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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 294 Related to ESBWR Design Certification Application - Auxiliary Systems - RAI Number 9.2-24**

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) sent by NRC Letter 294 dated January 13, 2009, Reference 1. GEH response to RAI Number 9.2-24 is addressed in Enclosure 1.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

Reference:

1. MFN 09-051, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 294 Related to ESBWR Design Certification Application,* January 13, 2009.

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 294 Related to ESBWR Design Certification Application - Auxiliary Systems - RAI Number 9.2-24

cc:	AE Cubbage	USNRC (with enclosure)
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	eDRF Section	0000-0096-5129

Enclosure 1

MFN 09-289

RESPONSE TO PORTION OF NRC REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 294 RELATED TO ESBWR DESIGN CERTIFICATION APPLICATION

AUXILIARY SYSTEMS

RAI NUMBER 9.2-24

GEH Note

GEH received RAI 9.2-24 on January 20, 2009. GEH and the NRC reviewer and project manager determined that the best method to resolve these issues was via audit, which was conducted at General Electric's Washington, D.C., offices on March 19 and 20, 2009. For convenience, GEH created Table 1 (below), Original RAI 9.2-24 Text Referenced to Audit Sections, to ensure every point in the RAI is addressed in GEH's audit response (also provided below), as applicable.

NRC RAI 9.2-24

Regulatory guidance related to the ESBWR passive plant design and regulatory treatment of non safety systems (RTNSS) systems and plant cooldown functions can be found in; (1) memorandum from the NRC Associate Director for Advanced Reactors and License Renewal to the Docket File dated July 24, 1995, "Consolidation of SECY 94-084 and SECY 95-132" (ML003708048); (2), memorandum from the NRC Executive Director for Operations to the Commissioners dated June 12, 1996, "Policy and Key Technical Issues Pertaining to the Westinghouse AP600 Standard Passive Reactor Design," (aka SECY 96-128) (ML003708224); and (3) memorandum from the NRC Executive Director for Operations to the Commissioners dated June 23, 1997, "Implementation of Staff Position in SECY 96-128, 'Policy and Key Technical Issues Pertaining to the Westinghouse AP600 Standard Pressurized Reactor Design,' Related to Post-72 Hour Actions" (ML003708229). From these memoranda, the NRC staff documented its policy that systems subject to RTNSS, including their support systems, and systems that are relied upon for achieving and maintaining cold shutdown conditions should be highly reliable.

Non-safety-related (NSR) active systems must be relied upon in order to achieve cold shutdown conditions in accordance with Technical Specification requirements, and these systems should be highly reliable and capable of achieving and maintaining cold shutdown conditions and there should be no single failure of these systems which would result in inability to terminate use of the passive safety related systems and achieve cold shutdown. In addition to the considerations discussed in the above memoranda, these NSR systems should be capable of cooling the plant to Mode 5 conditions within 36 or 37 hours in order to satisfy ESBWR Technical Specification requirements. Numerous Technical Specification Section required Mode 5 entry which includes; TS 3.0.3, TS 3.1.7. TS 3.3.4.1, TS 3.3.6.3, TS 3.3.6.4, TS 3.3.8.1, TS 3.4.1, TS 3.4.2, TS 3.4.3, TS 3.4.4, TS 3.5.1, TS 3.5.2, TS 3.6.1.1, TS 3.6.1.2, TS 3.6.1.3, TS 3.6.1.4, TS 3.6.1.5, TS 3.6.1.6, TS 3.6.1.7, TS 3.6.2.1, TS 3.6.2.2, TS 3.6.3.1, TS 3.7.1, TS 3.7.2, TS 3.7.3, TS 3.8.1, TS 3.8.4, and TS 3.8.6. NSR systems that are designated as RTNSS (including their support systems) are subject to enhanced design, quality, reliability, and availability provisions and are relied upon for performing functions as *discussed in Tier 2 of the Design Control Document (DCD), Appendix 19A, "Regulatory Treatment of Non-Safety Systems." Sufficient information needs to be included in Tier 1 and Tier 2 of the DCD in order to demonstrate that these systems are adequate for achieving and maintaining cold shutdown conditions (i.e., cooldown from Mode 4 to Mode 5) and for performing RTNSS functions and that applicable design consideration have been satisfied.*

The following RAIs are written for the plant service water system. Comparable concerns should be addressed as applicable for the reactor component cooling water system (RCCWS) and nuclear island chilled water subsystem (NICWS) as well:

Table 1 – Original RAI 9.2-24 Text Referenced to Audit Sections

Original RAI Text	Applicable Audit Sections		
	PSWS	RCCWS	NICWS
a. Although the plant service water system (PSWS) is non-safety related, it is relied upon to achieve cold shutdown. While this function is an important part of the PSWS design bases, they are not fully described in Design Control Document (DCD) Tier 2 Section 9.2.1, "Plant Service Water System." Instead, Section 9.2.1 refers to DCD Tier 2 Appendix 19A, "Regulatory Treatment of Non-Safety Systems," for information concerning PSWS functions that are subject to regulatory treatment of non-safety systems (RTNSS). In particular, the PSWS supports the normal capability of removing reactor and spent fuel decay heat. Furthermore, because the PSWS is relied upon for achieving cold shutdown and as expressed by the Electric Power Research Institute (EPRI) in its Utility Requirements Document for advanced light water reactors, the PSWS should be highly reliable and no single active failure should result in the inability to terminate use of passive safety-grade systems and achieve cold shutdown. RTNSS functions and cold shutdown provisions are important elements of the PSWS design bases and they need to be described in Design Control Document (DCD) Tier 2 Section 9.2.1. This is especially important for establishing appropriate Tier 1 inspections, tests, analyses, and acceptance criteria requirements for the PSWS, as well as for establishing appropriate quality assurance and design reliability assurance program specifications. Consequently, DCD Tier 2 Section 9.2.1 needs to be revised to fully describe the RTNSS functions and cold shutdown provisions that pertain to	a (and all sections)	a (and all sections)	a (and all sections)

Original RAI Text	Applicable Audit Sections		
	PSWS	RCCWS	NICWS
PSWS.			
b. The staff reviewed the plant service water system (PSWS) description and piping and instrumentation diagram (P&ID) to confirm that the design bases, flow paths, and components have been identified and described in sufficient detail to enable a complete understanding of the system design and operation. The staff found that additional information is needed in this regard and Design Control Document (DCD) Tier 2 Section 9.2.1 needs to be revised to address the following considerations:			
• *The most limiting conditions upon which the plant service water system (PSWS) design is based need to be described (e.g., shutdown/cooldown with maximum core decay heat and maximum allowed spent fuel pool heat load, capability to perform plant cooldown within specified criteria, single failure and loss of power considerations). The amount of excess margins that are included in the design to account for uncertainties, component wear and aging effects, fouling of heat transfer surfaces and spray nozzles, strainer debris collection, etc., need to be described and why the specified margins are considered to be adequate need to be explained. Finally, specific values or ranges of values chosen as the bounding conditions for the design need to be specified and explained (e.g., limiting temperatures; wet bulb, and dry bulb); both the specified design and minimum required capability of heat exchangers, cooling towers, and pumps based on excess margin considerations; minimum required water level in the service water basins to satisfy inventory and net positive suction head requirements). Note that combined license (COL) information items and interface requirements should be established as appropriate.*	b.1	b.1	b.1
• *Nominal pipe sizes for the main flow paths need to be shown on the system drawings and PSWS flow rates through individual coolers need to be specified.*	b.2	b.2	b.2
• *Train designations for cross-connect valves need to be shown on the system drawings.*	b.3	b.3	b.3

Original RAI Text	Applicable Audit Sections		
	PSWS	RCCWS	NICWS
• *The PSWS header temperature and pressure detectors need to be shown on the system drawings.*	b.4	b.4	b.4
• *The PSWS pump minimum flow recirculation lines need to be shown on the system drawings.*	b.5	b.5	b.5
• *A description of the air system interface needs to be provided for the air-operated valves and shown on the system drawings. Also, an explanation of how train separation is maintained, a description of valves, filters, and other components that are included in the design, as well as design provisions that assure the reliability of this arrangement need to be discussed.*	b.6	b.6	b.6
• *Valve failure modes need to be described.*	b.7	b.7	b.7
• *Provisions to prevent freezing and damage of PSWS piping, components, and basin areas (especially near the surface), as well as interfacing systems such as cooling tower makeup and blowdown, need to be described.*	b.8	b.8	b.8
• *A description is needed for how the water in the service water basin is replenished when the discharge is being directed to the normal power heat sink. Also, the minimum required makeup rates for the service water basin need to be specified for when the PSWS discharge is directed to the normal power heat sink and for when it is directed to the service water basin, along with the basis for the makeup rates that are specified.*	b.9	N/A	N/A
• *The system drawing for the PSWS shows a single shared service water basin whereas DCD Tier 2 Table 9.2-2 indicates that there are two separate service water basins and clarification is needed. Also, if a single shared basin is used, justification for not providing redundancy is needed. If separate service water basins are used, additional explanation is needed for how water levels are maintained when operating in a cross-connected configuration.*	b.10	N/A	N/A
• *The PSWS description indicates that valves will be provided with hard seats to withstand erosion where needed. Additional explanation is necessary to better define and specify when valves with hard seats need to be used, and an information item is needed for COL applicants to*	b.11	b.11	b.11

Original RAI Text	Applicable Audit Sections		
	PSWS	RCCWS	NICWS
identify where such valves will be installed to satisfy the specified criteria.			
• *A more detailed description of how the PSWS detects gross leakage is needed, and the instrumentation that is credited needs to be specified.*	b.12	b.12	b.12
• *A description is needed for how the PSWS pumps are protected from large debris that can end up in the service water basin either from makeup water sources or due to basin or cooling tower degradation, and how clogging due to silt accumulation is prevented from occurring (see Information Notice 2006-17, Recent Operating Experience of Service Water Systems Due to External Conditions," dated July 31, 2006).*	b.13	b.13	b.13
• *Nominal screen mesh size for the service water strainers need to be specified and explained.*	b.14	b.14	b.14
• *Although the description indicates that vacuum breakers will be installed at high points in system piping, none are shown on the system drawings. The system drawing needs to be revised to indicate where the high points are and to show the vacuum breakers, including where vacuum breakers are located in the heat rejection facility piping. Furthermore, an information item needs to be established for COL applicants to include vacuum breakers in the plant-specific heat rejection facility piping.*	b.15	b.15	b.15
• *DCD Tier 2 Section 9.2.1.5, "Instrumentation Requirements," indicates that with one PSWS pump operating, the respective standby pump starts automatically upon detection of a low system pressure signal in that train, loss of electric power to the operating pump, or an operating pump trip signal. This section also indicates that starting a PSWS pump automatically opens a flow path through the RCCWS and TCCWS heat exchangers. However, no description is provided under the operation discussion in Section 9.2.1.2, "System Description," about these operating features, and there is no discussion about operation of the self-cleaning strainers.*	b.16	b.16 (for I&C consis-tency)	b.16 (for I&C consiste ncy)
• *DCD Tier 2 Table 9.2-1 needs to indicate which alignment is for a 24-hour cooldown and which is*	b.17	b.17	b.17

Original RAI Text	Applicable Audit Sections		
	PSWS	RCCWS	NICWS
for a 36-hour cooldown to cold shutdown conditions.			
c. In order to satisfy system flow requirements, the plant service water system (PSWS) design should assure that the minimum net positive suction head (NPSH) for the PSWS pumps is satisfied for all postulated conditions, including vortex formation considerations. The system description indicates that the PSWS pumps have sufficient available NPSH under worst case conditions, and that the water levels in the service water basins are monitored to ensure sufficient NPSH. However, the specific NPSH requirements for the PSWS pumps; the minimum required service water basin water level that is necessary to satisfy NPSH requirements and the basis for this determination and limiting assumptions that were used (e.g., water level, maximum temperature, maximum flow rate, number of pumps operating, vortex effects); how this minimum required water level compares to the minimum water level that is maintained in the service water basins to satisfy excess margin and inventory considerations; and how combined license (COL) applicants will know to periodically confirm that adequate levels exist in the service water basins were not described. Therefore, the Design Control Document (DCD) Section 9.2.1 needs to be revised to include this information and to establish COL information items and interface requirements as appropriate.	C	C	C
d. The plant service water system (PSWS) description indicates that the potential for waterhammer is mitigated through the use of various system design and layout features, such as automatic air release/vacuum valves installed at high points in system piping and at the pump discharge, proper valve actuation times to minimize water hammer, procedural requirements ensuring proper line filling prior to system operation and after maintenance operations, and the use of a check valve at each pump discharge to prevent backflow into the pump. While these design features and provisions are considered to be appropriate and may be adequate, Design Control Document (DCD) Tier 2 Section 9.2.1 needs to be revised to address the following additional	[redacted]	[redacted]	[redacted]

Original RAI Text	Applicable Audit Sections		
	PSWS	RCCWS	NICWS
considerations:			
• *The amount of back leakage through the pump check valves that is considered to be excessive needs to be specified and explained, and how excessive check valve back leakage or system voiding will be prevented from occurring over time needs to be described.*	d.1	d.1	d.1
• *A description is needed for how proper operation of the automatic air release/vacuum valves will be assured over time.*	d.2	d.2	d.2
• *Valve actuation/stroke times that are considered to be appropriate (especially with respect to the air-operated valves) need to be specified and explained, and how these times will be maintained as the plant ages needs to be described.*	d.3, d.1	d.3, d.1	d.3, d.1
The initial test program to demonstrate that automatic actuation of a standby loop or actuation of both loops following a loss of power will not result in a significant waterhammer event with the PSWS return aligned to either the natural draft or mechanical draft cooling towers needs to be described in the appropriate FSAR Chapter (Chapters 9 or 14).	d.4, d, b.15	d.4, d, b.15	d.4, b.15

GEH Response

The GEH response is presented in Table 2 (below), RAI 9.2-24 Audit Items and GEH Response.

