environment" discusses nuclear industry operational experience concerning the contamination of nonradioactive systems).*

   It is the staff's position that any buried piping carrying radioactive or potentially radioactive fluids should have features (e.g., double walled piping, piping located in trenches with leak detection systems) associated with it to minimize the potential for unmonitored, uncontrolled releases of radioactivity to the environment. In addition, any such piping should be located so that any potential leakage could be detected and monitored, as described in RG 4.21.

i. Based on industry operating experience, the following are some of the SSCs which have experienced piping related occurrences which have resulted in unmonitored, uncontrolled releases of radioactivity to the environment;

-condensate storage tank and associated piping,
-radwaste/effluent discharge pipeline, and
-cooling tower blowdown line.

For each of these SSCs listed above, describe the associated design features which have been implemented to minimize the potential for unmonitored, uncontrolled releases of radioactivity to the environment from the SSC. Specify which of the above listed SSCs have associated buried piping and, for each of those SSCs, describe the piping features designed to minimize the potential for unmonitored, uncontrolled releases of radioactivity to the environment.

ii. Provide a description of the use of any buried piping (not described in response to c.i above) that may potentially contain radioactive fluids. For each description listed, verify that this piping will be designed to minimize leakage to the ground and describe the associated leak detection features that will be used to detect any potential leakage from the piping.

Amend the appropriate portions of the ESBWR DCD to include the responses to items b.i. and b.ii. above. In addition, modify the proposed ESBWR DCD subsection 12.3.1.5 to state that any buried piping that may potentially contain radioactive fluids shall be designed to minimize leakage to the ground and shall have leak detection features to detect any potential leakage from the piping.

d. The following items reflect staff concerns on various design features described in Table 12.3-18

i. (p.12.3-55) DCD subsection 3.4.1.2 refers to "flood and groundwater levels". Modify this description in the DCD to refer to "design basis maximum flood and groundwater levels".

ii. (p.12.3-56) DCD subsection 3.7.3.13 states that "there are no Seismic Category I utilities i.e., piping, conduits, or auxiliary system components that are directly buried underground." Similarly on page 12.3-104, DCD subsection 3.8.4 states that "the ESBWR Standard Plant does not contain underground Seismic Category I pipelines or masonry wall construction."

These statements are not correct. There is buried, Seismic Category I piping that goes from the fire protection system to FAPCS to provide long term makeup to pools in the Reactor Building. See proposed RAI response to RAI 9.1-16S03, dated May 28, 2009.

Please modify the table to reflect the existence of this buried Seismic Category I piping. Per item c. above, specify whether the buried, Seismic Category I piping that goes from the fire protection system to FAPCS to provide long term makeup to pools in the Reactor Building may potentially contain radioactive fluids. If so, verify that this piping will be designed to minimize leakage to the ground and describe the associated leak detection features that will be used to detect any potential leakage from the piping.

iii. (p. 12.3-60) The table discusses the use of a water-tight room to contain any potential leakage from the condensate filter backwash receiving tank in the Turbine Building (see DCD subsection 6.5.2.5). List any other components containing radioactive fluids located in the Turbine Building which could potentially develop leaks and which should be provided with some sort of containment to meet Design Objective 1 of Table 12.3-18.

iv. (p.12.3-69) DCD subsection 12.3.1.1.7 states that those floor drain lines having a potential for containing highly radioactive fluids are routed through pipe chases, shielded cubicles, or are embedded in concrete walls and floors. State if these floor drain lines having a potential for containing highly radioactive fluids are provided with shutoff valves to isolate the spill in the event of a spill of highly radioactive fluids into the drain line. If these lines are not provided with shutoff valves, state your reasons why shutoff valves are not used on these lines.

v. (p. 12.3-70) DCD subsection 12.3.1.2.6 states that contaminated piping systems are welded to the most practical extent to minimize leaks through screwed or flanged fittings. Verify that contaminated piping systems which are embedded will also utilize welded joints to minimize leaks through screwed or flanged fittings.

vi. (p.12.3-76) DCD subsection 9.1.3.5 states that "all other pools (upper transfer pool, lower fuel transfer pool, cask pool, buffer pool, reactor well, …) have local, nonsafety-related, panel mounted level transmitters …"

This statement is not correct. The buffer pool water level instrumentation is safety-related. Please modify Table 12.3-18, subsection 9.1.3.2 (p. 12.3-76) and subsection 9.1.3.5 (p. 12.3-76) to *reflect the response given by GEH to RAIs 9.1-18 S03 and 9.1-20 S03, in MFN 09-341, dated May 29, 2009, email from Art Alford, GEH, to Dennis Galvin, NRC.*

vii. *(p. 12.3.101) DCD subsection 12.3.1.1.5 states that radioactive piping may be embedded in concrete walls or floors. Describe what standards apply to the layout of embedded piping lines to minimize crud traps and facilitate access for cleaning and inspection (e.g. eliminate joints in embedded piping to minimize potential leakage, minimize the use of piping elbows to facilitate access for cleaning and inspection and minimize potential crud traps, minimize low spots which could become crud traps, and minimize high spots which could trap air).*

viii. *(p. 12.3-104) Describe how the use of composite construction techniques (as discussed in DCD subsection 4.2.4.8) will facilitate the eventual decommissioning of the plant.*

ix. *(p. 12.3-104) Provide some other examples of Seismic Category I structures where composite construction is used (see DCD subsection 3.8.4.6.5).*

x. *(p. 12.3-106) DCD subsection 9.3.3.4 states that drainage piping is hydrostatically tested prior to embedment in concrete. It also states that potentially radioactive drainage piping is pressure tested in accordance with ASME B31.1. If the ESBWR design specifies that some potentially radioactive drainage piping will be embedded in concrete, describe your criteria for determining when such piping will be embedded in concrete and justify how the embedment of potentially radioactive drainage piping meets the RG 4.21 design objective of facilitating the eventual decommissioning of the plant by minimizing embedded and buried piping. For potentially radioactive piping that is embedded in concrete, describe what standards apply to the layout of the embedded piping lines to minimize crud traps and facilitate access for cleaning and inspection (e.g. eliminate joints in embedded piping to minimize potential leakage, minimize the use of piping elbows to facilitate access for cleaning and inspection and minimize potential crud traps, minimize low spots which could become crud traps, and minimize high spots which could trap air).*

xi. *(p. 12.3-106) DCD subsections 11.2.2.3.4 and 11.2.2.3.5 state that the equipment and floor drain RO and mixed-bed demineralizer processing subsystems are designed and configured for installation ease and process reconfiguration. Describe those features of these systems which facilitate the removal of these systems during the eventual decommissioning of the plant.*

xii. (p. 12.3-107) DCD subsection 11.5.6.5 states that, to facilitate decommissioning, equipment will be provided, where feasible, that reduces the need for decontamination during the removal and disposal of the equipment. Provide some examples of such equipment that will be used to reduce the need for decontamination during the removal and disposal of equipment.

e. There are several places in GEH's response to RAI 12.7-5 where reference is made to functions/commitments that will be the responsibility of the COL applicant. For the items listed below, specify the mechanism (e.g., included in COL action item or operational program) that will be used to ensure that each of these functions/commitments will be performed/addressed by the COL applicant.

i. (p. 6 of 6) In section D) (3) of GEH's response, GEH states that the criteria for visual inspections of the piping in the Radwaste Tunnel will be addressed by the COL applicant.

ii. (p. 12.3-57) DCD Subsection 3.8.6.1 discusses foundation waterproofing. Verify that the COL applicant will be responsible for the sinking of wells in appropriate locations to monitor the location/movement of groundwater to detect for possible groundwater contamination from the facility.

iii. (p. 12.3-78) DCD Subsection 11.2.3.2 discusses provisions for sampling at important process points of the Liquid Waste Management System. Verify that the COL applicant will be responsible for the establishment of administrative controls to protect against accidental discharges from this system.

f. The staff identified the following items where GEH's responses to RAI 12.7-5 could be clarified by modifying GEH's response to the RAI:

i. (p. 12.3-14) In the first bullet on this page, explain why the word "(corrosion)" appears after the word "buildup".

ii. (p. 12.3-14) In the second bullet on this page, replace the word "potential" with "the potential for" and replace "low" with "lower".

iii. (p. 12.3-14) In the third bullet on this page, replace the word "water" with "the reactor coolant system".

iv. (p. 12.3-14) In the fourth bullet on this page, add the words "cubicles with" after the word "numerous".

v. *(pp. 12.3-75 through 81) In the description of Design Objective 3 at the top of Table 12.3-18, replace the word "conduce" with "conduct".*

vi. *(p. 12.3-97) In the sixth line of the description for DCD section 11.4.1, replace "Section 12.6" with "Section 12.3.1.5".*

vii. *(p. 6 of 6) In the second line of section D)(3) replace the word "address" with "addressed".*

viii. *(p. 6 of 6) The section of GEH's response entitled "DCD Impact" states that Subsection 12.3.6 will be deleted as part of the response to this RAI. The actual Subsection deleted is 12.6, not 12.3.6.*

GEH Response

NRC Question a:

In part B) of GEH's response, GEH states that "Regulatory objectives that are operational or procedural in nature (item numbers 5, 6a, 8, and 9 above) will be addressed by the COL applicant." In GEH's proposed (Revision 6) modification to DCD Section 12.3.1.5, these four objectives appear as four bullets in subsection 12.3.12.5.2. In the DCD, add a fifth bullet to subsection 12.3.12.5.2 to read:

"Establish and perform an onsite contamination monitoring program along the potential pathways from the release sources to the receptor points."

GEH Response to Question a:

The statement as shown above will be added as the fifth bullet in DCD Tier 2 Subsection 12.3.1.5.2 as described above.

NRC Question b:

In part C) of GEH's response (p. 5 of 6 and 6 of 6), GEH provided justification for the inclusion of some of the ESBWR design features listed in Table 12.3-18. Modify the proposed ESBWR DCD subsection 12.3.1.5 to include this justification (include the last two paragraphs of part C) in the DCD).

GEH Response to Question b:

The above referenced paragraphs will be added to DCD Tier 2 Subsection 12.3.1.5 as shown below:

"Not all of the ESBWR systems have significant design features that address 10 CFR 20.1406 requirements. The Standby Liquid Control, Isolation Condenser, and Turbine Generator systems do not have significant contamination during normal operations and have little propensity for significant radioactive leakage leading to resultant contamination of the facility or environment. High-energy systems associated with the reactor coolant pressure boundary (RCPB) such as Nuclear Steam Supply, RWCU/SDC, Main Steam, and Feedwater were judged to be low probability contamination mechanisms in which any leakage would be quickly detected. Leakage in these systems is identified by flow, level, temperature, pressure and other parameters monitored by numerous plant systems and action would be immediately taken to correct the condition. For example, the Leakage Detection and Isolation System (LD&IS) would also serve to detect any leakage near the reactor coolant pressure boundary.

DCD Tier 2 Table 12.3-18 shows design features in the specified DCD chapters and subsections that address the requirements of 10 CFR 20.1406."

NRC Question c.i:

In part D)(2) of GEH's response, GEH states that, although there will be no lines carrying radioactive waste that will be buried directly in the ground, there is a possibility that other buried piping carrying radioactive or potentially radioactive fluids will be routed outside the Radwaste Tunnels. Potentially radioactive fluids are normally nonradioactive fluids that could become contaminated with radioactive fluids through interfaces with radioactive systems. Some examples of how normally nonradioactive fluids that could become contaminated with radioactive fluids include leakage of radioactive fluids into nonradioactive fluids through leaks in heat exchanger tubes and cross contamination of systems due to valving errors or other operating conditions (NRC Bulletin 80-10, "Contamination of Nonradioactive Systems and Resulting Potential for Unmonitored, Uncontrolled Release to the Environment" discusses nuclear industry operational experience concerning the contamination of nonradioactive systems).

It is the staff's position that any buried piping carrying radioactive or potentially radioactive fluids should have features (e.g., double walled piping, piping located in trenches with leak detection systems) associated with it to minimize the potential for unmonitored, uncontrolled releases of radioactivity to the environment. In addition, any such piping should be located so that any potential leakage could be detected and monitored, as described in RG 4.21.

i. Based on industry operating experience, the following are some of the SSCs which have experienced piping related occurrences which have resulted in unmonitored, uncontrolled releases of radioactivity to the environment;

-condensate storage tank and associated piping,
-radwaste/effluent discharge pipeline, and
-cooling tower blowdown line.

For each of these SSCs listed above, describe the associated design features which have been implemented to minimize the potential for unmonitored, *uncontrolled releases of radioactivity to the environment from the SSC. Specify which of the above listed SSCs have associated buried piping and, for each of those SSCs, describe the piping features designed to minimize the potential for unmonitored, uncontrolled releases of radioactivity to the environment.*

GEH Response to Question c.i:

The pipe runs discussed in c.i above all have underground piping, and as such, those underground segments will be kept as short and direct as practicable. The condensate storage tank (CST) and associated piping and the radwaste effluent discharge pipeline are addressed here; the cooling tower blowdown line is addressed separately below.

The underground segments of the CST and associated piping and the radwaste effluent discharge pipeline are designed to preclude inadvertent or unidentified releases to the environment. They are either enclosed within a guard pipe and monitored for leakage, or are accessible for visual inspection via an accessible trench or tunnel. All joints will be welded with no threaded or flanged connections used underground. Furthermore, fittings will be kept to a minimum and no in-line components (e.g. valves) will be incorporated in these lines. These features substantially reduce the potential for unmonitored and uncontrolled releases to the environment and supports compliance with RG 4.21. These design attributes are described in DCD Tier 2 Subsection 12.3.1.5.

The cooling tower blowdown line also includes underground piping; however, enclosing this line within a guard pipe or in an accessible trench or tunnel is not practicable because the line is significantly larger and longer than the previously discussed lines. Furthermore, final material selection has not been made. Fiberglass or concrete are still under consideration. It is GEH’s opinion however that this line does not require these additional design features because, from a radiological viewpoint, the contents of this line are already released to the environment. The radwaste effluent discharge line discharges to the cooling tower blowdown sump, which in turn discharges to the lake, river or bay. The radiological monitoring and control that is performed for radwaste effluent occurs upstream (i.e. before) it is introduced to the cooling tower blowdown sump. If radioactivity levels in the radwaste effluent exceed the pre-established setpoint; flow will be shutdown before it reaches the cooling tower blowdown sump. As such, for radiological discharges, the cooling tower blowdown sump is treated as the environment. Furthermore, the control of flow is significantly easier with radwaste effluent than with cooling tower blowdown. The flow rate for radwaste effluent is 100 gallons per minute or less and affects only the associated radwaste pump and valves, whereas the cooling tower blowdown flow rate is several thousand gallons per minute and would affect additional equipment including cooling tower operation and therefore plant operation. It is for these practical reasons that the cooling tower blowdown line will not be considered for the same design features as the CST piping or the radwaste effluent pipeline.

The above discussion will be added to DCD Tier 2 Subsection 12.3.1.5.1.

<u>NRC Question c.ii</u>:

Provide a description of the use of any buried piping (not described in response to c.i above) that may potentially contain radioactive fluids. For each description listed, verify that this piping will be designed to minimize leakage to the ground and describe the associated leak detection features that will be used to detect any potential leakage from the piping.

Amend the appropriate portions of the ESBWR DCD to include the responses to items b.i. and b.ii. above. In addition, modify the proposed ESBWR DCD subsection 12.3.1.5 to state that any buried piping that may potentially contain radioactive fluids shall be designed to minimize leakage to the ground and shall have leak detection features to detect any potential leakage from the piping.

<u>GEH Response to Question c.ii</u>:

The design attributes added in GEH Response to Question c.i for the CST piping and the radwaste effluent line are also applicable to the drain line from the Hot Machine Shop to the Radwaste Building. This line is included in the discussion in DCD Tier 2 Subsection 12.3.1.5.

<u>NRC Question d.i</u>:

The following items reflect staff concerns on various design features described in Table 12.3-18

i. (p.12.3-55) DCD subsection 3.4.1.2 refers to "flood and groundwater levels". Modify this description in the DCD to refer to "design basis maximum flood and groundwater levels".

<u>GEH Response to Question d.i</u>:

The phrase "design basis maximum" will be added before "flood and groundwater levels" to the three applicable bullets in DCD Tier 2 Subsection 3.4.1.2.

In addition, the corresponding changes to DCD Tier 1 Subsection 2.16.5 (6), Table 2.16.5-2 and Tier 2 Table 12.3-18 will be made.

<u>NRC Question d.ii</u>:

(p.12.3-56) DCD subsection 3.7.3.13 states that "there are no Seismic Category I utilities i.e., piping, conduits, or auxiliary system components that are directly buried underground." Similarly on page 12.3-104, DCD subsection 3.8.4 states that "the ESBWR Standard Plant does not contain underground Seismic Category I pipelines or masonry wall construction."