In addition, Figure 2 from SR3-1-ECA-0036 (Rev. 0) is provided as reference to indicate instrument locations in support of GEH response to audit item b.4 for NICWS.

DCD Impact

As indicated in applicable sections of the GEH response in Table 2 below, the following DCD items are being revised in Revision 6 as shown in attached markups:

- Tier 1, Section 4.1
- Tier 2, Subsection 9.2.1.2
- Tier 2, Subsection 9.2.1.5
- Tier 2, COL Item 9.2.1-1-A
- Tier 2, Subsection 9.2.2.2
- Tier 2, Subsection 9.2.2.5
- Tier 2, Subsection 9.2.7.2
- Tier 2, Subsection 9.2.7.5
- Tier 2, Table 9.2-1
- Tier 2, Table 9.2-2
- Tier 2, Table 9.2-3
- Tier 2, Table 9.2-5
- Tier 2, Figure 9.2-1
- Tier 2, Figure 9.2-2b
- Tier 2, Figure 9.2-3
- Tier 2, Subsection 14.2.8.1.51

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
a. HIGH LEVEL GOAL: The staff/reviewer should determine if the system is considered highly reliable; and no single active failure should result in the inability to terminate use of passive safety-grade system and achieve cold shutdown.	The NRC staff conducted an audit of the ESBWR RTNSS Cooling Water Systems described in DCD Revision 5,Tier 2 Chapter 9.2, to obtain additional information requested under RAI 9.2-24. The systems within the scope of the audit included the Plant Service Water System (PSWS), Reactor Component Cooling Water System (RCCWS), and Nuclear Island Chilled Water System (NICWS). The purpose of the audit was to identify design information relied on to support RTNSS functions and cool-down functions, consistent with the technical specifications, but not currently documented in the DCD Tier 2, Chapter 9.2. PSWS, RCCWS and NICWS support plant investment protection (PIP) and defense-in-depth requirements, specified in Paragraph 2.18 of the ESBWR Composite Design Specification. In addition, these cooling water systems provide support of RTNSS functions. These nonsafety-related systems are designed to perform accident recovery functions to bring the plant to cold shutdown within 72 hours. Because these cooling water systems are also significant contributors to plant availability and plant investment protection, the ESBWR design is focused on ensuring these systems are available and reliable. Therefore, design requirements for PIP and defense-in-depth protection (seismic ruggedness, redundancy fire and missile, and flood protection) may be more restrictive than the system RTNSS requirements. Assurance of PSWS design function is validated during normal operation and worst-case heat load conditions can be created during a refueling outage by imposing a single train cooldown. As shown in Figure 9.2-1, PSWS heat loads placed on a single train are 138 % of design heat load during cooldown (111.9

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	Mw / 80.8 Mw) and 45 % of the design heat load (33.8 Mw /74.8 Mw) during normal operation. Assurance of RCCWS design function is validated during normal operation where worst case heat load conditions can be created during a refueling outage by imposing a single train cooldown. As shown in Figure 9.2-3, RCCWS heat loads exceed 100 % of design heat load during cooldown (90.9 Mw / 74.8 Mw) and 55% of the design heat load (33.8 Mw /74.8 Mw) during normal operation. PSWS, RCCWS and NICWS provide supporting functions for FAPCS suppression pool cooling and low pressure injection modes, and thus meet RTNSS Criteria C. RTNSS C SSCs are assumed to be available at the time of the initiating event. Validation of these RTNSS functions is assured by Tier 1 ITAAC (S2.12.7 PSWS;S2.12.3 RCCWS; 2.12.5 NICWS) where testing of the PSWS /RCCWS / NICWS demonstrate flow to the RCCWS (nuclear island chillers, diesel generators and FAPCS island chillers, diesel generators and FAPCS). The ESBWR RTNSS Criteria C Cooling Water System ITAAC scope and detail differs from that associated with validation of RTNSS Criteria B functions. The ESBWR is designed so that safety-related passive systems are able to perform all safety functions for at least 72 hours, after initiation of a design basis event, without the need for active systems or operator actions. After 72 hours, nonsafety-related systems (RTNSS Criteria B) can be used to replenish the passive systems or to perform core cooling and containment integrity functions directly. RTNSS Criteria B ITAAC (e.g FAPCS section 2.6.2 Item 7and FPS section 2.16.3 item 7) provides a greater assurance of function due to the safety significance of the RTNSS function. The staff identified design information needed to be included in the DCD in

Table 2 – RAI 9.2-24 Audit Items and GEH Response

<table>
<tr><th>RAI 9.2-24 NRC Audit Items, PSWS</th><th>GEH Response to Audit Findings/Comments, PSWS</th></tr>
<tr><td></td><td>order to reach reasonable assurance that these systems will perform their intended non-safety function related to RTNSS; as well as cool-down function and performance. The following ESBWR design input documents, associated with PSWS, were reviewed as part of this audit.

<table>
<tr><th>Document Type/Title</th><th>Document Number</th><th>Revision</th></tr>
<tr><td>Composite Design Specification</td><td>26A6007</td><td>2</td></tr>
<tr><td>Project Design Manual</td><td>NEDO-33271P</td><td>2</td></tr>
<tr><td>System Design Specification</td><td>SR3-1-P41-SDS-6401</td><td>3</td></tr>
<tr><td>P&ID</td><td>SR3-1-P41-PID-1000</td><td>0</td></tr>
<tr><td>Calculation: Design Parameters</td><td>SR3-1-P41-CAD-0001</td><td>0</td></tr>
<tr><td>Calculation: Pipeline Sizing</td><td>SR3-1-P41-CAD-0002</td><td>0</td></tr>
<tr><td>Calculation: Pressure Drop</td><td>SR3-1-P41-CAD-0003</td><td>0</td></tr>
<tr><td>Calculation: Equipment Sizing</td><td>SR3-1-P41-CAD-0004</td><td>0</td></tr>
<tr><td>PRA Model</td><td>NEDO-33201</td><td>3</td></tr>
<tr><td>P41 PRA System Notebook</td><td>NEDO-33201 Section 4.11, P41</td><td>0</td></tr>
</table></td></tr>
<tr><td>b.1
Determine the most limiting conditions upon which the plant service water system (PSWS) design is based need to be described (e.g., shutdown/ cooldown with maximum core decay heat and maximum allowed spent fuel pool heat load, capability to perform</td><td>Single train failure during cooldown results in the greatest heat load per PSWS train at 80.8 MW. This transient mode occurs with one train of PSW in operation (two (2) PSW pumps) and all heat loads are dissipated through two (2) RCCW heat exchangers and two (2) TCCW heat exchangers. The RCCWS heat loads considered under this event include the following:

RWCU/SDC (G31) 36 MW
FAPCS (G21) 9.6 MW</td></tr>
</table>

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
plant cooldown within specified criteria, single failure and loss of power considerations. Determine the amount of excess margins that are included in the design to account for uncertainties, component wear and aging effects, fouling of heat transfer surfaces and spray nozzles, strainer debris collection, etc., need to be described and why the specified margins are considered to be adequate need to be explained. Determine the specific values or ranges of values chosen as the bounding conditions for the design need to be specified and explained (e.g., limiting temperatures; wet bulb, and dry bulb); both the specified design and minimum required capability of heat exchangers, cooling towers, and pumps based on excess margin considerations; minimum required water level in the service water basins to satisfy inventory and	NICWS (P25) 12.3 MW Other 1.9 MW The TCCWS heat load considered under this event is 21 MW. This value is considered a conservative estimate of ESBWR Turbine Island heat loads. Loss of Preferred Power Cooldown (LOPP) with Single Train Failure is the most limiting system heat removal design condition for the RCCWS. This mode of operation differs from single train failure during cooldown in that the TCCWS heat loads are replaced with the heat loads associated with a standby diesel generator. This transient mode occurs when a LOPP and a single train failure occur concurrently. Similar to the single train failure transient, only one train is in operation and all heat loads are dissipated using the RCCW heat exchangers (3) and PSW pumps (2) on the active PSWS train. Two PSWS pumps provide sufficient cooling capacity to the RCCWS heat exchangers in order to bring the plant to cold shutdown condition within 36 hours. This mode of operation removes 74.8 MW from RCCWS using one train of PSWS. No TCCWS heat loads are present during this condition but a TCCW heat exchanger is in bypass to maintain required PSW pump flow. The RCCWS heat loads considered under this event include the following: RWCU/SDC (G31) 36 MW FAPCS (G21) 9.6 MW NICWS (P25) 12.3 MW Standby Diesel Generator (R21) 15 MW Other 1.9 MW The RWCU/SDC design non-regenerative heat exchanger heat load of 36 MW

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
net positive suction head requirements). Note that combined license (COL) information items and interface requirements should be established as appropriate. Determine what needs to be included in the DCD.	for one train assumes a maximum RCCWS discharge temperature of 130°F in the limiting shutdown cooling analysis. Spent fuel storage capacity evaluated for 20 years results in the bounding heat load to 9.6 MW. Significant margins and conservative assumptions are applied to the heat loads for the PSWS: • While the PSWS is designed for 1% exceedance conditions, the system is capable of operating during 0% exceedance conditions but will not be expected to produce the design cold leg temperature of 88°F. • A heat load value equal to 10% of the "Normal Power" heat load from RWCU/SDC (G31) and FAPCS (G21) is used for each train of G31 and G21 equipment that is active to account for the miscellaneous RWCU/SDC (G31) and FAPCS (G21) equipment cooler heat loads not yet defined. • The CWS bounding heat load assumed for PSWS/RCCWS sizing calculations is 12.3 MW. This design value is based on the heat rejection from two 1380 ton chillers. • The Standby Diesel Generator heat load is conservatively figured by assuming a 15 MW diesel generator has a heat load of 15 MW. This assumption was made to ensure that any additional heat load imposed by the diesel generators would not impact the sizing of the RCCWS heat exchangers. Significant margins and conservative assumptions are applied to the design of the heat removal facility (conceptual design information) for the PSWS. Each PSWS train receives cooling water from the PSWS basin and rejects heat to the Auxiliary Heat Sink (AHS) or the Normal Power Heat Sink (NPHS). The

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	reference design for the AHS consists of two mechanical draft cooling towers and the reference design for the NPHS consists of two hyperbolic natural-draft cooling towers. • Margin is applied to the design heat load for the mechanical draft cooling towers. The margin reflects the difference between the maximum PSWS train design heat load (Single Train Failure Cooldown) listed in DCD Table 9.2-1 and PSWS Cooling Towers and Basins heat load listed in DCD Table 9.2-2. DCD Revision 6 will provide a PSW Cooling Tower heat load value of 83.5 MW that equals 3.3% margin over the PSWS design heat load. • The PSWS is designed for 1% exceedance values. One percent annual exceedance values were selected in order to bound the values presented in the URD and available Early Site Permit applications. The ESBWR 1% exceedance wet bulb temperature provides a 2ºF margin to the URD exceedance value and 1.6ºF to 3ºF margin between the ESBWR wet-bulb and ESP site wet-bulb temperatures. The heat removal facility (conceptual design information) interface requirements are necessary for supporting the post-72-hour cooling function of the PSWS. The PSWS is required to remove 2.02×10^7 MJ (1.92×10^{10} BTU) over a period of 7 days without active makeup. During the worst-case accident scenario for PSWS heat removal requirements (PRA for Single Active Failure w/LOPP for 7 days), the loads considered were as follows: • Combined core and spent fuel decay heat loads (avg. 19.5 MW from 34 hrs to 7 days); • Heat load due to Diesel Generators and NI Chillers (average 18 MW over 7

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	days). Diesel loads during the limiting event are preliminary and require detail design (i.e. pump & piping sizing) for refinement. It is anticipated that diesel electrical loads will be reduced with refinement of the load sizing calculation. The plant operator could limit electric loads if required to ensure adequate PSWS make-up capacity; • The calculated value assumes the 1% exceedance value is constant for the 7 day time. Significant margins are applied to the PSWS during the design process to account for uncertainties, component wear and aging effects, fouling of heat transfer surfaces and spray nozzles, and strainer debris collection. The design basis documents reviewed by the NRC considers the following margins and conservative assumptions in the design of the system: • PSW pumps are sized using a friction factor 20% greater than that of clean, new commercial pipe to account for biological growth and aging effects; • A corrosion allowance for above ground PSWS carbon steel piping is 3.0 mm to account for aging issues and degradation; • The PSWS design temperatures and pressures are determined from the operating conditions with a margin of 5.6°C (10° F) added to the operating temperature (rounded up to the next 5°C increment) to determine the design temperature. A margin of 172.4 kPag (25 psig) is added to the operating pressure (rounded to the next 100 kPag increment) to determine the design pressure; • The test pressure for carbon steel pipe is defined by multiplying the design pressure by a factor of 1.5.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	The ESBWR PSWS design has considered operating experience such as Generic Letter (GL) 89-13, SERVICE WATER SYSTEM PROBLEMS AFFECTING SAFETY-RELATED EQUIPMENT and Information Notice 2006-17, Recent Operating Experience of Service Water Systems Due to External Conditions," dated July 31, 2006. The ESBWR PSWS is not committed to meeting the recommendations of Generic Letter 89-13 Ref DCD Table 1C-1, Operating Experience Review Results Summary – Generic Letters, because ESBWR has no safety-related service water and applies water quality standards to the use of water for safety functions. But, the recommendations have been integrated in the cooling water system design. • *"Conduct, on a regular basis, performance testing of all heat exchangers, which are cooled by the service water system. Testing should be done with necessary and sufficient instrumentation, though the instrumentation need not be permanently installed. The relevant temperatures should be verified to be within design limits. An example of an alternative action that would be acceptable to the NRC is frequent regular maintenance of a heat exchanger in lieu of testing for degraded performance of the heat exchanger"* **ESBWR PSWS design includes sufficient instrumentation to monitor performance of individual heat exchangers. The plate heat exchanger design utilized for PSWS heat loads could also be maintained through a preventative / predictive maintenance program.** • *"Verify that their service water systems are not vulnerable to a single failure of an active component"*. **All ESBWR RTNSS Systems are designed with component redundancy so the system will remain functional**

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	**GEH Response to Audit Findings/Comments, PSWS**
	assuming a single active failure coincident with a loss of preferred power (LOPP). • *"Inspect, on a regular basis, important portions of the piping of the service water system for corrosion, erosion, and biofouling. Ensure by establishing a routine inspection and maintenance program for open-cycle service water system piping and components that corrosion, erosion, protective coating failure, silting, and biofouling cannot degrade the performance of the safety-related systems supplied by service water. The maintenance program should have at least the following purposes: To remove excessive accumulations of biofouling agents, corrosion products, and silt;To repair defective protective coatings and corroded service water system piping and components that could adversely affect performance of their intended safety functions".* **The PSWS design incorporates features to facilitate inspection and allow for planned maintenance. Material selection for all PSWS components wetted by raw cooling water will match the corrosion resistance of the material to the water chemistry. Both operating and stagnant (shutdown) conditions will be addressed. Including placing components and idle loops in wet layup. Erosion resistance will also be addressed. Pipe size and routing support remote visual inspections and repairs. The PSWS basin is equipped with a trash rack in order to prevent damage to the PSWS pumps due to ingestion of large debris and minimize macrofouling.** • *"Reduce human errors in the operation, repair, and maintenance of the service water system"* **The ESBWR Human Factors Engineering (HFE) design process integrates human capabilities and limitations into the**

Table 2 – RAI 9.2-24 Audit Items and GEH Response

<table>
<tr><th>RAI 9.2-24 NRC Audit Items, PSWS</th><th>GEH Response to Audit Findings/Comments, PSWS</th></tr>
<tr><td></td><td>PSWS.