These statements are not correct. There is buried, Seismic Category I piping that goes from the fire protection system to FAPCS to provide long term makeup to pools in the Reactor Building. See proposed RAI response to RAI 9.1-16S03, dated May 28, 2009.

Please modify the table to reflect the existence of this buried Seismic Category I piping. Per item c. above, specify whether the buried, Seismic Category I piping that goes from the fire protection system to FAPCS to provide long term makeup to pools in the Reactor Building may potentially contain radioactive fluids. If so, verify that this piping will be designed to minimize leakage to the ground and describe the associated leak detection features that will be used to detect any potential leakage from the piping.

GEH Response to Question d.ii:

The correction to DCD Tier 2 Subsection 3.7.3.13 has already been made via RAI 3.7-52 S03 in DCD Revision 6. The following change will be made to DCD Tier 2 Subsection 3.8.4 to provide the correct description (NOTES: (1) The underlined words are new; (2) This change is in a section that has been designated as Tier 2*.): "The ESBWR Standard Plant does not contain underground Seismic Category I pipelines that are directly buried in the ground (i.e., all are contained in concrete trenches/tunnels or concrete duct bank) or masonry wall construction." In addition, the corresponding changes to DCD Tier 2 Table 12.3-18 will be made.

Consistent with the above discussion, the Seismic Category I piping that goes from the Fire Protection System to the Fuel and Auxiliary Pool Cooling System is not directly buried in the ground. Furthermore, the water in that line is not contaminated and cannot become contaminated because normal isolation is maintained between the two systems by either manual lock-closed valves, spectacle flanges or some other positive means of isolation.

NRC Question d.iii:

(p. 12.3-60) The table discusses the use of a water-tight room to contain any potential leakage from the condensate filter backwash receiving tank in the Turbine Building (see DCD subsection 6.5.2.5). List any other components containing radioactive fluids located in the Turbine Building which could potentially develop leaks and which should be provided with some sort of containment to meet Design Objective 1 of Table 12.3-18.

GEH Response to Question d.iii:

During the initial response to RAI 12.7-5, a review was performed on the components in the Turbine Building. The review identified the major components in the Turbine Building that contain significant amounts of radioactive fluids to be: condensate demineralizers, condensate filters, feedwater heaters, and the main condenser hot-well. Of these it was determined that only the Condensate Filter Backwash Receiving Tank warranted mention of this additional consideration.

The reasoning for this determination is as follows:

The watertight feature of the Condensate Filter Backwash Receiving Tank Room, as described in DCD Tier 2 Subsection 6.5.2.5, is provided to restrict the release of fission products. There are only two major processes in the Turbine Building whose function is to remove fission products: (1) the Off Gas System and (2) the Condensate Purification System (i.e. filtration and demineralization). A significant release of fission products to the environment would not result in the event of a breach of either system because the activities contained in those systems are relatively fixed (i.e. captured in either charcoal or resin).

Although each charcoal adsorber in the Off Gas System normally processes all of the off-gas flow they are sized for the lifetime of the plant (i.e., 60 years) and should never require charcoal replacement. Because the activity is relatively fixed within the charcoal, a breach of the system would not release significant activity.

Each condensate demineralizer and filter only processes a fraction of the total condensate flow and they are backwashed frequently. Over a two-year cycle each condensate demineralizer could be backwashed based upon radiation levels or differential pressure. The spent resin will be sent directly to the Radwaste Building. It is anticipated that each condensate filter will be backwashed approximately once every one to three months depending on filter media. Here the filter sludge will be directed to the Condensate Filter Backwash Receiving Tank. While it is intended to transfer the contents of this tank to the Radwaste Building upon each backwash it may be necessary to hold the contents depending on the status of the receiving tank in the Radwaste Building. As such it could be possible that this tank could hold more than one filter backwash. Because this tank can contain more radioactive material than the individual demineralizer or filter vessels it was decided that further discussion of the rooms watertight capability was appropriate.

The Turbine Building General Arrangements (ESBWR DCD Tier 2 Figures 1.2-12, 13, 19 and 20) show that the condensate demineralizers, the condensate demineralizer strainers, the condensate filters and the main condenser hot-well are located in vaults; that is, access to the room is either through a hatchway or through watertight doors.

No DCD changes are required as a result of this response.

<u>NRC Question d.iv</u>:

(p.12.3-69) DCD subsection 12.3.1.1.7 states that those floor drain lines having a potential for containing highly radioactive fluids are routed through pipe chases, shielded cubicles, or are embedded in concrete walls and floors. State if these floor drain lines having a potential for containing highly radioactive fluids are provided with shutoff valves to isolate the spill in the event of a spill of highly radioactive fluids into the drain line. If these lines are not provided with shutoff valves, state your reasons why shutoff valves are not used on these lines.

<u>GEH Response to Question d.iv</u>:

As described in DCD Tier 2 Section 9.3.3, the Equipment and Floor Drain System (EFDS) consists of the Clean (nonradioactive) Drain Subsystem and the following five potentially contaminated subsystems;

- Low Conductivity Waste (LCW) Drain Subsystem;
- High Conductivity Waste (HCW) Drain Subsystem;
- Detergent Drain Subsystem;
- Chemical Waste Drain Subsystem; and
- Reactor Component Cooling Water System (RCCWS) Drain subsystem.

These five (5) subsystems collect liquid drainage from various plant areas and transfer them to the Radwaste system.

The EFDS meets the requirements of GDC 60 by providing a design to avoid the transfer of contaminated fluids to a non-contaminated drainage system. To preclude inadvertent transfer of radioactive liquids to non-radioactive systems, the radioactively contaminated or potentially contaminated liquids are collected by completely separate systems (i.e. no cross connections) from those that collect non-radioactive liquids.

Drain lines go to the appropriate sumps, which interface with either the clean waste system or the Liquid Waste Management System. The sumps have level alarms, which would identify to the control room if excessive leakage to the sumps had occurred.

Isolation valves in drain lines as well as separate drain lines and watertight walls, floors and doors are features provided for the purpose of preventing the flooding of multiple safety-related compartments, not for any radiological purpose. See DCD Tier 2 Subsections 3.4.1.4 and 9.3.3.

Containment isolation valves are provided for the EFDS Drywell LCW and HCW drain lines and are isolated on appropriate system logic. These lines have the potential for containing highly radioactive fluids. As described in DCD Tier 2 Subsection 5.2.5.2, Leak Detection Instrumentation and Monitoring, isolation of these drain paths will occur upon indication of unacceptable leakage inside the drywell. As described in DCD Tier 2 Subsection 5.2.5.1.1, the primary detection methods that are used for monitoring small unidentified leakage inside the drywell are:

- The drywell floor drain HCW sump pump activity;
- The drywell sump level changes;
- The drywell air coolers condensate flow rate; and
- The fission products radioactivity.

These parameters are continuously monitored and recorded in the main control room and alarm on abnormal indications.

Outside of the containment, the features described in DCD Tier 2 Subsection 12.3.1.1.7 are deemed sufficient for personnel radiation protection purposes and shutoff valves are not installed in the individual drain lines from equipment and areas potentially containing highly radioactive fluids. Any spills from equipment in the Turbine or Radwaste Buildings will be contained in their rooms (i.e. vaults) or the floor drain system serving those rooms or open areas will adequately handle and disposition the spill via the appropriate sump to the Floor Drain Collector Tanks.

Piping systems transporting potentially highly radioactive fluids are designed, constructed and maintained in accordance with a quality assurance program meeting the guidance of Regulatory Guide 1.143, as applied to radioactive waste management systems, with components conforming to Regulatory Guide 1.143. In case of flooding / spills in the Radwaste Building, the building substructure serves as a large sump that can collect and hold any leakage within the building. The Radwaste Building is designed using a quality assurance program meeting the guidance of NRC Regulatory Guide 1.143, Category RW-IIa as applied to radioactive waste management systems (See DCD Tier 2 Table 3.2-1, Note 5.d).

<u>NRC Question d.v</u>:

(p. 12.3-70) DCD subsection 12.3.1.2.6 states that contaminated piping systems are welded to the most practical extent to minimize leaks through screwed or flanged fittings. Verify that contaminated piping systems which are embedded will also utilize welded joints to minimize leaks through screwed or flanged fittings.

<u>GEH Response to Question d.v</u>:

As a general rule, piping is only embedded in concrete if no other reasonable configuration can be developed. Threaded and flanged joints are typically not embedded since embedding in concrete negates the usefulness of a joint that can be disassembled.

Furthermore, the ESBWR design is in compliance with NRC Regulatory Guide 1.143 and ANSI/ANS-55.6, Liquid Radioactive Waste Processing System for Light Water Reactor Plants.