GEH considers sufficient information is included in this response to resolve this issue. No DCD updates will be included for this issue.</td></tr>
<tr><td>b.2
Review the supplied documents and drawings for nominal pipe sizes and flow rates through individual coolers.

Determine what needs to be included in the DCD.</td><td>The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the design calculation, SR3-1-P41-CAD-0002, Plant Service Water System (PSWS) Pipeline Sizing.

The ESBWR Project Design Manual (NEDE 33271) provides requirements for maximum fluid velocity applied to the PSWS piping under this calculation. The maximum recommended water velocity for piping containing general service water pump suction and discharge is shown in the table below.

<table><tr><th></th><th>50 mm (2 in.)</th><th>200 mm (8 in.)</th><th>350 mm (14 in.)</th><th>500 mm (20 in.)</th><th>>600 mm (24 in.)</th></tr><tr><td>Pump Suction</td><td>2 fps</td><td>5 fps</td><td>6 fps</td><td>8 fps</td><td>10 fps</td></tr><tr><td>Pump Discharge</td><td>5 fps</td><td>10 fps</td><td>12 fps</td><td>15 fps</td><td>15 fps</td></tr></table>
Based on the piping configuration shown in the PSWS piping and instrument</td></tr>
</table>

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	diagrams, the following pipe runs were sized for the required flow: 1. PSWS Pump Discharge Piping 2. PSWS Main Supply/Return Piping 3. RCCWS Heat Exchangers' Header Supply/Return Piping 4. TCCWS Heat Exchangers' Header Supply/Return Piping 5. RCCWS/TCCWS Heat Exchanger's Inlet/Outlet Piping 6. PSWS Blowdown Piping 7. PSWS Makeup Piping Pipe runs 1 - 6 are sized for the maximum possible flow through the pipe depending on the number of heat exchangers in use during the most limiting mode of operation. Pipe run 7 is sized for the required blowdown flow and pipe run 8 is sized for the required makeup flow The NRC reviewed the nominal pipe sizes and flow rates provided and found the resulting fluid parameters to be acceptable GEH considers sufficient information is included in this response to resolve this issue. No DCD updates will be included for this issue.
b.3 Review the supplied documents for train designations for cross-connect valves. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401) and Plant Service Water PRA Model (NEDO 33201 Rev 3). The following information is contained in the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). DCD Figure 9.2-1 reflects motor operated valves and air operated valves located in the PSWS Pump House

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	(Site Specific Interface) Since no instrument air is supplied to the yard, local air would be required for operation. The Utility may take a deviation from the DCD if it is determined to be cost effective. The PSWS includes the following train cross-connect valves: • PSWS Train A and B cross-tie motor-operated valves - manually open and close from the MCR. In the event of a LOPP, the valves automatically close; • The mechanical draft cooling tower cross-tie motor-operated valves - manually open and close from the MCR. In the event of a LOPP, the valves automatically close, • The PSWS basin full-flow bypass motor-operated block valves - manually open and close from the MCR. The valves fail as-is; • The NPHS supply motor-operated block valve - manually open and close from MCR. The valve fails as-is; • When the NPHS is used for heat rejection, water is returned to the PSWS basin via a branch from the Circulating Water System (CIRC). Controls associated with PSWS basin level transmitters and PSWS / CIRC flow transmitters would maintain required PSWS cooling tower basin level while systems are operated cross connected. Air -operated isolation valves and a cross-tie line permit routing of the PSWS return to either the AHS or NPHS; • A full flow cooling tower bypass is provided to return PSWS water directly to the PSWS basin to allow ease of cold weather startup and prevent freezing. GEH considers sufficient information is included in this response to resolve this

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	issue. No DCD updates will be included for this issue.
b.4 Review the supplied documents and drawings for header temperature and pressure detectors. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board for header temperature and pressure detectors and found the PSWS instrumentation layout to be acceptable. GEH considers sufficient information was provided during the audit to resolve this issue. No DCD updates will be included for this issue.
b.5 Review the supplied documents and drawings for pump minimum flow recirculation lines. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). PSWS pump minimum flow recirculation lines are not required because the system design and operation will ensure that the required minimum pump flow will be maintained under all conditions. The PSWS pump will trip if the pump discharge valve fails to open ensuring minimum flow conditions are maintained. Both the RCCWS and TCCWS heat exchanger isolation valves will be open prior to pump start to provide two flow paths to mitigate transient conditions during filling in case a heat exchanger valve fails to fully open (or a vacuum/air release valve fails to operate). After the filling process is completed, any excess capacity heat exchangers will be isolated. A full flow tower bypass, provided to return water directly to the PSWS basin for freeze protection, would also provide a minimum flow path if required during testing or operation. DCD Tier 2 subsection 9.2.1.5, Instrumentation Requirements, will be revised under revision 6 to specify that a PSWS pump will trip if the pump discharge valve fails to open ensuring minimum flow conditions are maintained

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	**GEH Response to Audit Findings/Comments, PSWS**
	GEH considers sufficient information is provided in this response to resolve this issue. DCD updates will be included for this issue.
b. 6 Review the supplied documents and drawings for related to the air system interface for the air-operated valves. Review for how train separation is maintained and reliability of this air system arrangement. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-P41-SDS-6401) and the Plant Service Water PRA Model (NEDO 33201 Rev 3). Air operated valves are located at the discharge of the RCCW and TCCW heat exchangers and the NPHS PSWS hot water return line. Heat Exchanger Outlet Flow Control Valve - RCCWS and TCCWS heat exchanger outlet air-operated flow control valves. The position of these valves is regulated to keep heat exchanger flow within a specified range. The valves automatically open when the associated heat exchanger is placed in service. The valves fail open. NPHS PSW Hot Water Return Line – This air operated value is normally closed and fails closed upon loss of electrical power or air to ensure separation of PSWS from NPHS (non RTNSS system) DCD Figure 9.2-1 reflects motor operated valves and air operated valves located in the PSWS Pump House (Site Specific Interface). Since no instrument air is supplied to the yard, local air would be required for operation. The Utility may take a deviation from the DCD if it is determined to be cost effective. Train redundancy ensures that single failure of any air-operated valve will not impact the other train. As described in the PSWS PRA Model (NEDO 33201

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	Section 4.11 Rev 3), periodic change in train operation is assumed (PRA assumption) such that the relevant train components are checked quarterly. The importance of non-safety related compressed-gas supplies was evaluated relative to the criteria for special regulatory treatment of non-safety systems in DCD Tier 2 Appendix 19A. Compressed gas supplies and valves, including PSWS valves, were evaluated as described in response to RAI 9.3-32 (MFN LTR 07-259 dated May 8, 2007), and do not meet the criteria for special regulatory treatment. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
b. 7 Review the supplied documents and drawings for valve failure modes. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401 and the Plant Service Water PRA Model (NEDO 33201 Rev 3). The failure modes and effects associated with PSWS components are modeled in the PSWS PRA model fault tree for LOPP and non-LOPP sequences. Common cause failures are the dominant contributors to system failure for both LOPP and non-LOPP top events. The LOPP sequence failures are significantly higher than the non-LOPP sequence failures, primarily because the probabilities used for failures to open or failure to start are significantly higher than those used for failure to remain open or failure to run. System importance sensitivities were performed. Details are provided in NEDO 33201, Rev. 3, Section 11.3.1.15. Tables 11.3-15 and 11.3-16 contain the PSWS importance rankings based on RAW and FV, respectively.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	GEH considers providing system valve failure position on DCD figures detailed design information that is beyond that necessary for the NRC to make its safety finding. Therefore, DCD update for valve failure position will not be included in the DCD. GEH considers sufficient information is provided in this response and described in the Plant Service Water PRA Model to resolve this issue. No DCD updates will be included for this issue.
b. 8 Review the supplied documents and drawings for provisions to prevent freezing and damage of PSWS piping, components, and basin areas (especially near the surface), as well as interfacing systems such as cooling tower makeup and blowdown. Determine what needs to be included in the DCD.	These features may vary on a site-specific basis, depending upon the location of the plant and the site-specific weather conditions. Thus, freeze protection is not part of the ESBWR Standard Plant as described in DCD Tier 2, Subsection 1.2.2.12.16. Freeze protection is incorporated at the individual system level in the COL Applicant FSAR using insulation and heat tracing for all external tanks and piping that may freeze during winter weather The ESBWR DCD, Subsection 14.2.8.1.51, specifies an initial test be performed, if applicable, to demonstrate proper operation of freeze protection methods and devices. GEH considers sufficient information is provided in this response. No DCD updates will be included for this issue.
b. 9 Review the supplied documents and drawings for how the water in the service water basin is replenished when the discharge is being directed to the normal power heat sink. Review the minimum required makeup	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). As explained in GEH's response to RAI 9.2-23 (MFN LTR 08-342 dated April 11, 2008), the heat removal facility and basin design are considered conceptual design information. This would include the makeup and makeup rates for the basin.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
rates for the service water basin when the PSWS discharge is directed to the normal power heat sink and for when it is directed to the service water basin, along with the basis for the makeup rates that are specified. Determine what needs to be included in the DCD.	If desired by the COL Applicant, PSWS flow could be directed to the NPHS cooling tower during normal power operation, where heat removed from the RCCWS and TCCWS is rejected to the NPHS. During this mode of operation, the NPHS basin provides makeup to the AHS basin. During other modes of power operation, PSWS flow is directed to the AHS cooling tower where heat removed from the RCCWS and TCCWS is rejected to the AHS. The PSWS basin makeup supply motor-operated block valves have the ability to manually open and close from the MCR. The opening and closing of the valves is controlled by basin level transmitters. As described in response to b.3 above, controls associated with PSWS basin level transmitters and PSWS / CIRC flow transmitters would maintain required PSWS cooling tower basin level while systems are operated cross connected. During these modes of operation, makeup to the NPHS or AHS basin is provided from the Station Water System (SWS). Makeup to the NPHS basin or AHS basin would be site specific with allowances for blowdown, drift and evaporation losses. In addition, makeup water would be required to replace water used for strainer backwashes. As noted in DCD Tier 2 Table 9.2-2 and described in DCD Tier 1 Section 4.1, the PSWS provides the RTNSS functions to support the post-72 hour cooling for RCCWS. The PSWS system must have the volume of water necessary to accommodate losses due to evaporation, drift, etc., without make-up for seven days using the most limiting condition of operation as defined by the PRA model. Under these conditions, the NPHS will be isolated from the PSWS cooling towers (AHS) and PSWS will be operated for 7 days without makeup. GEH considers sufficient information is provided in this response. No DCD

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	updates will be included for this issue.
b.10 Review the supplied documents and drawings for clarification of the water basin. The system drawing for the PSWS shows a single shared service water basin whereas DCD Tier 2 Table 9.2-2 indicates that there are two separate service water basins and clarification is needed. If a single shared basin is used review the justification for not providing redundancy. If separate service water basins are used, review how water levels are maintained when operating in a cross-connected configuration. Determine what needs to be included in the DCD.	As explained in GEH's response to RAI 9.2-23 (MFN LTR 08-342 dated April 11, 2008), the heat removal facility and basin design are considered conceptual design information. With this understanding, DCD Table 9.2-2 indicates two cooling towers and basins as does the proprietary P&ID submitted in MFN-05-164 dated Dec. 15, 2005. Figure 9.2-1, simplified layout drawing, depicts only one basin for the two mechanical-draft cooling towers. For consistency, DCD Tier 2, Figure 9.2-1 will be updated in revision 6 to reflect separate service water basins. Since the PSWS tower basins are passive components not subject to single failure, they could be operated cross-connected as a common basin or operated separated with the PSWS basin makeup supply motor-operated block valves controlled by the individual basin level transmitters. GEH considers sufficient information is provided in this response to resolve this issue. DCD updates will be included for this issue.
b.11 Review the supplied documents and drawings for valves with hard seats. The PSWS description indicates that valves will be provided with hard seats to withstand erosion where needed. Review the bases of this valves and when valves with hard seats need to	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). Hard seats for valves are generally used when deemed necessary due to the system site-specific water quality conditions, such as temperature and dissolved oxygen, which can cause increased wear from erosion and corrosion. The NRC

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
be used. This maybe an information item for COL applicants to identify where such valves will be installed to satisfy the specified criteria. Determine what needs to be included in the DCD.	requested information on measures for precluding long-term corrosion and organic fouling that would degrade PSWS performance. GEH responded to RAI 9.2-9 (MFN LTR 06-417dated Dec. 1, 2006). ESBWR DCD Tier 2, Subsection 9.2.1.6 COL Information, requires the COL Applicant to determine material selection and provide provisions to preclude long-term corrosion and fouling of the PSWS based on site water quality analysis. This requirement will ensure appropriate valve seat material will be specified based on site specific PSWS water chemistry. For the PSWS within the scope of the certified design, the valves and valve material will be part of detailed design with procurement requirements specified by GEH. For the cooling towers and basins, COL Information Item COL 9.2.1-1-A addresses material selection to preclude long-term corrosion and fouling of the PSWS equipment based on site water quality analysis. DCD Tier 2 subsection 9.2.1, Detailed System Description, and COL Item 9.2.1-1-A will be revised under revision 6 to specify PSWS valve hard seat material when required based on site water quality analysis (COL 9.2.1-1-A). GEH considers sufficient information is provided in this response to resolve this issue. DCD updates will be included for this issue.
b.12 Review the supplied documents and drawings for related to the detection of gross leakage and related instruments. Determine what needs to be included	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). PSWS gross leakage was addressed in GEH's responses to RAIs 9.2-7 (MFN LTR 07-039 dated Mar. 30, 2007). As described in ESBWR DCD Tier 2, Subsection 9.2.1.5, flow elements and transmitters (shown on the proprietary P&ID) provide monitoring of system flow in the Main Control Room

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
in the DCD.	and can be used to assist in leak detection. GEH considers a detailed description of how PSWS detects gross leakage detailed design information that is beyond that necessary for the NRC to make its safety finding. In addition, instrumentation specifications are finalized through the Design Acceptance Criteria ITAAC process. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
b.13 Review the supplied documents and drawings for how the PSWS pumps are protected from large debris that can end up in the service water basin either from makeup water sources or due to basin or cooling tower degradation, and how clogging due to silt accumulation is prevented from occurring (see Information Notice 2006-17, Recent Operating Experience of Service Water Systems Due to External Conditions," dated July 31, 2006). Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). DCD tier 2 section 18.3, Operational Experience Review, describes the process for review, capture and incorporation of operating experience. As described in response b.1 above, Information Notice 2006-17, Recent Operating Experience of Service Water Systems Due to External Conditions, has been reviewed and the following design and operational details are applied to the ESBWR PSWS to avoid similar problems. The heat rejection facilities (cooling towers and basins) and tower makeup systems are site-specific. The conceptual design information in the DCD will be replaced with site-specific design information by the licensee of a plant. The COL applicant site specific design information and operational programs will address design details regarding strainers and the monitoring of cooling tower degradation and silt accumulation. As described in DCD, Tier 2, Subsection 9.2.10.2, the Plant Cooling Water Makeup System includes strainers, which will prevent large debris from being

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	introduced to the basins. The Pretreated Water Supply System, which can be used as an alternate to the Plant Cooling Water Makeup System, also includes strainers. As described in the Plant Service Water System Design Specification, the PSWS basin is provided with provisions to protect the pumps from clogging or damage due to debris and will be equipped with a trash rack and screens in order to prevent damage to the PSWS pumps due to ingestion of large debris. Provisions are also provided for dewatering of the PSWS basin to prevent the accumulation of silt and sediment in the basin. As shown on the reference plant PSWS pump specification sheet, a basket type suction strainer could be specified to prevent ingestion of large debris into the PSWS pump. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
b.14 Review the supplied documents and drawings for nominal screen mesh size for the service water strainers need to be specified and explained. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). As described in ESBWR DCD Tier 2, Subsection 9.2.1.2, self-cleaning service water strainers are located in the discharge lines of each of the plant service water pumps. The strainer mesh size is considered detailed design and will be dictated by the design of the plate-type heat exchangers dependent on site water quality. Plate heat exchangers require the use of a relatively fine strainer (< 0.08 in.) because of their narrow passages. The required strainer size is determined using generic plate heat exchanger sizing guidelines and site specific parameters. For service water containing particles

Table 2 – RAI 9.2-24 Audit Items and GEH Response

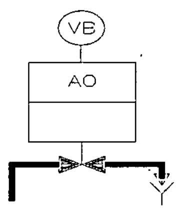
RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	larger than 50% of the nominal plate gap, strainers will be provided. The specific strainer mesh size will be specified in procurement specifications. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
b 15 Review the supplied documents and drawings for vacuum breakers at high points. Although the description indicates that vacuum breakers will be installed at high points in system piping, none are shown on the system drawings. An information item may need to be established for COL applicants to include vacuum breakers in the plant-specific heat rejection facility piping. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). Automatic check type air release/vacuum valves are shown on the detailed P&IDs and DCD Figure 9.2-1 designated as illustrated below.  Automatic check type air release/vacuum valves will be installed in the pump discharges and/or system high points as required. A detailed hydrodynamic analysis is required to determine the size, location and number of vacuum breaker valves based on the site specific configuration (i.e. PSWS cooling tower elevation). Once this analysis is performed (as part of the piping Design Acceptance Criteria), vacuum breakers, if deemed necessary for the heat rejection facility systems, will be specified. The heat removal facility is conceptual design information in the DCD that will be replaced by the licensee of the plant.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	DCD Tier 2 Figure 9.2-1 will be revised in Rev 6 to replace the automatic check type air release/vacuum valve symbol with a VB in accordance with the ESBWR P&ID Specification SR3-A10-PID-1002, and DCD Tier 2, Figure 1.7-1. GEH considers sufficient information is provided in this response to resolve this issue. DCD updates will be included for this issue.
b.16 Review the supplied documents and drawings for DCD consistence between sections related to instruments. DCD Tier 2 Section 9.2.1.5, "Instrumentation Requirements," indicates that with one PSWS pump operating, the respective standby pump starts automatically upon detection of a low system pressure signal in that train, loss of electric power to the operating pump, or an operating pump trip signal. This section also indicates that starting a PSWS pump automatically opens a flow path through the RCCWS and TCCWS heat exchangers. However, no description is provided under the operation discussion in Section	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). ESBWR DCD Tier 2, Subsections 9.2.1.2 and 9.2.1.5 address instrumentation and control design performance requirements for the PSWS. Including the same description of PSWS operation would be redundant. PSWS pump operation is described in the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). PSWS pumps are manually started and stopped from the MCR. The pump start is permitted when the PSWS basin level is not low. Normally, one PSWS pump is in operation in each train and the other is in standby. The pump trips if the pump discharge valve fails to open or upon low pump discharge pressure. The standby pump automatically starts when the running pump trips in the same train. In the event of a LOPP, the pumps are sequenced to automatically start. The RCCW System Design Specification (SR3-1-P21-SDS-6399) describes interlock logic between PSWS flow signal and RCCW heat exchanger isolation valves. The RCCW heat exchangers not in use have the cooling water supply

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
9.2.1.2, "System Description," about these operating features, and there is no discussion about operation of the self-cleaning strainers. Determine what needs to be included in the DCD.	(PSWS) isolated to reduce wear on the unused heat exchanger, and reduce the required PSWS water flow rate during normal operation. The RCCWS heat exchanger motor-operated block valves operate in coordination with the PSWS to ensure that there is PSWS water flowing on the other side of the heat exchanger to absorb the heat load. This condition is overridden during the initial system startup or under LOPP conditions when RCCWS is sequenced to start before PSWS in the DG loading sequence. Flow on the PSWS side of an RCCWS heat exchanger is required to open that heat exchanger's motor-operated block valve. The block valves are controlled by the MCR N-DCIS. The block valve fails as-is. Subsection 9.2.1.5 describes the operation of the motor operated self-cleaning strainers. The pump discharge self-cleaning strainers have remote manual override features for their automatic cleaning cycle. The pressure drop across the strainer is indicated in the MCR and a high-pressure drop is annunciated in the control room. During a LOPP, PSWS components including the strainers and strainer blowdown valves will be powered from the two nonsafety-related on-site standby diesel generators. This ensures PSWS pumps are available in case of a loss of power to one electrical train while maintaining frequent backwashing to ensure minimal differential pressure across the strainers. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
b.17 Review the supplied documents and drawings related to cooldown alignments. DCD Tier 2 Table 9.2-1	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401) and the RCCWS System Design Specification (SR3-1-P21-SDS-

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
needs to indicate which alignment is for a 24 hour cooldown and which is for a 36 hour cooldown to cold shutdown conditions. Determine what needs to be included in the DCD.	6399). As stated in Subsection 9.2.1.2, in the event of a LOPP, the PSWS supports the RCCWS function to bring the plant to cold shutdown in 36 hours, assuming the most limiting single active failure or a passive component failure. Table 9.2-1 provides the heat load for LOPP operation for both two PSWS pumps and three PSWS pumps. As described in the RCCWS System Design Specification (SR3-P21-SDS-6399), RCCWS, in conjunction with the RWCU/SDC and ICS, is designed to remove sufficient heat from the reactor to enable cooling the reactor from 100% rated power to the cold shutdown conditions of 93.3℃ (200℉) in 36 hours, assuming the most restrictive single active failure (only one train of pumps and heat exchangers available) and LOPP. This is done while simultaneously preventing fuel pool boiling through the FAPCS. The PSWS configuration supporting this mode of operation is listed in Table 9.2-1 LOPP Operation Single Train Failure. DCD Tier 2 Table 9.2-1 will be revised in Rev 6 to add a note to table designating the 36 hour cooldown condition. As described in the RCCW System Design Specification (SR3-P21-SDS-6399), the RCCWS, in conjunction with the RWCU/SDC and FAPCS have sufficient capacity to meet the requirements for normal shutdown cooling such that the reactor coolant temperature is reduced to 60℃ (140℉) in 24 hours. DCD Tier 2 Table 9.2-1 will be revised in Rev 6 to add a note to the table designating the 24-hour cooldown condition.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	GEH considers sufficient information is provided in this response to resolve this issue. DCD updates will be included for this issue.
c. Review the supplied documents and drawings for plant service water system (PSWS) design related to the minimum net positive suction head (NPSH) for the PSWS pumps (needs to be satisfied for all postulated conditions, including vortex formation considerations.) The system description indicates that the PSWS pumps have sufficient available NPSH under worst case conditions, and that the water levels in the service water basins are monitored to ensure sufficient NPSH. However, the specific NPSH requirements for the PSWS pumps; the minimum required service water basin water level that is necessary to satisfy NPSH requirements and the basis for this determination and limiting assumptions that were used (e.g., water level, maximum temperature, maximum flow rate, number of pumps operating, vortex effects); how this	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401. GEH response to RAI 9.2-23S01 (MFN LTR 08-473 dated May 16, 2008) added a description defining the interface between standard plant design for the ESBWR and conceptual design to be addressed by COL applicants and included consideration of NPSH requirements under worst case conditions. DCD Tier 2, subsection 14.2.8.1.51, Plant Service Water System Preoperational Test, performs a series of individual component and integrated system tests to demonstrate acceptable pump suction under the most limiting design flow conditions. For the PSWS, DCD Tier 1,section 4.1 includes the interface item for the conceptual design feature of the PSWS and the functional capability of the PSWS cooling towers and basins. DCD Tier 1 Interface Section 4.1, Plant Service Water System, will be updated in revision 6 to reflect the minimum heat sink volume must also consider pump NPSH requirements. The Plant Service Water System (PSWS) is the heat sink for the Reactor Component Cooling Water System (RCCWS). PSWS does not perform any safety-related function. There is no interface with any safety-related component. The PSWS provides the non-safety related functions to support the post-72 hour cooling for RCCWS. The PSWS system must have the volume of water necessary to accommodate losses due to evaporation, drift, etc. without make-

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
minimum required water level compares to the minimum water level that is maintained in the service water basins to satisfy excess margin and inventory considerations. Review GEH response to RAI 9.2-23. Determine how the combined license (COL) applicants will know to periodically confirm that adequate levels exist. Determine what needs to be included in the DCD.	up for seven days using the most limiting condition of operation as defined by the PRA model. The volume maintained must also ensure that the PSWS pumps have sufficient available net positive suction head at the pump suction location for the lowest probable water level of the heat sink. The most limiting condition equates to 2.02×10^{7} MJ (1.92×10^{10} BTU) over a period of 7 days. GEH considers sufficient information is provided in this response to resolve this issue. DCD updates will be included for this issue.
d. Review the supplied documents and drawings related to waterhammer. The plant service water system (PSWS) description indicates that the potential for waterhammer is mitigated through the use of various system design and layout features, such as automatic air release/vacuum valves installed at high points in system piping and at the pump discharge, proper valve actuation times to	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401) and Plant Service Water PRA Model (NEDO 33201 Rev 3) with respect to design and layout features to mitigate the potential for water hammer. The ESBWR Project Design Manual (NEDE 33271) section 5.3.1.6 provides provisions to prevent water hammer by preventing voiding in liquid lines, control valve instability and excessive valve actuation time. As discussed in response to b15 above, a detailed hydrodynamic analysis will be performed to determine the size, location and number of vacuum breaker valves required to prevent voiding. Operational and maintenance procedures