Section C.4.3 of RG 1.143 states in part:

> “Pressure-retaining components of process systems should use welded construction to the maximum practicable extent.”
>
> And;
>
> “Flanged joints or suitable rapid-disconnect fittings should be used only where maintenance or operational requirements clearly indicate such construction is preferable. Screwed connections in which threads provide the only seal should not be used except for instrumentation and cast pump body drain and vent connections where welded connections are not suitable.”

In addition, Section 4.5 of ANSI/ANS-55.6 states in part:

> "Pressure retaining components of the Liquid Radioactive Waste Processing System shall utilize welded construction to the maximum practical extent."

Finally, no distinction is made as to whether the piping is embedded or not. As such, there is high confidence that threaded or flanged joints will not be embedded in concrete.

No DCD changes are required as a result of this response.

<u>NRC Question d.vi</u>:

(p.12.3-76) DCD subsection 9.1.3.5 states that "all other pools (upper transfer pool, lower fuel transfer pool, cask pool, buffer pool, reactor well, …) have local, nonsafety-related, panel mounted level transmitters …"

This statement is not correct. The buffer pool water level instrumentation is safety-related. Please modify Table 12.3-18, subsection 9.1.3.2 (p. 12.3-76) and subsection 9.1.3.5 (p. 12.3-76) to reflect the response given by GEH to RAIs 9.1-18 S03 and 9.1-20 S03, in MFN 09-341, dated May 29, 2009, email from Art Alford, GEH, to Dennis Galvin, NRC.

<u>GEH Response to Question d.vi</u>:

RAIs 9.1-18 S03 and 9.1-20 S03 did not contain any changes to DCD Tier 2 Subsection 9.1.3.2. As such, the corresponding entry in Table 12.3-18 is consistent with Subsection 9.1.3.2 and no change is necessary. Table 12.3-18 will be revised in this response to be consistent with DCD Tier 2 Subsection 9.1.3.5 as described in the GEH response to RAI 9.1-18 S03 transmitted via Letter MFN 09-341, May 29, 2009.

<u>NRC Question d.vii</u>:

(p. 12.3.101) DCD subsection 12.3.1.1.5 states that radioactive piping may be embedded in concrete walls or floors. Describe what standards apply to the layout of embedded piping lines to minimize crud traps and facilitate access for cleaning and inspection (e.g. eliminate joints in embedded piping to minimize potential leakage, minimize the use of piping elbows to facilitate access for cleaning and inspection and minimize potential crud traps, minimize low spots which could become crud traps, and minimize high spots which could trap air).

<u>GEH Response to Question d.vii</u>:

The ESBWR will follow the guidance in NRC Regulatory Guides 1.143, 4.21 and 8.8 as well as ANSI/ANS Standards 55.1 and 55.6. See DCD Tier 2 Table 1.9-21 for the

Regulatory Guides and DCD Tier 2 Table 1.9-22 for the ANSI/ANS Standards. The following is a summary of guidelines used for the layout of piping carrying radioactive liquids taken from the previously referenced documents. (Note that some of these guidelines appear in more than one document.)

- Minimize “dead spaces” or “traps” (i.e., zones of low fluid flow where contaminants settle out).
- Take advantage of gravity flow (i.e., slope lines where possible to reduce the potential for contamination buildup).
- Avoid stagnant legs and locate connections above the pipe centerline.
- Provide adequate drain and flush connections.
- Minimize the length of pipe runs and the number of fittings.
- Minimize flow restrictions; use full port valves without cavities.
- For solid waste piping, use 5 diameter bends where possible, or at a minimum, long radius elbows.
- Pressure retaining components shall utilize welded construction to the fullest extent practical.
- Use butt welds rather than socket welds.
- Do not use non-consumable backing rings for welds.
- Flanged joints or suitable rapid-disconnect fittings should be used only where maintenance or operational requirements so dictate.
- Screwed connections in which threads provide the only seal should not be used except for instrumentation and cast pump body drain and vent connections where welding is not suitable.

As stated in the response to Item d.v, the guidelines for the layout of radioactive piping are the same whether the piping is embedded in concrete or not. These guidelines include all of the generally accepted methods for minimizing crud traps and simplifying cleaning as described above. Typically, the only piping that will definitely be embedded in concrete is the floor and equipment drain piping in the base-mats. There is no reasonable way around this since the lines must tie into sumps below the floor grade. This piping is of all welded construction and is hydrostatically tested in accordance with the applicable piping specification prior to placement of concrete.

Short vertical runs of drain piping are embedded as they penetrate floors on higher elevations. Piping through walls is typically accommodated by the use of pipe sleeves. This permits the general construction of the structure to proceed and accommodates piping installation upon its completion. This sequence also permits final inspection and testing of pipe prior to sealing the annular space between the inside of the sleeve and the outside of the pipe. The decision of when piping must be embedded is generally left to the detail designer on a case-by-case basis. The design is then evaluated through a series of reviews.

No DCD changes are required as a result of this response.

<u>NRC Question d.viii</u>:

(p. 12.3-104) Describe how the use of composite construction techniques (as discussed in DCD subsection 4.2.4.8) will facilitate the eventual decommissioning of the plant.

<u>GEH Response to Question d.viii</u>:

DCD Tier 2 Subsection 4.2.4.8 discusses control rod material selection. Composite construction techniques cannot be used on the ESBWR in the United States and as such, reference to them has been removed via GEH response to RAI 3.8-121 S02 from the DCD Tier 2 Revision 6, Subsection 3.8.4.6.5. Table 12.3-18 will also be revised accordingly.

<u>NRC Question d.ix</u>:

(p. 12.3-104) Provide some other examples of Seismic Category I structures where composite construction is used (see DCD subsection 3.8.4.6.5).

<u>GEH Response to Question d.ix</u>:

Composite construction techniques cannot be used on the ESBWR in the United States and as such, reference to them has been removed via GEH response to RAI 3.8-121 S02 from the DCD Tier 2 Revision 6, Subsection 3.8.4.6.5. DCD Tier 2, Table 12.3-18 will also be revised accordingly.

<u>NRC Question d.x</u>:

(p. 12.3-106) DCD subsection 9.3.3.4 states that drainage piping is hydrostatically tested prior to embedment in concrete. It also states that potentially radioactive drainage piping is pressure tested in accordance with ASME B31.1. If the ESBWR design specifies that some potentially radioactive drainage piping will be embedded in concrete, describe your criteria for determining when such piping will be embedded in concrete and justify how the embedment of potentially radioactive drainage piping meets the RG 4.21 design objective of facilitating the eventual decommissioning of the plant by minimizing embedded and buried piping. For potentially radioactive piping that is embedded in concrete, describe what standards apply to the layout of the embedded piping lines to minimize crud traps and facilitate access for cleaning and inspection (e.g. eliminate joints in embedded piping to minimize potential leakage, minimize the use of piping elbows to facilitate access for cleaning and inspection and minimize potential crud traps, minimize low spots which could become crud traps, and minimize high spots which could trap air).

GEH Response to Question d.x:

As stated in the response to Item d.v, the guidelines for the layout of radioactive piping are the same whether the piping is embedded in concrete or not. These guidelines include all of the generally accepted methods for minimizing crud traps and simplifying cleaning. Typically, the only piping that will definitely be embedded in concrete is the floor and equipment drain piping in the base-mats. There is no reasonable way around this since the lines must tie into sumps below the floor grade. This piping is of all welded construction and is hydrostatically tested in accordance with the applicable piping specification prior to placement of concrete. Short vertical runs of drain piping are embedded as they penetrate floors on higher elevations. Piping through walls is typically accommodated by the use of pipe sleeves. This permits the general construction of the structure to proceed and accommodates piping installation upon its completion. This sequence also permits final inspection and testing of pipe prior to sealing the annular space between the inside of the sleeve and the outside of the pipe. The decision of when piping must be embedded is generally left to the detail designer on a case-by-case basis. The design is then evaluated through a series of reviews.

No DCD changes are required as a result of this response.

NRC Question d.xi:

(p. 12.3-106) DCD subsections 11.2.2.3.4 and 11.2.2.3.5 state that the equipment and floor drain RO and mixed-bed demineralizer processing subsystems are designed and configured for installation ease and process reconfiguration. Describe those features of these systems which facilitate the removal of these systems during the eventual decommissioning of the plant.