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
minimize water hammer, procedural requirements ensuring proper line filling prior to system operation and after maintenance operations, and the use of a check valve at each pump discharge to prevent backflow into the pump Determine what needs to be included in the DCD.	will be employed to prevent water hammer caused by improper filling of voided lines. Control valve instability will be prevented through specifying valve design parameters such as actuator type, flow coefficient and trim to be compatible with final designed operating conditions. For piping systems that rise more than 9.75m (32 ft), column separation is prevented by taking care to insure the pressure in any portion of the system will not be below the vapor pressure of the fluid. The valve and its control system will be designed to minimize the potential for oscillation instability by including features such as balanced trim design for all pressure drop and flow configurations, stiff actuators, moderate rate of operator response, long valve strokes, and minimal pressure drop. Proper operation of system valves, including timing, under expected operating conditions will be verified during preoperational startup testing described in DCD section 14.2.8.1.51. The detailed hydrodynamic analysis for the PSWS will ensure all valves will be designed and controlled so the opening and closing time is sufficiently long to prevent unacceptably high pressure waves. Where water hammer could be caused by a stuck-open check valve slamming shut or by an abnormal valve actuation resulting from actuator failure, the valves will be designed to allow thorough and proper inspection, testing and maintenance. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
d.1 Review the supplied documents and drawings for the amount of back leakage through the pump check valves that is considered to be	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401) and Plant Service Water PRA Model (NEDO 33201 Rev 3) with respect to design operation and layout features associated with the PSW pump

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
excessive. Review how excessive check valve back leakage or system voiding will be prevented from occurring over time. Determine what needs to be included in the DCD.	discharge check valves to prevent excessive backleakage and prevent line voiding. Preoperational startup testing described in DCD section 14.2.8.1.51 will verify proper operation of system valves, including timing, under expected operating conditions. Maintenance, testing, and operating procedures will include provisions for regular inspection testing and maintenance of valves to prevent leakage that can cause void formation during periods of standby. PSWS pump and integrated flow tests will ensure discharge check valve leakage will not impact pump or system flow performance requirements. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
d. 2 Review the supplied documents and drawings for how proper operation of the automatic air release/vacuum valves will be assured over time. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). DCD section 14.2.8.1.51 will be updated under revision 6 to include preoperational testing and / or inspection of air release valves to ensure proper operation under expected operating conditions. In response to RAI 9.2-11 S04, GEH revised ESBWR DCD Tier 2, Subsection 13.5.2, to ensure procedures developed for RTNSS systems will address water hammer. The initial test program described in Subsection 14.2 for the PSWS describes that testing includes proper operation of the system under expected operating conditions. In addition, testing, inspection, or quality assurance programs will verify design features intended to prevent or mitigate water hammer such a as proper operation of automatic air release/vacuum valves.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
	GEH considers sufficient information is provided in this response to resolve this issue. DCD updates will be included for this issue.
d. 3 Review the supplied documents and drawings for valve actuation/stroke times. Review that the valve actuation/stroke times are considered to be appropriate (especially with respect to the air-operated valves) and how these times will be maintained as the plant ages needs to be described. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary PSWS P&IDs updated for the PSWS Value Added Board. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401). As described in response to d.1 above, preoperational startup testing (DCD section 14.2.8.1.51) will verify proper operation of system valves, including timing, under expected operating conditions. Maintenance, testing, and operating procedures will include provisions for regular inspection testing and maintenance of valves to prevent degradation over time. As described in DCD Appendix 19A.8, all RTNSS systems are in the scope of the Design Reliability Assurance Program, as directed by DCD Tier 2 Chapter 17, which will be incorporated into the Maintenance Rule Program. Performance monitoring of RTNSS components is required by the Maintenance Rule. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
d. 4 Review the supplied documents and drawings for features related to water hammer. Review that the initial test program will demonstrate that automatic actuation of a standby loop or actuation of both loops following a loss of power will not result in a significant water hammer event with	The NRC reviewed the current Phase 1 P&IDs and proprietary PSWS P&IDs updated for PSWS VAB. In addition, the NRC reviewed the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401) for design details associated with mitigation of water hammer. As described in response to b.15 and d above, a detailed hydrodynamic analysis will determine the size, location and number of vacuum breaker valves based on the site specific configuration (i.e. PSWS cooling tower elevation) necessary to mitigate water hammer. In response to RAI 9.2-11 S04, GEH

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, PSWS	GEH Response to Audit Findings/Comments, PSWS
the PSWS return aligned to either the natural draft or mechanical draft cooling towers. Determine what needs to be included in the DCD.	revised ESBWR DCD Tier 2, subsection 13.5.2, to ensure procedures developed for RTNSS systems will address water hammer. The initial test program described in Subsection 14.2 for the PSWS describes that testing includes proper operation of the system under expected operating conditions. In addition, testing, inspection, or quality assurance programs will verify design features intended to prevent or mitigate water hammer. The initial test program for the PSWS described in DCD Tier 2 subsection 14.2.8.1.51 demonstrates proper operation of system valves, including timing, under expected operating conditions; and proper operation of pumps and motors in all design operating modes. As described in the Plant Service Water System Design Specification (SR3-1-P41-SDS-6401), testing is performed to simulate all normal modes of operation, to the greatest extent practical. Transfer between normal and standby power source are part of these periodic tests. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

<table>
<tr><th>RAI 9.2-24 NRC Audit Items, RCCWS</th><th>GEH Response to Audit Findings/Comments, RCCWS</th></tr>
<tr><td>a. HIGH LEVEL GOAL:

The staff/reviewer should determine if the system is considered highly reliable and no single active failure should result in the inability to terminate use of passive safety-grade system and achieve cold shutdown.</td><td>The staff identified design information needed to be included in the DCD in order to reach reasonable assurance that the Reactor Component Cooling Water System (RCCWS) will perform its intended non-safety function related to RTNSS; as well as cool-down function and performance. The following ESBWR design input documents, associated with RCCWS, were reviewed as part of this audit.
<table>
<tr><th>Document Type/Title</th><th>Document Number</th><th>Revision</th></tr>
<tr><td>Composite Design Specification</td><td>26A6007</td><td>2</td></tr>
<tr><td>Project Design Manual</td><td>NEDO-33271P</td><td>2</td></tr>
<tr><td>System Design Specification</td><td>SR3-1-P21-SDS-6399</td><td>3</td></tr>
<tr><td>P&ID</td><td>SR3-1-P21-PID-1000</td><td>0</td></tr>
<tr><td>Calculation: Design Parameters</td><td>SR3-1-P21-CAD-0001</td><td>0</td></tr>
<tr><td>Calculation: Pipeline Sizing</td><td>SR3-1-P21-CAD-0002</td><td>0</td></tr>
<tr><td>Calculation: Pressure Drop</td><td>SR3-1-P21-CAD-0003</td><td>0</td></tr>
<tr><td>Calculation: Heating/Cooling Load and Flow</td><td>SR3-1-P21-CAD-0004</td><td>0</td></tr>
<tr><td>Calculation: Equipment Sizing</td><td>SR3-1-P21-CAD-0005</td><td>0</td></tr>
<tr><td>PRA Model</td><td>NEDO-33201</td><td>3</td></tr>
<tr><td>P21 PRA System Notebook</td><td>NEDO-33201 Section 4.10, P21</td><td>0</td></tr>
</table></td></tr>
<tr><td>b.1
Determine the most limiting conditions upon which the RCCWS design is based need to be described (e.g.,</td><td>The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and</td></tr>
</table>

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
shutdown/cooldown with maximum core decay heat and maximum allowed spent fuel pool heat load, capability to perform plant cooldown within specified criteria, single failure and loss of power considerations. Determine the amount of excess margins that are included in the design to account for uncertainties, component wear and aging effects, fouling of heat transfer surfaces and spray nozzles, strainer debris collection, etc., need to be described and why the specified margins are considered to be adequate need to be explained. Determine the specific values or ranges of values chosen as the bounding conditions for the design need to be specified and explained (e.g., limiting temperatures) both the specified design and minimum required capability of heat exchangers, cooling towers, and pumps based on excess margin considerations.	RCCWS Equipment Sizing Calculation SR3-1-P21-CAD-0004. As described in question b.1 for PSWS above, Loss of Preferred Power Cooldown with Single Train Failure is the most limiting system heat removal design condition for the RCCWS. This transient mode occurs when a LOPP and a single train failure occur concurrently. Similar to the single train failure transient, only one train is in operation and all heat loads are dissipated using the RCCW heat exchangers (3) and RCCW pumps (3) on the active RCCW train. This mode of operation provides sufficient cooling capacity in order to bring the plant to cold shutdown condition within 36 hours. The RCCW heat loads considered under this event include the following: RWCU/SDC (G31) 36 MW FAPCS (G21) 9.6 MW NICWS (P25) 12.3 MW Standby Diesel Generator (R21) 15 MW Other 1.9 MW The RWCU/SDC design non-regenerative heat exchanger heat load of 36 MW for one train assumes a maximum RCCWS discharge temperature of 130 °F in the limiting shutdown cooling analysis. Spent fuel storage capacity evaluated for 20 years results in the bounding heat load of 9.6 MW. The most limiting condition for RCCWS heat exchanger design is a Single Train Failure Cooldown without a LOPP; which has a design heat load of 59.8 MW divided between two heat exchangers. With rounding up to nearest 5

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
Note that combined license (COL) information items and interface requirements should be established as appropriate. Determine what needs to be included in the DCD.	GJ/hr, the RCCWS heat exchangers are designed for 30.6 MW. The Single Train Failure Cooldown with a LOPP has a design heat load of 74.8 MW, but is divided between three heat exchangers, resulting in a heat load of approximately 25 MW per heat exchanger. Therefore the limiting condition for design of the P21 heat exchangers is a Single Train Failure Cooldown without a LOPP. Significant margins and conservative assumptions are applied to the heat loads for the RCCWS. • A heat load value equal to 10% of the "Normal Power" heat load from RWCU/SDC (G31) and FAPCS (G21) is used for each train of G31 and G21 equipment that is active to account for the miscellaneous RWCU/SDC (G31) and FAPCS (G21) equipment cooler heat loads not yet defined. • The CWS bounding heat load assumed for PSWS / RCCWS sizing calculations is 12. 3 MW. • The Standby Diesel Generator heat load is conservatively figured by assuming a 15 MW diesel generator has a heat load of 15 MW. This assumption was made to ensure that any additional heat load imposed by the diesel generators would not impact the sizing of the RCCWS heat exchangers. • The RCCWS / PSWS is designed for 1% exceedance values. One

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	percent annual exceedance values were selected in order to bound the values presented in the URD and available Early Site Permit applications. The ESBWR 1% exceedance wet-bulb temperature provides a 2ºF margin to the URD exceedance value. • Margin is considered with respect to RCCW pressure drop calculations. To account for pipe fittings and unknown routing, the pressure drop of the estimated lengths for each piping section is doubled. This doubled pressure drop will then have a 20% margin added on to account for pipe aging. The piping losses including the 20% aging factor will then be added to the inline equipment losses for each segment. The segments will be combined as appropriate, and a separate 15% margin will be added to the combined pressure drops. This 15% margin accounts for the pump head margin on piping losses and equipment pressure drops that may increase during design or with increased fouling. This 15% value exceeds the 7% minimum specified URD recommendations. In addition to the margins added to the calculated pressure drops, the control valves will be modeled with pressure drops of 7 kPa (1 psi) instead of a fully open valve. This is to account for valve trim characteristics that might be present. • Fouling Factor -SWS Side 10% excess surface area to account for fouling/CCWS side 10% excess surface area to account for fouling • The surge tank volume due to leakage will be increased by a minimum of 25% to account for unknown routing variances. The overall surge tank

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	volume will be rounded up to a nominal value. Significant margins are applied to the RCCWS during the design process to account for uncertainties, component wear and aging effects, fouling of heat transfer surfaces and spray nozzles, and strainer debris collection. The design basis documents reviewed by the NRC consider the following margins and conservative assumptions in the design of the system: • A corrosion margin is applied to RCCW piping to account for aging and degradation. RCCWS water is treated with corrosion inhibitors to minimize the corrosion of the RCCWS piping. For carbon steel piping, the minimum corrosion allowance will be 1.54 mm (0.060 in.); which is conservative based on engineering design requirements on the ABWR project which used a corrosion allowance of 0.76 mm (0.030 in.) for a plant with a 60 year life. RCCWS surge tank makeup water lines are stainless steel and contain demineralized water supplied by the MWS. The minimum corrosion allowance for these stainless steel lines will be 0.26 mm (0.010 in.); which is conservative based on engineering design requirements on the ABWR project which used a corrosion allowance of 0.13 mm (0.005 in.) for a plant with a 60 year life. • The RCCWS design temperatures and pressures are determined from the operating conditions with a margin of 5.6°C (10°F) added to the operating temperature (rounded up to the next 5°C increment) to determine the design temperature. A margin of 172.4 kPag (25 psig) is added to the operating pressure (rounded to the next 100 kPag

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	increment) to determine the design pressure. • The test pressure for system piping is defined by multiplying the design pressure by a factor of 1.5. • The design flow rate at a rated head is specified to ensure that the pump will not operate below 85% or above 125% of its best efficiency point. Pump mechanical efficiency is assumed to be greater than or equal to 85%. Pump motor efficiency is conservatively assumed to be greater than or equal to 90%. • Design flow determination incorporates flow margin; however, for conservatism the FAPCS IC/PCCS heat exchanger flow is increased to 15 m^3/hr (66 gpm) for pipe size determination based on conservative maximum flow combinations. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
b.2 Review the supplied documents and drawings for nominal pipe sizes and flow rates through individual coolers. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and RCCWS Equipment Sizing Calculation SR3-1-P21-CAD-0004. The NRC reviewed the nominal pipe sizes and flow rates provided and found the resulting fluid parameters to be acceptable.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

<table>
<tr><th>RAI 9.2-24 NRC Audit Items, RCCWS</th><th>GEH Response to Audit Findings/Comments, RCCWS</th></tr>
<tr><td></td><td>The ESBWR Project Design Manual (NEDE 33271) provides requirements for maximum fluid velocity applied to the RCCWS piping under this calculation. The maximum recommended water velocity for piping containing general component cooling water pump suction and discharge is shown in the table below.