GEH Response to Question d.xi:

The following features, which facilitate removal and decommissioning, apply to both the equipment and floor drain processing subsystems:

- Both the Equipment Drain and Floor Drain Processing Subsystems are skid-mounted and are located adjacent to the truck bay. They can be picked up from a flat bed truck and installed or easily removed using the Radwaste Building Crane. No walls/floors/ceilings need to be removed to install or remove these systems.
- The skid-mounted systems are connected to permanent plant piping via hose and easily disconnected therefore removal or replacement is simplified.
- The skid-mounted systems are provided with numerous flush connections to permit decontamination in place prior to removal or replacement.
- Most of the shielding is provided with the skids and will be removed with the skids. Any additional modular shielding can be moved using the Radwaste Building Crane.

No DCD changes are required as a result of this response.

<u>NRC Question d.xii</u>:
(p. 12.3-107) DCD subsection 11.5.6.5 states that, to facilitate decommissioning, equipment will be provided, where feasible, that reduces the need for decontamination during the removal and disposal of the equipment. Provide some examples of such equipment that will be used to reduce the need for decontamination during the removal and disposal of equipment.

<u>GEH Response to Question d.xii</u>:

The following are examples of design attributes that will reduce the need for decontamination:

- Extensive use of corrosion resistant materials (e.g. stainless steel) reduces corrosion products and the resulting need for decontamination.
- Underground lines carrying radioactive or potentially radioactive liquids will be run in a guard pipe or tunnel/trench substantially reducing the possibility of contaminating the ground and the need for remediation and allowing for relatively easy removal without the release of further contamination.
- The quality assurance program will comply with Regulatory Guide 1.143 to ensure compliance in material and component selection and installation.
- Radwaste tank vents are connected directly to Radwaste Building HVAC ducts. This prevents the contamination of larger areas and directs the air/vapor directly to filtration and discharge via the Radwaste Building monitored release point (i.e. stack).
- Equipment and component drains will be hard piped directly to the floor or equipment drain. Barriers, dike or curbs will be used as appropriate to restrict the spread of spills.
- Provisions for decontamination of casks or components are provided at the Fuel Building, the Reactor Building and the Turbine Building. Furthermore, the Reactor Water Cleanup System, the Fuel and Auxiliary Pool Cooling System, and the Liquid and Solid Radwaste Systems are provided with numerous flush connections to permit flushing and decontamination in place. Prudent use of these connections throughout the service life of the plant will reduce the required decontamination and waste generation at plant closure.

<u>NRC Question e.i</u>:

There are several places in GEH's response to RAI 12.7-5 where reference is made to functions/commitments that will be the responsibility of the COL applicant. For the items listed below, specify the mechanism (e.g., included in COL action item or operational program) that will be used to ensure that each of these functions/commitments will be performed/addressed by the COL applicant.

i. *(p. 6 of 6) In section D) (3) of GEH's response, GEH states that the criteria for visual inspections of the piping in the Radwaste Tunnel will be addressed by the COL applicant.*

GEH Response to Question e.i:

The last sentence of DCD Tier 2 Subsection 12.3.1.5.2 states: "The COL Applicant will address the operational and post-construction objectives of Regulatory Guide 4.21 (COL 12.3-4-A)." DCD Tier 2 Subsection 12.3.7, COL Information, contains COL Applicant Item 12.3-4-A, which also states the same previously quoted sentence. Visual inspection of piping is one of the specific measures for minimizing the potential for contamination of the environment contained in Regulatory Guide 4.21. As such, this requirement is captured.

No DCD changes are required as a result of this response.

NRC Question e.ii:

(p. 12.3-57) DCD Subsection 3.8.6.1 discusses foundation waterproofing. Verify that the COL applicant will be responsible for the sinking of wells in appropriate locations to monitor the location/movement of groundwater to detect for possible groundwater contamination from the facility.

GEH Response to Question e.ii:

The last sentence of DCD Tier 2 Subsection 12.3.1.5.2 states: "The COL Applicant will address the operational and post-construction objectives of Regulatory Guide 4.21 (COL 12.3-4-A)." DCD Tier 2 Subsection 12.3.7, COL Information, contains COL Applicant Item 12.3-4-A, which also states the same previously quoted sentence. Monitoring ground water is one of the specific measures for minimizing contamination of the environment contained in Regulatory Guide 4.21. As such, this requirement is captured.

No DCD changes are required as a result of this response.

NRC Question e.iii:

(p. 12.3-78) DCD Subsection 11.2.3.2 discusses provisions for sampling at important process points of the Liquid Waste Management System. Verify that the COL applicant will be responsible for the establishment of administrative controls to protect against accidental discharges from this system.

GEH Response to Question e.iii:

DCD Tier 2 Subsection 11.5.4.5 states: "The COL Applicant will develop the setpoint calculation methodology for radiation monitors and address programs for monitoring and controlling the release of radioactive material to the environment, which eliminates the potential for unmonitored and uncontrolled release." Furthermore, DCD Tier 2

Subsection 11.5.4.6 states: "In addition, the COL Applicant is responsible for the site specific programs, aspects of the process and effluent monitoring and sampling as specified in Table 11.5-5 and 11.5-6 per ANSI N13.1 and RG 1.21 and 4.15."

No DCD changes are required as a result of this response.

<u>NRC Question f.i:</u>

The staff identified the following items where GEH's responses to RAI 12.7-5 could be clarified by modifying GEH's response to the RAI:

i. (p. 12.3-14) In the first bullet on this page, explain why the word "(corrosion)" appears after the word "buildup".

<u>GEH Response to Question f.i:</u>

This has been reworded in the Preliminary version of DCD Tier 2 Chapter 12, Revision 6, transmitted via MFN 09-410, June 19, 2009.

The bullet has been reworded as follows: "Equipment and floor drain sumps are stainless steel lined to reduce crud buildup due to corrosion and provide surfaces that are easily decontaminated;".

<u>NRC Question f.ii:</u>

(p. 12.3-14) In the second bullet on this page, replace the word "potential" with "the potential for" and replace "low" with "lower".

<u>GEH Response to Question f.ii:</u>

"Low" was replaced with "lower" but "potential" was left as is. This has been reworded in the Preliminary version of the DCD Tier 2 Chapter 12, Revision 6, transmitted via MFN 09-410, June 19, 2009.

<u>NRC Question f.iii:</u>

(p. 12.3-14) In the third bullet on this page, replace the word "water" with "the reactor coolant system".

<u>GEH Response to Question f.iii:</u>

"Water" has been replaced with "reactor coolant." This has been reworded in the Preliminary version of the DCD Tier 2 Chapter 12, Revision 6, transmitted via MFN 09-410, June 19, 2009.

<u>NRC Question f.iv:</u>

(p. 12.3-14) In the fourth bullet on this page, add the words "cubicles with" after the word "numerous".

<u>GEH Response to Question f.iv:</u>

This has been reworded in the Preliminary version of the DCD Tier 2 Chapter 12, Revision 6, transmitted via MFN 09-410, June 19, 2009.

<u>NRC Question f.v:</u>

(pp. 12.3-75 through 81) In the description of Design Objective 3 at the top of Table 12.3-18, replace the word "conduce" with "conduct".

<u>GEH Response to Question f.v:</u>

This has been reworded in the Preliminary version of the DCD Tier 2 Chapter 12, Revision 6, transmitted via MFN 09-410, June 19, 2009.

<u>NRC Question f.vi:</u>

(p. 12.3-97) In the sixth line of the description for DCD section 11.4.1, replace "Section 12.6" with "Section 12.3.1.5".

<u>GEH Response to Question f.vi:</u>

This has been reworded in the Preliminary version of the DCD Tier 2 Chapter 12, Revision 6, transmitted via MFN 09-410, June 19, 2009.

<u>NRC Question f.vii:</u>

(p. 6 of 6) In the second line of section D)(3) replace the word "address" with "addressed".

<u>GEH Response to Question f.vii:</u>

The GEH Response to RAI 12.7-5 on page 6 of 6 in Section D)(3) should read:

"The requirements for the COL applicant to describe the criteria for visual inspections of the piping in the Radwaste Tunnel will be addressed by the COL applicant as part of the new DCD Tier 2 subsection 12.3.1.5.3 COL action item 12.3.2.5-1-A."

NRC Question f.viii:

(p. 6 of 6) The section of GEH's response entitled "DCD Impact" states that Subsection 12.3.6 will be deleted as part of the response to this RAI. The actual Subsection deleted is 12.6, not 12.3.6.

GEH Response to Question f.viii:

The GEH Response to RAI 12.7-5 on page 6 of 6 under "DCD Impact" should read:

"DCD Tier 2, Chapter 12 Subsection 12.3.1.5 and Table 12.3-18 will be added and Subsection 12.6 will be deleted as noted in the attached markups."