<table>
<tr><th></th><th>50 mm (2 in.)</th><th>200 mm (8 in.)</th><th>350 mm (14 in.)</th><th>500 mm (20 in.)</th><th>>600 mm (24 in.)</th></tr>
<tr><td>Pump Suction</td><td>2 fps</td><td>5 fps</td><td>6 fps</td><td>8 fps</td><td>10 fps</td></tr>
<tr><td>Pump Discharge</td><td>5 fps</td><td>10 fps</td><td>12 fps</td><td>15 fps</td><td>15 fps</td></tr>
</table>

The RCCWS pipe sizes were calculated to ensure that the system flow velocities are enveloped by the velocity limits provided above. In addition, pipe size / fluid velocity was based on ensuring the RCCWS can be filled in less than 6 hours using the makeup water fill connection. The RCCWS Surge tank makeup pipe sizing ensures the system is capable of maintaining the surge tank level with a relief valve stuck open.

As described in RCCWS Equipment Sizing Calculation SR3-1-P21-CAD-0004, the FAPCS Fuel Pool heat exchangers have two possible flow rates that need to be accounted for. To support the PRA event, FAPCS would provide cooling by keeping the suppression pool from boiling. In this scenario, the cooling water supply to the FAPCS Fuel Pool heat exchangers needs to be increased to 1075 m3/hr, and it is assumed that both FAPCS trains are available since</td></tr>
</table>

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	the failure was on the RWCU/SDC system. The failure of the RWCU/SDC allows for the 1350 m3/hr to be divided between the two FAPCS Fuel Pool heat exchangers. This is a conservative value for line sizing because it is possible that the 800 m3/hr that is being bypassed around the standby NICWS chillers (400 m 3/hr per chiller) could be used instead of the RWCU/SDC dedicated flow. However, it is also possible that all four NICWS chillers are in use to facilitate Drywell cooling. Therefore, the FAPCS Fuel Pool heat exchanger pipeline will be sized based on the sum of the normal FAPCS Fuel Pool heat exchanger flow plus half of the RWCU/SDC flow. Regarding the FAPCS PRA sizing, either using the bypassed NICWS chiller flow or the RWCU/SDC flow would be feasible with the single speed pumps sized for 1350 m 3/hr. However, given that this is a highly unlikely event, the piping velocity will be allowed to exceed the recommended velocity. The allowable exceedance will be based on engineering judgment. The NI Supply/Return Header for FAPCS Equipment sizing calculation showed that a 250 mm (10 in.) Schedule STD pipe would be adequate for normal operation conditions, however, to accommodate the PRA Event, which only requires flow to the FAPCS Fuel Pool heat exchangers, the 300 mm (12 in.) Schedule STD pipe calculated earlier for G21 FAPCS Hx (PRA Scenario) will be used for the header. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
b.3	The NRC reviewed the current Phase 1 Design P&IDs and proprietary

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
Review the supplied documents for train designations for cross-connect valves. Determine what needs to be included in the DCD.	RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and Reactor Component Cooling Water PRA Model (NEDO 33201 Rev 3). The RCCWS includes the following train cross-connect valves as described in the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399): • RCCWS Train A and B cross-tie air operated valves are normally open fail closed upon loss of power. These valves manually open and close from the MCR. In a train separation event, the valves automatically close. There shall be two automatic train separation signals used to close the cross-tie valves: 1) detection of unbalanced flow; and, 2) a LOPP event. Manually initiated train separations also close the cross-tie valves. • The RCCWS equipment load and equipment bypass line motor-operated block valves are manually and automatically controlled by the MCR N-DCIS. The equipment load and equipment bypass line motor-operated block valves are manually controlled for all modes and automatically close in the event a train shutdown signal is received. In the event of a train separation signal, the equipment bypass line motor-operated valves will automatically open if the equipment load motor-operated block valves are closed. The valves fail as-is. • Cross-ties between all pumps, heat exchangers, and building train cooling water distribution piping. These cross-ties allow for increased

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	flexibility during all operational modes, and minimize actions required (both manual and automatic) in the event of a RCCWS pump trip or pipe failure. RCCWS cross-tie valves are normally open. If the cross-tie valves need to be closed, the CWPS, RWCU/SDC, FAPCS, heat exchangers that are not required to be in operation shall be bypassed. The separation of trains shall be considered an abnormal operating condition. Opening the bypass line valves for CWS, FAPCS, and RWCU/SDC shall be required to keep the RCCWS pumps within their operating ranges. RCCWS cooling water train supply valves are shown as motor operated valves in DCD Figure 9.2-2.a and are automatically and manually opened and closed by the MCR N-DCIS. The valves are normally open and automatically close upon a LOPP and open after the diesel generators are running as part of the load sequencing. The valves fail as-is. The RCCWS Diesel Generator cooling water return valves are air-operated block valves (AOV) and are automatically and manually opened and closed by the MCR N-DCIS. The valves will normally be closed and automatically open upon a LOPP. The valves fail open (FO). The RCCWS cooling water flow rate through the RWCU/SDC heat exchangers is regulated with bypass and discharge air-operated flow control valves. These valves are controlled using RWCU/SDC discharge temperature process data, not RCCWS. Control of these valves by RWCU/SDC prevents overcooling of the reactor coolant. The bypass and discharge valves can also

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	be controlled manually from the MCR N-DCIS. The bypass valve fails closed (FC) and the discharge valve fails open (FO). The RCCWS equipment load and equipment bypass line motor-operated block valves are manually and automatically controlled by the MCR N-DCIS. The equipment load and equipment bypass line motor-operated block valves are manually controlled for all modes and automatically close in the event a train shutdown signal is received. In the event of a train separation signal the equipment bypass line motor operated valves will automatically open if the equipment load motor-operated block valves are closed. The valves fail as-is. The RCCWS surge tank level is controlled by air-operated block valves. The valves automatically open and close and can be manually controlled by the MCR N-DCIS. The block valves are opened when the RCCWS surge tank level drops to a predetermined low level. The block valves close when the RCCWS surge tank level rises to a predetermined high level. Extended makeup water supply requirements indicate that there is a leak in the RCCWS, and the cooling water trains should be separated, and the damaged train repaired. The separation of trains due to extended makeup water supply requirements is a manually initiated event. The RCCWS surge tank makeup water inlet block valves fail closed. GEH considers sufficient information is provided in this response based on the RCCWS PRA to resolve this issue. No DCD updates will be included for this issue.
b.4	The NRC reviewed the current Phase 1 Design P&IDs and proprietary

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
Review the supplied documents and drawings for header temperature and pressure detectors. Determine what needs to be included in the DCD.	RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and Reactor Component Cooling Water PRA Model (NEDO 33201, Rev. 3).for header temperature and pressure detectors and found the RCCWS instrumentation layout to be acceptable. GEH considers sufficient information was provided during the audit to resolve this issue. No DCD updates will be included for this issue.
b.5 Review the supplied documents and drawings for pump minimum flow recirculation lines. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and Reactor Component Cooling Water PRA Model (NEDO 33201 Rev 3). RCCWS pump minimum flow recirculation lines are not required because the system design and operation will ensure that the required minimum pump flow will be maintained under all conditions. The design flow rate at the RCCWS pump rated head is specified to ensure that the pump will not operate below 85% or above 125% of its best efficiency point. When the RCCWS train cross-tie valves are open, any four pumps and heat exchangers can be used. When the RCCWS train cross-tie valves are closed, two pumps and heat exchangers must be used on each train with any two of the three pumps and heat exchangers on the train. Upon a train separation signal, opening the bypass line valves for CWS, FAPCS, and RWCU/SDC is required to keep the RCCWS pumps within their operating ranges. If the bypass line for the RWCU/SDC heat exchanger fails, then the

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	isolation valves for that heat exchanger will automatically open to maintain an adequate flow path. Each flow path to all interface system heat exchangers is designed to have flow balancing features that may include fixed plate orifices and/or control, or manual, valves. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.
b. 6 Review the supplied documents and drawings for related to the air system interface for the air-operated valves. Review for how train separation is maintained and reliability of this air system arrangement. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and Reactor Component Cooling Water PRA Model (NEDO 33201 Rev 3). Air operated valves are located at the discharge of the RCCW heat exchangers, RCCW heat exchanger bypass line and RCCWS cross-tie line (suction and discharge), RCCW surge tank level control, SDG cooling water return, RCCW RWCU/SDC heat exchanger bypass and discharge flow control valves. The following valve descriptions are provided in the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399). The RCCWS heat exchanger flow control air-operated valves are normally open, fail open valves. RCCW heat exchanger bypass valves are fail closed upon loss of control signal or loss of power to the control signal. The RCCWS air-operated heat exchanger bypass and flow control valves work in coordination to regulate the

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	RCCWS supply temperature. The position of these valves is regulated by the redundant discharge temperature elements. The valves are programmed such that when one valve opens, the other valve will close. The RCCWS cross-tie valves are air-operated block valves, automatically and manually opened and closed by the MCR N-DCIS. The valves are normally open and automatically close upon a train separation event and fail close. There are two automatic train separation signals used to close the cross-tie valves, detection of unbalanced flow and a LOPP event. Manually initiated train separations also close the cross-tie valves. The RCCWS surge tank level is controlled by air-operated block valves. The valves are automatically opened and closed and can be manually controlled by the MCR N-DCIS. The block valve is opened when the RCCWS surge tank level drops to a predetermined low level. The block valve closes when the RCCWS surge tank level rises to a predetermined high level. Extended makeup water supply requirements indicate that there is a leak in the RCCWS, and the cooling water trains should be separated, and the damaged train repaired. The separation of trains due to extended makeup water supply requirements is a manually initiated event. The RCCWS surge tank makeup water inlet block valves fail close (FC). The RCCWS Diesel Generator cooling water return valves are air-operated block valves (AOV), automatically and manually opened and closed by the MCR N-DCIS. The valves normally are closed and will automatically open upon a LOPP. The valves fail open (FO).

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	The RCCWS cooling water flow rate through the RWCU/SDC heat exchangers is regulated with a bypass and discharge air-operated flow control valve. These valves are controlled using RWCU/SDC discharge temperature process data, not RCCWS. Control of these valves by RWCU/SDC will prevent overcooling of the reactor coolant. The bypass and discharge valves can also be controlled manually from the MCR N-DCIS. The bypass valve will fail close (FC) and the discharge valve will fail open (FO). Train redundancy ensures that single failure of any air-operated valve will not impact the other train. As described in the RCCWS PRA Model (NEDO 33201 Section 4.11 Rev 3), periodic change in train operation is assumed (PRA assumption) such that the relevant train components are checked quarterly. As described in DCD subsection 9.3.6.1, the Instrument Air System is designed to ensure that failure of the IAS does not compromise any safety-related system or component nor does it prevent a safe shutdown. The importance of non-safety related compressed air supplies was evaluated relative to the criteria for special regulatory treatment of non-safety systems in DCD Tier 2 Appendix 19A. Compressed air supplies and valves, including RCCWS valves, were evaluated as described in response to RAI 9.3-32 (MFN LTR 07-259 dated May 8, 2007) and do not meet the criteria for special regulatory treatment. GEH considers sufficient information is provided in this response to resolve this issue. No DCD updates will be included for this issue.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
b. 7 Review the supplied documents and drawings for valve failure modes. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3). The failure modes and effects associated with RCCWS components are modeled in the RCCWS PRA model fault tree for LOPP and non-LOPP sequences. The design redundancy of the RCCW system provides for good system reliability. For sequences in which preferred power is available, failure of support systems dominate the cutsets. For LOPP sequences, the results show dominance of test and maintenance unavailability and restoration errors following LOPP, which tends to be misleading because that is due to the relatively high screening values used for modeling those events. A system importance sensitivity was performed for RCCWS. Additional details of the sensitivity are provided in NEDE-33201 Rev 3. Section 11.3.1.15. Tables 11.3-15 and 11.3-16 contain the system importance rankings based on RAW and FV, respectively. There are no key insights or assumptions for RCCWS. GEH considers sufficient information is provided in this response based on the RCCWS PRA to resolve this issue. No DCD updates will be included for this issue.
b. 8	Freeze protection is not a concern for RCCWS design because the system

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
Review the supplied documents and drawings for provisions to prevent freezing and damage.	piping and components are located within heated buildings and structures. Freeze protection features vary on a site-specific basis, depending upon the location of the plant and the site-specific weather conditions. Thus, freeze protection is not part of the ESBWR Standard Plant as described in DCD Tier 2, Subsection 1.2.2.12.16. The ESBWR DCD Tier 2, Subsection 14.2.8.1.51, specifies an initial test be performed, if applicable, to demonstrate proper operation of freeze protection methods and devices. GEH considers sufficient information is provided in the DCD text and figures to resolve this issue.
b. 9 Review the supplied documents and drawings for how the water in the service water basin is replenished when the discharge.	This issue is not applicable to the RCCWS. GEH considers sufficient information is provided in the DCD text and figures to resolve this issue. No DCD updates will be included for this issue.
b.10 Review the supplied documents and drawings for clarification of the water basin. Determine what needs to be included in the DCD.	This issue is not applicable to the RCCWS. GEH considers sufficient information is provided in the DCD text and figures to resolve this issue. No DCD updates will be included for this issue.
b.11 Review the supplied documents and drawings for valves with hard seats. This maybe an information item for COL	Valves are usually provided with hard seats to withstand erosion due to water quality issues. RCCWS water is treated with corrosion inhibitors to minimize the corrosion of the RCCWS piping and components. Therefore, specifying hard seats for RCCWS valves is not required.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
applicants to identify where such valves will be installed to satisfy the specified criteria. Determine what needs to be included in the DCD.	GEH considers sufficient information is provided in the DCD text and figures to resolve this issue. No DCD updates will be included for this issue.
b.12 Review the supplied documents and drawings for related to the detection of gross leakage and related instruments. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3). RCCWS gross leakage was addressed in GEH's response to RAI 9.2-7 (MFN 07-039 dated Mar. 30, 2007). As described in ESBWR DCD Tier 2, Subsection 9.2.2, the RCCWS is designed to limit leakage of radioactive or chemical contamination to the environment. RCCWS radiation monitors are provided for monitoring radiation levels and alerting the plant operator of abnormal radiation levels. The minimum amount of monitoring required is at two points in each train. The first is after the RWCU/SDC heat exchangers to detect potential reactor coolant leakage. The second is at the pump suction return line upstream of the cross-tie header, but downstream of the heat exchanger hot leg connections. RCCWS is designed such that a major line break is automatically detected through the process monitoring of flow rates. This is accomplished by monitoring flow rates at key points in the piping network and confirming that the flow rates are balanced such that the inlet and outlet flows in the given

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	section of piping are equal. These points will be determined based on the actual system routing and flow configurations to ensure adequate response time. Upon receipt of an unbalanced flow in a major supply or return line, the cooling water trains will be separated and the damaged train shut down either manually or automatically. Inconsistent RCCWS flow rates based on upstream and downstream flow values that are greater than or equal to the MWS flow rate will generate an unbalanced flow signal. These flow rates will also be used by RCCWS to determine if an automatic train separation is necessary. GEH considers a detailed description of how RCCWS detects gross leakage detailed design information that is beyond that necessary for the NRC to make its safety finding. In addition, instrumentation specifications are finalized through the Design Acceptance Criteria ITAAC process. DCD Tier 2, Figure 9.2-2b illustrates a radiation detector downstream of the A Train RWCU/SDC heat exchangers. This instrument is not shown downstream of B Train RWCU/SDC heat exchangers. DCD revision 6 will correct this omission and add the radiation detector downstream of the B Train RWCU/SDC heat exchangers. The RCCWS surge tank levels are used to monitor losses of cooling water, and detect intersystem leakage intrusions into RCCWS. The level transmitters in the surge tank standpipes in combination with low-low surge tank level automatically initiate a train shut down. A train shutdown signal will trip off all pumps in the train and close all isolation, bypass, and flow control

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	valves. GEH considers sufficient information is provided in the DCD text and figures to resolve this issue. DCD updates will be included for this issue.
b.13 Review the supplied documents and drawings for how the RCCWS pumps are protected from large debris.	This issue is not applicable to the RCCWS. RCCWS is a closed system with clean de-mineralized water that is treated with corrosion inhibitors to minimize the corrosion of the RCCWS piping and components. Therefore, RCCW pumps are not susceptible to failure from large debris during normal operation. As described in the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399), the RCCWS pumps are provided with temporary suction strainers designed to remove post-construction corrosion products and other debris that may have accumulated in the piping system during construction. These strainers are removed after initial plant startup. GEH considers sufficient information is provided in the DCD text and figures to resolve this issue. No DCD updates will be included for this issue.
b.14 Review the supplied documents and drawings for nominal screen mesh size. .	This issue is not applicable to the RCCWS. RCCWS is initially filled and maintained with de-mineralized water from the Makeup Water System. RCCWS water is treated with corrosion inhibitors to minimize the corrosion of the RCCWS piping and components. Due to high purity RCCWS water and minimal corrosion expected based on RCCWS chemistry control, strainers and filters are not specified for this system. RCCWS pumps are provided with temporary suction strainers designed to remove post-construction corrosion products and other debris that may have accumulated in the piping system during construction. These strainers are removed after initial plant startup.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	GEH considers sufficient information is provided in the DCD text and figures to resolve this issue. No DCD updates will be included for this issue.
b 15 Review the supplied documents and drawings for high points vents. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3). DCD subsection 9.2.2.2 describes that RCCWS surge tanks provide a constant pump suction head and allow for thermal expansion of the RCCWS inventory for this closed-loop system. The tanks are located above the highest point in the system. The surge tanks will remove air and gases coming out of solution for this closed system. GEH considers sufficient information is provided in the DCD text and figures to resolve this issue. No DCD updates will be included for this issue.
b.16 Review the supplied documents and drawings for DCD consistence between sections related to instruments. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3). To the extent that aspects of this question relate to the RCCWS, Subsection 9.2.2.5 addresses instrumentation and control design performance requirements. GEH considers sufficient information is provided in the DCD text and figures related to RCCWS instrumentation. No DCD updates will be included for this issue.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
b.17 Review the supplied documents and drawings related to cooldown alignments. DCD Tier 2 Table 9.2-1 needs to indicate which alignment is for a 24 hour cooldown and which is for a 36 hour cooldown to cold shutdown conditions. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3). As described in PSWS b.17 above, RCCWS, in conjunction with the RWCU/SDC and ICS, is designed to remove sufficient heat from the reactor to enable cooling the reactor from 100% rated power to the cold shutdown conditions of 93.3°C (200°F) in 36 hours, assuming the most restrictive single active failure (only one train of pumps and heat exchangers available) and LOPP. This is done while simultaneously preventing fuel pool boiling through the FAPCS. The RCCWS configuration supporting this mode of operation is listed in Table 9.2-3 LOPP Operation Single Train Failure and Table 9.2-5, RCCWS Configuration by Mode. DCD Tier 2 Table 9.2-3, RCCW Nominal Heat Loads and Table 9.2-5, RCCWS Configuration by Mode, will be revised in Rev 6 to add a note to table designating either the 24 or 36 hour cooldown condition. As described in the RCCW System Design Specification (SR3-1-P21-SDS-6399), the RCCWS, in conjunction with the RWCU/SDC and FAPCS have sufficient capacity to meet the requirements for normal shutdown cooling such that the reactor coolant temperature is reduced to 60°C (140°F) in 24 hours. GEH considers sufficient information is included in the DCD describing limiting conditions of operation for the RCCWS. DCD updates will be included for this

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	issue.
c. Review the supplied documents and drawings for RCCWS design related to the minimum net positive suction head (NPSH) for the pumps (needs to be satisfied for all postulated conditions, including vortex formation considerations.) The system description indicates that the surge tanks provide NPSH and maintain system pressures above the vapor pressures to mitigate voiding. However, the specific NPSH requirements for the RCCWS pumps; the minimum water level that is necessary to satisfy NPSH requirements and the basis for this determination and limiting assumptions that were used (e.g., water level, excess margin, maximum temperature, maximum flow rate, number of pumps operating, vortex effects). Determine how the combined license (COL) applicants will know to periodically confirm that adequate levels	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3) related to NPSH requirements for the RCCWS pumps. As described in DCD subsection 9.2.2.2, surge tanks provide a constant pump suction head and allow for thermal expansion of the RCCWS inventory. The tanks are located above the highest point in the system. Makeup to the RCCWS inventory is from the Makeup Water System (MWS) through an automatic level control valve. SR3-1-P21-CAD-0005, Reactor Component Cooling Water System (RCCWS) Equipment Sizing determined the NPSHR for the RCCW pumps specified. The RCCWS pumps are sized to discharge 1350 m^3/hr of 35°C (95°F) water, at a Total Discharge Head (TDH) equal to the minimum NPSH plus the frictional head resistance. The frictional head resistance of the RCCWS is expected to be constant for all operating modes because the RCCWS trains are cross tied together; which results in the pumps of both trains overcoming the same frictional resistance. Significant margin is applied to account for pipe fittings and unknown routing. The pressure drop of the estimated lengths for each piping section is doubled. This doubled pressure drop then has a 20% margin added on to account for pipe aging. The piping losses including the 20% aging factor is then added to

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
exist. Determine what needs to be included in the DCD.	the inline equipment losses for each segment. The segments are combined as appropriate, and a separate 15% margin added to these combined pressure drops. This 15% margin accounts for the pump head margin on piping losses and equipment pressure drops that may increase during design or with increased fouling. This 15% value exceeds the 7% minimum specified in the URD Section 3.3.1.1. As described in the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399), the surge tank level is monitored to ensure that sufficient NPSH is available for pump operation. During cooling water train separation, low surge tank standpipe level, in combination with low-low surge tank level, automatically initiates a train shutdown. A train shutdown signal trips off all pumps in the train and closes all isolation, bypass, and flow control valves. The automatic train shutdown signal shall be the only automated pump trip signal based on process conditions for the RCCWS pumps. The Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3) considers the probability of a spurious low surge tank standpipe level during cooling water train separation in combination with a spurious low-low surge tank level that automatically trips all pumps on the train with the spurious signal. The NRC Staff noted during the audit that the DCD does not describe surge tank level controls and train separation / shutdown upon indication of low level. GEH will add description of the function of RCCWS train separation

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	and signals that initiate train shutdown under revision 6 of the DCD Tier 2 subsection 9.2.2.2. During the audit, the NRC Staff questioned the operation of the RCCWS cooling water train supply valves shown on DCD Figure 9.2-2a and designated as FO23A and FO23B in the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3). These valves are automatically and manually opened and closed by the MCR N-DCIS. The valves are normally open and automatically close upon a LOPP. The valves re-open after the diesel generators are running as part of the load sequencing. These valves isolate the Diesel Generator (DG) from the rest of the RCCWS supply distribution to ensure a flow path for system operation after a LOPP. The valve closes upon loss of AC power and is re-opened once the DG is providing electrical power. These valves were modeled in the PRA model as air operated valves P21-F0023A and B; normally open, fail open valves. They close on LOPP to isolate all loads except the associated DG, and reopen as part of the load sequencing once the applicable DG is running. The failure to close function is addressed under the R21 system in support of DG operation. PRA results, including common cause failure (probability of 1.930E-04), are acceptable with the valve configuration described above. Figure 9.2-2a and the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) denote these valves as motor operated valves. Modeling these valves as air operated is conservative with the failure probability exceeding that of a motor operated valve performing the same function. The Reactor Component Cooling Water System PRA Model (NEDO 33201

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	Rev 3) assumes active components other than pumps and heat exchangers are tested every 24 months during the plant shutdown for refueling. The function of these valves would be verified every refueling outage during standby diesel LOPP testing. As described in DCD Tier 2, Appendix 19A.8, all RTNSS systems are in the scope of the Design Reliability Assurance Program, as directed by DCD Tier 2 Chapter 17, which will be incorporated into the Maintenance Rule Program. Performance monitoring of RTNSS components is required by the Maintenance Rule GEH considers sufficient information is included in the DCD to resolve this issue related to RCCWS pump NPSHR and acceptability of the RCCWS cooling water train supply valves. DCD updates are provided to discuss train separation / shutdown upon loss of surge tank level.
d. Review the supplied documents and drawings related to waterhammer. The RCCWS description indicates that the potential for waterhammer is mitigated through the use of various system design and layout features, such as high point vents, operating and maintenance procedures. Determine what needs to be included in the DCD.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3) related to water hammer events for the RCCWS pumps. RCCWS is a closed system and does not require air release/vacuum values due to minimal air ingestion and the system design hydraulic gradient. Therefore, this issue is not applicable to the RCCWS. For the RCCWS, as explained in DCD subsection 9.2.2.2, surge tanks provide a constant pump suction head and allow for thermal expansion of the RCCWS inventory for this closed-loop system. The tanks are located above the

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	highest point in the system. Makeup to the RCCWS inventory is from the Makeup Water System through an automatic level control valve. The potential for water hammer is mitigated through the use of various system design and layout features, such as venting high points in system piping (surge tank), valve actuation times that are slow enough to prevent water hammer, procedural requirements ensuring proper line filling prior to system operation and after maintenance operations, and the use of check valves at pump discharge to prevent backflow into the pump. The ESBWR Project Design Manual provides guidance for valve actuation/stroke time development during system design to prevent water hammer and control instability while minimizing operation of pumps below minimum flow while the valves stroke open to establish system flowpaths GEH considers sufficient information is included in the DCD describing measures taken to mitigate water hammer. No DCD updates will be included for this issue.
d.1 Review the supplied documents and drawings for the amount of back leakage through the pump check valves.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3) with respect to design operation and layout features associated with the RCCWS pump discharge check valves to prevent excessive back-leakage and line voiding.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	Preoperational startup testing described in DCD Tier 2 subsection 14.2.8.1.21 will verify proper operation of system valves, including timing, under expected operating conditions. Maintenance test and operating procedures will include provisions for regular inspection testing and maintenance of valves to prevent leakage that can cause void formation during periods of standby. RCCWS pump test and integrated flow tests will ensure discharge check valve leakage will not impact pump or system flow performance requirements. As described in DCD Tier 2, Appendix 19A.8, all RTNSS systems are in the scope of the Design Reliability Assurance Program, as directed by DCD Tier 2 Chapter 17, which will be incorporated into the Maintenance Rule Program. Performance monitoring of RTNSS components is required by the Maintenance Rule. GEH considers sufficient information is included in the DCD to resolve this issue related to pump check valve back leakage. No DCD updates will be included for this issue.
d. 2 Review the supplied documents and drawings for how proper operation of the automatic air release/vacuum valves will be assured over time.	RCCWS is a closed system and does not require air release/vacuum values due to minimal air ingestion and the system design hydraulic gradient. Therefore, this issue is not applicable to the RCCWS. As described in DCD subsection 9.2.2.2, Surge tanks provide a constant pump suction head and allow for thermal expansion of the RCCWS inventory. The tanks are located above the highest point in the system. GEH considers sufficient information is included in the DCD to resolve this issue related to system air binding and venting. No DCD updates will be included for this issue.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
d. 3 Review the supplied documents and drawings for valve actuation/stroke times.	The NRC reviewed the current Phase 1 Design P&IDs and proprietary RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201 Rev 3) with respect to valve actuation and stroke times. As described in response to d.1 above, preoperational startup testing (DCD Tier 2 subsection 14.2.8.1.21) will verify proper operation of system valves, including timing, under expected operating conditions. Maintenance, test and operating procedures will include provisions for regular inspection, testing and maintenance of valves to prevent degradation over time. As described in DCD Appendix 19A.8, all RTNSS systems are in the scope of the Design Reliability Assurance Program, as directed by DCD Tier 2 Chapter 17, which will be incorporated into the Maintenance Rule Program. Performance monitoring of RTNSS components is required by the Maintenance Rule. The ESBWR Project Design Manual provides guidance for valve actuation/stroke time development during system design to prevent water hammer and control instability while minimizing operation of pumps below minimum flow while the valves stroke open to establish system flowpaths. GEH considers sufficient information is included in the DCD to resolve this issue related to valve actuation/stroke time concerns. This level of detail is beyond that available in the DCD for similar sections. No DCD updates will be included for this issue.
d. 4	The NRC reviewed the current Phase 1 Design P&IDs and proprietary