DCD Impact

The following DCD Subsections and Tables will be revised as noted in the attached markup:

TIER 1: Subsection 2.16.5 (6) and Table 2.16.5-2.

TIER 2: Subsections: 3.4.1.2, 3.8.4, 12.3.1.5, 12.3.1.5.1, 12.3.1.5.2 and Table 12.3-18.

Enclosure 2

MFN 09-507

Response to Portion of NRC Request for Additional Information Letter No. 348 Related to ESBWR Design Certification Application

Radiation Protection

RAI Number 12.7-5 S01

DCD Markups

- Water stops are provided in all expansion and construction joints below design basis maximum flood and groundwater levels;
- Waterproofing of external surfaces below design basis maximum flood and groundwater levels ~~external surfaces~~;
- Water seals in external walls at pipe penetrations below design basis maximum flood and groundwater levels; and
- Roofs designed to prevent pooling of large amounts of water in excess of the structural capacity of the roof for design loads.

(7) Protective features used to mitigate or eliminate the consequences of internal flooding are:

- Structural enclosures or barriers;
- Curbs and sills;
- Leakage detection components; and
- Drainage systems.

(8) The internal flooding protection features prevent flood water in one division from propagating to other division(s) and ensure equipment necessary for safe shutdown is located above the maximum flood level for that location or is qualified for flood conditions by:

- Divisional walls
- Sills
- Watertight doors.

(9) The RB is protected against pressurization effects associated with postulated rupture of pipes containing high-energy fluid that occur in subcompartments of the RB.

(10) The Reactor Building ~~minimum passive mixing~~CONAVS area volume meets design assumptions for the mixing of fission products following a LOCA.

(11) RTNSS equipment in the RB is located above the maximum flood level for that location or is qualified for flood conditions.

(12) The buffer pool is a reinforced concrete structure with a stainless steel liner that is equipped with embedments designed to Seismic Category I requirements.

Inspections, Tests, Analyses and Acceptance Criteria

Table 2.16.5-2 provides a definition of the inspections, tests and/or analyses, together with associated acceptance criteria for the RB.

Table 2.16.5-2

ITAAC For The Reactor Building

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
6. For external flooding, the RB incorporates structural provisions into the plant design to protect the structures, systems and components from postulated flood and groundwater conditions. This approach provides: • Wall thicknesses below flood level designed to withstand hydrostatic loads; • Water stops are provided in all expansion and construction joints below design basis maximum flood and groundwater levels; • Waterproofing of external surfaces below design basis maximum flood and groundwater levels ~~external surfaces~~; • Water seals in external walls at pipe penetrations below design basis maximum flood and groundwater levels; and • Roofs designed to prevent pooling of large amounts of water in excess of the structural capacity of the roof for design loads.	Inspection of the as-built flood control features will be conducted.	~~Inspection report(s) document that t~~The as-built RB conforms with the following flood protection features specified in the Design Description of this subsection 2.16.5. • Wall thicknesses below flood level are designed to withstand hydrostatic loads; • Water stops are provided in all expansion and construction joints below design basis maximum flood and groundwater levels; • Waterproofing of external surfaces below design basis maximum flood and groundwater levels ~~external surfaces~~; • Water seals in external walls at pipe penetrations below design basis maximum flood and groundwater levels; and • Roofs are built to prevent pooling of large amounts of water in excess of the structural capacity of the roof for design loads.

3.4.1.1 Flood Protection Summary

The safety-related systems and components of the ESBWR standard plant are located in the Seismic Category I structures that provide protection against external flood and groundwater damage. External flood design considerations for safety-related systems and components are provided for the postulated flood and groundwater levels and conditions described in Tables 2.0-1 and 3.4-1.

The Seismic Category I structures that house safety-related systems and equipment and that offer flood protection are described in Section 3.8. All exterior access openings are above flood level and exterior penetrations below design flood and groundwater levels are appropriately sealed.

The internal flood analysis evaluates whether a single pipe failure, a fire fighting event or other flooding source, as described in Subsection 3.4.1.4, could prevent safe reactor shutdown. In all cases, system components are located above the flood level or are capable of operating in a flooded environment. Appropriate means are provided to prevent flooding compartments that house redundant system trains or divisions. Some of the mechanisms used to minimize flooding are structural barriers or compartments; curbs and elevated thresholds, at least 200 mm (8 in) high; and a leak detection system. See Subsection 3.4.1.3 for further discussion.

3.4.1.2 Flood Protection From External Sources

Safety-related systems and components are protected from exterior sources (e.g., floods, groundwater) because they are located above design flood level or because they are enclosed in groundwater protected concrete structures.

The Seismic Category I structures that may be subjected to the design basis flood are designed to withstand the flood level and groundwater level stated in Table 2.0-1. This is done by locating the design plant grade elevation at least 300 mm (1 ft.) above the design flood level and by incorporating structural provisions into the plant design to protect the SSCs from the postulated flood and groundwater conditions.

These provisions include:

- Walls below flood level designed to withstand hydrostatic loads.
- Water stops provided in all expansion and construction joints below design basis maximum flood and groundwater levels.
- Waterproofing of external surfaces below design basis maximum flood and groundwater levels ~~external surfaces~~.
- Water seals at pipe penetrations below design basis maximum flood and groundwater levels.
- Roofs designed to prevent pooling of large amounts of water in accordance with RG 1.102.
- No exterior access openings below grade.

The flood protection measures that are described above are not only for external natural floods but also guard against flooding from onsite storage tank rupture. Such tanks are designed and

3.8.4 Other Seismic Category I Structures

Other Seismic Category I structures which are not inside the containment and which constitute the ESBWR Standard Plant are RB, CB, FB and FWSC. Figure 1.1-1 shows the spatial relationship of these buildings. Although the Radwaste Building (RW) that houses non safety-related facilities is not a Seismic Category I structure, it is designed to meet requirements as defined in RG 1.143 under Safety Class RW-IIa. The seismic design of the Radwaste Building is full SSE instead of 1/2 SSE as shown in Table 2 of RG 1.143. The RB and FB are built on a common foundation mat and structurally integrated into one building. The FWSC consists of Firewater Storage Tank (FWS) and Fire Pump Enclosure (FPE) structures that share a common basemat. The other structures in close proximity to these structures are the Turbine Building (TB) and Service Building. The Ancillary Diesel Building is located at least 15.2 meters from the Fuel Building. They are structurally separated from the other ESBWR Standard Plant buildings. [*Seismic gaps ~~capable of a minimum 100 mm (3-15/16 in) free movement~~ are provided with no less than the calculated maximum relative displacement during SSE event, considering out-of-phase motion between independent Nuclear Island buildings to eliminate seismic interaction.*]*

Among the Seismic Category I structures within the ESBWR Standard Plant, other than the containment structure, only the RB contains certain rooms that have high-energy pipes, and therefore these rooms are more structurally demanding. The main steam tunnel walls protect the RB from potential impact by rupture of the high-energy main steam pipes that extend to the TB. Thus the RB walls of the main steam tunnel are designed to accommodate the pipe support forces and the environmental conditions during and after the postulated high-energy pipe break. Longitudinal pipe breaks required by BTP ~~EMEB~~ 3-~~1~~4 of SRP 3.6.2 are postulated inside the main steam tunnel and cause a slight pressurization that is used for environmental qualification. See Subsection 6.2.3.2 for the main steam tunnel functional design.

[*The ESBWR Standard Plant does not contain underground Seismic Category I pipelines that are directly buried in the ground (i.e. all are contained in concrete trenches/tunnels or concrete duct bank) or masonry wall construction.*

Removable shield blocks consisting of metallic forms filled with grout or concrete designed to Seismic Category II requirements are used. The shield blocks are provided with removable structural steel frame also designed to Seismic Category II requirements to prevent the shielding blocks from sliding or tipping under seismic events.]*

Text sections that are bracketed and italicized with an asterisk following the brackets are designated as Tier 2. Prior NRC approval is required to change.

3.8.4.1 Description of the Structures

3.8.4.1.1 Reactor Building Structure

[*Key dimensions of the RB are summarized in Table 3.8-8.*]*

The RB encloses the concrete containment and its internal systems, structures, and components. Located above the concrete containment in the RB are the IC/PCCS pools (including expansion pools), the buffer pool, which is also used to store the dryer, and the equipment storage pool, which is also used to store the chimney partitions and the separator. Main Steam and Feedwater high activity sources. Permanently installed cubical walls provide shielding sufficient to maintain a general area radiation level inside the control room below 10 µSv/hr. Cubical walls surrounding installed radioactive waste tanks and components are also designed to reduce the radiation level to less than 10 µSv/hr in areas where routine worker access is required.

LWMS and SWMS process systems are located in the RW process systems area, as shown in Figures 12.3-21 and 12.3-41. LWMS and SWMS process systems are described in DCD Section 11.2 and 11.4, respectively. Radiation levels in the Rradwaste Bbuilding process systems area shown in Figure 12.3-21 will vary based on site-specific processing technology and process control considerations. LWMS and SWMS process subsystems include modular shielding and controls sufficient to limit accessible general area radiation levels to less than 10 mSv/hr during normal processing. Radiation levels are limited to permit infrequent operator access to perform activities such as component flushing or sampling. Transient radiation levels during filter media or waste container transfer operations may exceed these levels, but Rradwaste Bbuilding and process system provisions for remote operation limit average worker radiation dose rates to less than 150 µSv/hr during these operations.

The Rradwaste bBuilding process systems area is designed to accommodate modular shield walls to further limit access and reduce radiation levels from waste processing equipment.

Dry active waste (DAW) sorting, processing, and packaging operations are also performed in the Rradwaste Bbuilding. These operations rely on portable radiation detectors, portable shielding, and remote handling tools when appropriate to reduce radiation levels and occupational exposure.

12.3.1.5 Minimization of Contamination and Radioactive Waste Generation

The ESBWR design features and operational programs that aid in the minimization of contamination of the facility and environment, facilitate decommissioning, and aid in the minimization of the generation of radioactive waste in compliance with Title 10, Section 20.1406, "Minimization of Contamination," of the Code of Federal Regulations (10 CFR 20.1406) (Reference 12.3-19) are discussed in this section.

Design concepts associated with Regulatory Position C.1 through C.4 of Regulatory Guide 4.21 (Reference 12.3-20) are addressed in this section. The COL Applicant will describe operational procedures and program concepts associated with the Regulatory Position. A summary of the relevant design and operational concepts from the Regulatory Position are described in the following subsections.

Not all of the ESBWR systems have significant design features that address 10 CFR 20.1406 requirements. The Standby Liquid Control, Isolation Condenser, and Turbine Generator systems do not have significant contamination during normal operation and have little propensity for significant radioactive leakage leading to resultant contamination of the facility or environment. High-energy systems associated with the reactor coolant pressure boundary (RCPB) such as Nuclear Steam Supply, RWCU/SDC, Main Steam, and Feedwater were judged to be low probability contamination mechanisms in which any leakage would be quickly detected. Leakage in these systems is identified by flow, level, temperature, pressure and other parameters monitored by numerous plant systems and action would be immediately taken to correct the condition. For example, the Leakage Detection and Isolation System (LD&IS) would also serve to detect any leakage near the reactor coolant pressure boundary.

Table 12.3-18 shows design features in the specified DCD chapters and subsections that address the requirements of 10 CFR 20.1406.

12.3.1.5.1 Design Considerations

The following design objectives summarize the objectives contained in Regulatory Position C.1 through C.4 of Regulatory Guide 4.21:

- Objective 1 - Minimize leaks and spills and provide containment in areas where such events might occur.
- Objective 2 - Provide adequate leak detection capability to provide prompt detection of leakage from any structure, system, or component that has the potential for leakage.
- Objective 3 - Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult (inaccessible) to conduct regular inspections (such as spent fuel pools, tanks that are in contact with the ground, and buried, embedded, or subterranean piping) to avoid release of contamination.
- Objective 4 - Reduce the need to decontaminate equipment and structures by decreasing the probability of any release, reducing any amounts released, and decreasing the spread of the contaminant from the source.
- Objective 5 - Facilitate decommissioning by (1) minimizing embedded and buried piping, and (2) designing the facility to facilitate the removal of any equipment or components that may require removal or replacement during facility operation or decommissioning.
- Objective 6 - Minimize the generation and volume of radioactive waste during operation and decommissioning (by minimizing the volume of components and structures that become contaminated during plant operation).

ESBWR design features that address the above design objectives are described in individual DCD sections and subsections. Table 12.3-18 provides a cross reference of applicable DCD chapters and subsections for structures/systems that address the six design objectives. Note that the systems/structures that employ the subject design features are of varied construction and purpose and can provide differing functions. As such, not all of the above design concepts are present as a design feature in each system/structure. Additionally, examples of generic and specific design features present in the ESBWR are listed below.

Generic ESBWR design features used to minimize contamination and generation of radioactive waste and facilitate decommissioning include the following:

- Design of equipment to minimize the buildup of radioactive material and to facilitate flushing of crud traps;
- Provisions for design features to plant systems such as the RWCU/SDC System, liquid and solid radwaste systems and the condensate demineralizer to minimize crud buildup;
- Provisions for draining, flushing, and decontaminating equipment and piping;

- Penetrations through outer walls of a building containing radiation sources are sealed to prevent miscellaneous leaks to the environment;
- Equipment drain sump vents are hard-piped directly to the RW HVAC System to collect airborne contaminants released from discharges to the sump;
- Appropriately sloped floors around floor drains in areas where the potential for a spill exists to limit the extent of contamination. The floor drains are monolithic in construction to minimize possibility of liquid penetrating at embedment boundaries. No grout is used in the installation of floor drains. Periodic visual inspections of the installation around the floor drains are performed to ensure no bypass exists in these floor drain areas;
- Provisions for decontaminable epoxy-type wall and floor coverings, which provide smooth surfaces to ease decontamination. Epoxy-type coatings are applied to both steel surfaces and concrete areas appropriate for contamination control. These areas consist of the walls and floors of the RB, FB, and TB, radwaste areas, rooms containing equipment with liquid radioactive sources, floor drain areas, washdown bays, and the RW Tunnel;
- Equipment and floor drain sumps are stainless steel lined to reduce crud buildup due to corrosion and provide surfaces that are easily decontaminated;
- For all areas with the potential for airborne radioactivity, the ventilation systems are designed such that during normal and maintenance operations, airflow between areas is always from an area of lower potential contamination to an area of higher potential contamination;
- The ESBWR is designed to limit the use of cobalt bearing materials on moving components that have historically been identified as major sources of radioactivity in reactor coolant;
- To facilitate decommissioning, the RB, FB, TB, and RW are designed for large equipment removal, consisting of entry doors from the outside and numerous cubicles with equipment hatches inside the buildings;
- To facilitate decommissioning and ease of access, the radwaste process systems are skid-mounted and located in the RW to allow truck access, and system skid loading and unloading; and
- For some piping, feed-throughs with short sections, the piping may be embedded in concrete as discussed in DCD Subsection 12.3.1.2.4. Minimization of short sections with embedded piping to the extent practicable facilitates the dismantlement of the systems and decommissioning.
- The following piping contain segments that will have to run underground:
  - Condensate Storage Tank (CST) Piping and CST Retention Area Drain
  - Radwaste Effluent Discharge Pipeline
  - Cooling Tower Blowdown Line
  - Hot Machine Shop Drain

  As such, these lines will be kept as short and direct as practicable.

The underground piping associated with the CST, Radwaste Effluent and the Hot Machine Shop will be designed to preclude inadvertent or unidentified leakage to the environment. They are either enclosed within a guard pipe and monitored for leakage, or are accessible for visual inspections via a trench or tunnel. All joints are welded with no threaded or flanged connections used underground. Furthermore, fittings will be kept to a minimum and no in-line components (e.g., valves) will be incorporated into these lines. These features substantially reduce the potential for unmonitored and uncontrolled releases to the environment and support compliance with RG 4.21.

The cooling tower blowdown line also includes underground piping; however, enclosing this line within a guard pipe or in an accessible trench or tunnel is not practicable because the line is significantly larger and longer than the previously discussed lines. However, this line does not require these additional design features because, from a radiological viewpoint, the contents of this line are already released to the environment. The radwaste effluent discharge line discharges to the cooling tower blowdown sump, which in turn discharges to the lake, river or bay. The radiological monitoring and control that is performed for radwaste effluent occurs upstream (i.e. before) it is introduced to the cooling tower blowdown sump. If radioactivity levels in the radwaste effluent exceed the pre-established setpoint; flow will be shutdown before it reaches the cooling tower blowdown sump. As such, for radiological discharges, the cooling tower blowdown sump is treated as the environment. Furthermore, the control of flow is significantly easier with radwaste effluent than with cooling tower blowdown. The flow rate for radwaste effluent is 100 gallons per minute or less and affects only the associated radwaste pump and valves, whereas the cooling tower blowdown flow rate is several thousand gallons per minute and would affect additional equipment including cooling tower operation and therefore plant operation. It is for these practical reasons that the cooling tower blowdown line will not be considered for the same design features as the CST piping, radwaste effluent pipeline or Hot Machine Shop Drain.

Specific ESBWR design features used to minimize the generation of radioactive waste include the following:

- LWMS is divided into several subsystems, so liquid wastes from various sources can be segregated and processed separately, based on the most efficient process for each specific type of impurity and chemical content. This segregation allows for efficient processing and minimization of overall liquid waste.
- During liquid processing by LWMS, radioactive contaminants are removed and the bulk of the liquid is purified and either returned to the condensate storage tank or discharged to the environment, minimizing overall liquid waste. The radioactivity removed from liquid waste is concentrated in filter media ion exchange resins and concentrated waste. The filter sludge, ion exchange resins and concentrated waste are discharged to SWMS for further processing.
- SWMS is designed to segregate and package wet and dry types of radioactive solid waste for off-site shipment and storage. This segregation allows for efficient processing and minimization of overall quantity of solid waste.
- For management of gaseous radioactive waste, the Offgas System (OGS) minimizes and controls the release of radioactive material into the atmosphere by delaying release of the

offgas process stream initially containing radioactive isotopes of krypton, xenon, iodine, nitrogen, and oxygen.

12.3.1.5.2 Operational/Programmatic Considerations

Operational programs and procedures that address the requirements of 10 CFR 20.1406 are necessary adjuncts of the design features. The following operational and post-construction objectives summarize Regulatory Guide 4.21 Position C.1 through C.4 and are addressed by the COL applicants:

- Periodically review operational practices to ensure operating procedures reflect the installation of new or modified equipment, personnel qualification and training are kept current, and facility personnel are following the operating procedures.
- Facilitate decommissioning by maintenance of records relating to facility design and construction, facility design changes, site conditions before and after construction, onsite waste disposal and contamination and results of radiological surveys.
- Develop a conceptual site model (based on site characterization and facility design and construction) that aid in the understanding of the interface with environmental systems and the features that control the movement of contamination in the environment.
- Evaluate the final site configuration after construction to assist in preventing the migration of radionuclides offsite via unmonitored pathways.
- Establish and perform an onsite contamination monitoring program along the potential pathways from the release sources to the receptor points.

The COL Applicant will address the operational and post-construction objectives of Regulatory Guide 4.21 (COL 12.3-4-A).

12.3.2 Shielding

12.3.2.1 General Design Guides

The primary objective of the radiation shielding is to protect operating personnel and the general public from radiation emanating from the reactor, the power conversion systems, the radwaste process systems, and the auxiliary systems, while maintaining appropriate access for operation and maintenance. The radiation shielding is also designed to keep radiation doses to equipment below levels where disabling radiation damage occurs.

Specifically, the shielding requirements in the plant are designed to perform the following functions:

- Limit the exposure of the general public, plant personnel, contractors, and visitors to levels that are ALARA and within 10 CFR 20 requirements;
- Limit the radiation exposure of personnel, in the unlikely event of an accident, to levels that are ALARA and which conform to the limits specified in 10 CFR 50, Appendix A, GDC 19 to ensure that the plant is maintained in a safe condition during an accident; and
- Limit the radiation exposure of critical components within specified radiation tolerances, to assure that component performance and design life are not impaired.

Table 12.3-18

Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 1: Minimize leaks and spills and provide containment in areas where such events may occur	
DCD Chapter Section/Subsection	**Description of design feature in DCD to meet design objective**
3.1	Design of Structures, Components, Equipment, and Systems: Conformance With NRC General Design Criteria
3.1.2.5 Criterion 14 — Reactor Coolant Pressure Boundary	Piping and equipment pressure parts of the RCPB are assembled and erected by welding unless applicable codes permit flanged or threaded joints. Welding procedures are employed which produce welds of complete fusion that are free of unacceptable defects.
3.4	Design of Structures, Components, Equipment, and Systems: Water Level (Flood) Design
3.4.1.2 Flood Protection From External Sources	These provisions include: • Walls below flood level designed to withstand hydrostatic loads. • Water stops provided in all expansion and construction joints below design basis maximum flood and groundwater levels. • Waterproofing of exterior surfaces below design basis maximum flood and groundwater levels. • Water seals at pipe penetrations below design basis maximum flood and groundwater levels. • Roofs designed to prevent pooling of large amounts of water in accordance with RG 1.102. • No exterior access openings below grade. The flood protection measures that are described above are not only for external natural floods but also guard against flooding from on-site storage tank rupture. Such tanks are designed and constructed to minimize the risk of catastrophic failure and are located to allow drainage without damage to site facilities.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 3: Use leak detection methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult or impossible to conduct regular inspections (such as for spent fuel pools, tanks that are in contact with the ground and buried, embedded, or subterranean piping) to avoid release of contamination from undetected leaks and to minimize contamination of the environment.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
9.1.3.2 Fuel and Auxiliary Pools Cooling System Description	The spent fuel pool is equipped with drainage paths behind the liner welds. These paths are designed to: • Prevent stagnant water buildup behind the liner plate; • Prevent the uncontrolled loss of contaminated pool water; and • Provide liner leak detection and measurement. The reactor well, equipment storage pool, buffer pool, upper and lower fuel transfer pools, cask pool, and IC/PCCS pools are also equipped with stainless steel liners, and shall be equipped with leak detection drains as part of the FAPCS. All leak detection drains are designed to permit free gravity drainage to the Liquid Waste Management System.
9.1.3.5 Fuel and Auxiliary Pools Cooling System Instrumentation and Control	The Spent Fuel Pool and buffer pool each have two wide-range safety-related level transmitters that transmit signals to the MCR. These signals are used for water level indication and to initiate high/low-level alarms. The SFP and IC/PCCS pools contain backup nonsafety-related resistive type level indicators that can be operated using portable onsite power supplies to indicate when the pools have been replenished to their normal water level. All other pools (upper transfer pool, lower fuel transfer pool, cask pool, reactor well, dryer and separator storage pool) have local, nonsafety-related, panel-mounted level transmitters to provide signals for high/low-level alarms in the MCR.
9.2	Auxiliary Systems: Water Systems
9.2.2.5 Reactor Component Cooling Water System Instrumentation Requirements	RCCWS radiation monitors are provided for monitoring radiation levels and alerting the plant operator of abnormal radiation levels.
9.2.6.5 Condensate Storage and Transfer System Instrumentation Requirements	The makeup water control valve level transmitters control the CST water level. An alarm is initiated if the CST level decreases below the level that opens the makeup water valve. An alarm actuates in the MCR if the CST water level increases above the level that isolates makeup water to the tank. This alarm point is lower than the overflow level. CST level indication is provided in the MCR.

Table 12.3-18
Regulatory Guide 4.21 Design Objective and Applicable DCD Subsection Information

Design Objective 5: Facilitate the decommissioning by (1) minimizing embedded and buried piping, and (2) designing the facility to facilitate the removal of any equipment and/or components that may require removal and/or replacement during facility operation or decommissioning.

DCD Chapter Section/Subsection	Description of design feature in DCD to meet design objective
3.8 Seismic Category I Structures	Design of Structures, Components, Equipment, and Systems: Seismic Category I Structures
3.8.1.1.1 Concrete Containment	The containment is a low-leakage reinforced concrete structure with an internal steel liner in the drywell and wetwell to serve as a leaktight membrane. The containment and the structures integrated with the containment are constructed of cast-in-place, reinforced concrete.
3.8.4 Other Seismic Category I Structures	The ESBWR Standard Plant does not contain underground Seismic Category I pipelines that are directly buried in the ground (i.e. all are contained in concrete trenches/tunnels or concrete duct bank) or masonry wall construction. Removable shield blocks consisting of metallic forms filled with grout or concrete designed to Seismic Category II requirements are used. The shield blocks are provided with removable structural steel frame also designed to Seismic Category II requirements to prevent the shielding blocks from sliding or tipping under seismic events
3.8.4.1.1 Reactor Building Structure	These structures are tied together by a system of internal concrete bearing walls and concrete floor slabs. Floor slabs are designed, in general, as composite structures supported by embedded beams during construction
4.2 Fuel System Design	Reactor: Fuel System Design
4.2.4.8 Materials	Materials selected for use in the Marathon control rod components are chosen to minimize the component end-of-life radioactivity in order to reduce personnel exposure during handling on-site, and for final offsite shipping and burial. All Marathon control rod materials are less than 0.03 weight percent cobalt. The average niobium content for the handle and absorber section, less boron carbide and hafnium, is less than 0.1 weight percent.
4.6 Functional Design of Reactivity Control System	Reactor: Functional Design of Reactivity Control System