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
Review the supplied documents and drawings for related to water hammer. Review that the initial test program will demonstrate that automatic actuation of a standby loop or actuation of both loops following a loss of power will not result in a significant water hammer event. Determine what needs to be included in the DCD.	RCCWS P&IDs. In addition, the NRC reviewed the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399) and the Reactor Component Cooling Water System PRA Model (NEDO 33201, Rev. 3) with respect to the mitigation of water hammer. The initial test program for the RCCWS described in DCD Tier 2 subsection 14.2.8.21 demonstrates proper operation of system valves, including timing, under expected operating conditions; and proper operation of pumps and motors in all design operating modes. This includes startup of a standby loop or actuation following a loss of power with proper operation ensuring that water hammer does not occur. In response to RAI 9.2-11-S04, GEH revised ESBWR DCD Tier 2, subsection 13.5.2, to ensure operating and maintenance procedures developed for RTNSS systems will address water hammer. .In addition, testing, inspection, or quality assurance programs will verify design features intended to prevent or mitigate water hammer. Design features to preclude or mitigate water hammer in the RCCWS are described in the ESBWR DCD, Tier 2, subsection 9.2.2.1. The RCCWS meets the intent of the acceptance criteria of GDC 4 for normal operation, maintenance, and testing. The RCCWS meets the intent of the acceptance criteria of GDC 4 with respect to dynamic effects associated with water hammer. The RCCWS has high point vents and operation and maintenance procedures assure sufficient measures are taken to avoid water hammer.: Information was added to DCD Revision 5, as explained in GEH's response to

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, RCCWS	GEH Response to Audit Findings/Comments, RCCWS
	RAI 9.2-11S04 (Resolved). As described in response to b.15 above, RCCWS is a closed loop system with an atmospheric head surge tank and does not require a detailed hydrodynamic analysis. As described in the Reactor Component Cooling Water System Design Specification (SR3-1-P21-SDS-6399), the potential for water hammer is mitigated through the use of various system design and layout features, such as venting all high points in system piping, valve actuation times that are slow enough to prevent water hammer, procedural requirements ensuring proper line filling prior to system operation and after maintenance operations, and the use of check valves at pump discharge to prevent backflow into the pump. GEH considers sufficient information is included in the DCD to resolve this issue related to water hammer concerns. No DCD updates will be included for this issue.

ATTACHMENT 1, TYPICAL Chilled Water System Instrumentation

<table>
<tr><th>RAI 9.2-24 NRC Audit Items, NICWS</th><th>GEH Response to Audit Findings/Comments, NICWS</th></tr>
<tr><td>a. HIGH LEVEL GOAL:

The staff/reviewer should determine if the system is considered highly reliable and no single active failure should result in the inability to terminate use of passive safety-grade system and achieve cold shutdown.</td><td>The staff identified design information needed to be included in the DCD in order to reach reasonable assurance that Nuclear Island Chilled Water System (NICWS) will perform its intended non-safety function related to RTNSS; as well as cool-down function and performance. The following ESBWR design input documents, associated with NICWS, were reviewed as part of this audit.
<table>
<tr><th>Document Type/Title</th><th>Document Number</th><th>Revision</th></tr>
<tr><td>Composite Design Specification</td><td>26A6007</td><td>2</td></tr>
<tr><td>Project Design Manual</td><td>NEDO-33271P</td><td>2</td></tr>
<tr><td>System Design Specification</td><td>SR3-1-P25-SDS-6417</td><td>2 (Open 06/30/08)</td></tr>
<tr><td>P&ID</td><td>105E3898</td><td>0</td></tr>
<tr><td>Calculation: Design Parameters</td><td>SR3-1-P25-CAD-0001</td><td>0 (Open 06/25/08)</td></tr>
<tr><td>Calculation: Heat Load</td><td>SR3-1-P25-CAD-0002</td><td>0 (Open 06/25/08)</td></tr>
<tr><td>Calculation: Pipeline Sizing</td><td>SR3-1-P25-CAD-003</td><td>0 (Open 06/25/08)</td></tr>
<tr><td>PRA Model</td><td>NEDO-33201</td><td>3</td></tr>
<tr><td>Engineering Change, Optimization of the Chilled Water System (P25)</td><td>SR3-1-ECA-0036</td><td>0</td></tr>
</table></td></tr>
<tr><td>b.1
Determine the most limiting conditions upon which the NICWS design is based need to be described (e.g., shutdown/cooldown with maximum core</td><td>The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417).</td></tr>
</table>

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
decay heat and maximum allowed spent fuel pool heat load, capability to perform plant cooldown within specified criteria, single failure and loss of power considerations. Determine the amount of excess margins that are included in the design to account for uncertainties, component wear and aging effects, fouling of heat transfer surfaces and spray nozzles, strainer debris collection, etc., need to be described and why the specified margins are considered to be adequate need to be explained. Determine the specific values or ranges of values chosen as the bounding conditions for the design need to be specified and explained (e.g., limiting temperatures) both the specified design and minimum required capability of heat exchangers, and pumps based on excess margin considerations. Note that combined license (COL) information items and interface	There is no specific NICWS alignment specified for the 24 hour or 36 hour cooldown conditions. DCD Table 9.2-11, Chilled Water System Component Design Characteristics listed a CWS chiller heat load of 4850 Kw (16.55 Mbtu/hr) and total system heat load of 19,110 kW (6.5 x 10^7Btu/hr) based on conservative preliminary calculations. This CWS heat load was used to size chillers as input for TCCWS and RCCWS heat load calculations. NICWS and BOPCWS heat loads are considered bounding with final actual heat loads determined upon completion of HVAC calculations for the Nuclear Island and Turbine Island HVAC systems. As described in SR3-1-P25-CAD-0002, Chilled Water System (CWS) Heat Load Calculation, the NICWS and BOPCWS Chillers will be sized for a heat load of 4,638 kW (1,319 tons) per chiller. The NICWS consists of two trains with two 50% chillers in each train resulting in a total NICWS heat load of 9.3 MW. The system cooling loads and chilled water flows were developed using ABWR design heat loads and applying a 25% additional margin to selected loads. A 10% margin is applied to the identified loads to account for unidentified loads in both the NICWS and BOPCWS. The heat loads for the NICWS and BOPCWS chillers are summed separately and compared. If the difference in heat loads is less than 15%, the bounding load is used for both NICWS and BOPCWS chiller sizing. This is done to simplify procurement and maintenance. The total NICWS and BOPCWS total heat loads are within 15% of each other. The BOPCWS heat load is used as the bounding load for each NICWS and BOPCWS train. As reflected in SR3-1-P21-CAD-0004, Reactor Component Cooling Water System (RCCWS) Heat Load and Flow Rate Calculation, the CWS bounding

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
requirements should be established as appropriate. Determine what needs to be included in the DCD.	heat load is 12.3 MW, with a temperature rise of 13.9°C (25°F) across the chiller condenser and an inlet temperature of 35°C (95°F). This is a conservative value based on the heat rejection load of two 1380 Ton chillers. The 1380 ton chiller size is a conservative value based on initial calculations and is consistent with the size of chiller specified in the DCD. Significant margins will be applied to the NICWS during the design process to account for uncertainties as listed in b.1 above for the NICWS. The preliminary design basis documents reviewed by the NRC consider the following margins and conservative assumptions in the design of the system. • A corrosion margin is applied to NICWS piping to account for aging and degradation. CWS water is treated with corrosion inhibitors to minimize the corrosion of the CWS piping. For carbon steel piping, the minimum corrosion allowance will be 1.54 mm (0.060 in.); which is conservative based on engineering design requirements on the ABWR project that used a corrosion allowance of 0.76 (0.030 in.) for a plant with a 60 year life. • The design pressure for NICWS piping and components applies a margin of 172.4 kPag (25 psig) to the operating pressure and rounds up to the nearest 100 kPag increment to obtain design pressure • The test pressure for carbon steel pipe is defined by multiplying the design pressure by a factor of 1.5 The CWS detailed design margin for limiting temperature will include conservatisms in addition to flow margin. All building HVAC systems include a

Table 2 – RAI 9.2-24 Audit Items and GEH Response

<table>
<tr><th>RAI 9.2-24 NRC Audit Items, NICWS</th><th>GEH Response to Audit Findings/Comments, NICWS</th></tr>
<tr><td></td><td>15% margin for projected heating/cooling load and 15% margin for airflow (Ref URD Chapt 9 Sect 8.2.1.1.12).

GEH considers sufficient information is provided in this response to conclude that sufficient margin is applied to the design of the NICWS. No DCD updates will be included for this issue</td></tr>
<tr><td>b.2
Review the supplied documents and drawings for nominal pipe sizes and flow rates through individual coolers.

Determine what needs to be included in the DCD.</td><td>The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). The NRC also reviewed the Chilled Water System (CWS) Pipeline Sizing Calculation, SR3-1-P25-CAD-0003.

The ESBWR Project Design Manual (NEDE 33271) provides requirements for maximum fluid velocity applied to the CWS piping under this calculation. The maximum recommended water velocity for piping containing general service water pump suction and discharge is shown in the table below.

<table><tr><th></th><th>50 mm (2 in.)</th><th>200 mm (8 in.)</th><th>350 mm (14 in.)</th><th>500 mm (20 in.)</th><th>>600 mm (24 in.)</th></tr><tr><td>Pump Suction</td><td>2 fps</td><td>5 fps</td><td>6 fps</td><td>8 fps</td><td>10 fps</td></tr><tr><td>Pump Discharge</td><td>5 fps</td><td>10 fps</td><td>12 fps</td><td>15 fps</td><td>15 fps</td></tr></table>
The NRC staff questioned the ASME class breaks for CWS containment isolation noted on DCD Figure 9.2-3, Chilled Water System Simplified Diagram. As listed in DCD tier 2,Table 3.2-1, Classification Summary, NICWS</td></tr>
</table>

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	Piping and valves (including supports) forming part of the containment boundary are safety class 2, Quality Class B, seismic I. NICWS piping and components inside containment (and the Reactor Building) are classified nonsafety–related, Quality Group D and seismic II. DCD Figure 9.2-3, Chilled Water System Simplified Diagram, is updated in revision 6 to reflect the CWS piping classification inside the containment (Quality Group D and seismic II). DCD updates will be included for this issue.
b.3 Review the supplied documents for train designations for cross-connect valves. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). The CWS is divided in two independent chilled water subsystems, the Nuclear Island Chilled Water System (NICWS) and the Balance of Plant Chilled Water System (BOPCWS). The NICWS contains two redundant trains for active components, Train A and Train B. The NICWS redundant trains share passive components (e.g., piping, supports, manual shutoff valves). The BOPCWS is a single train. NICWS Train A and Train B, and BOPCWS are each powered by separate buses. A secondary loop arrangement including pumps and control valves may be utilized for some user loads. The active components in NICWS Train A and Train B chilled water trains are identical. Each train contains two 50% chillers, two 50% primary pumps, one surge tank, one air separator, optional secondary pumps, and a shared chemical addition skid. DCD subsection 9.2.7.1 states that the CWS is designed so that a single active failure or malfunction of one NICWS train does not affect system

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	functionality. In case of failure, the system automatically generates a isolation signal. Detail design will ensure valve failure modes will allow achieving this design requirement. Chilled water is supplied from either train to a common header, thus distributing chilled water to the NICWS loads throughout the facility via a single piping distribution loop. The potential risk impact with the single chilled water distribution loop for passive components of the two (2) trains of the Nuclear Island Chilled Water Subsystem (NICWS) (design change approved under ECA-0036) was evaluated under the ESBWR PRA L2 Internal Event Model. The bounding results show that the CWS design change would result in moderate CDF and LRF increases. With more realistic estimates used for CWS piping leakage & rupture, the increases are not significant. NICWS chilled water is supplied by both chilled water trains during normal operation with one primary pump and chiller in service on each train and the other primary pump and chiller set in standby. A normally shut manual cross-tie line connects the chilled water supply and return headers of BOPCWS and NICWS. The manual valves may be opened to support maintenance activities. The CWS surge tank levels are used to monitor losses of chilled water, and detect intersystem leakage or intrusions into CWS. Low-low surge tank level alarms in the Control Room. This alarm indicates that system leakage has exceeded makeup water capacity. High-high surge tank level alarms in the Control Room. This alarm indicates that there is intersystem leakage into NICWS. The level transmitters in the surge tank standpipes monitor the surge

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	tank levels to ensure that sufficient NPSH is available for pump operation. In the event of a LOCA, the only function of the NICWS is to close the NICWS containment isolation valves. The CWS automatically performs a containment isolation function by closing its containment isolation valves upon receipt of an isolation signal from the Leak Detection and Isolation System (LD&IS). GEH considers sufficient information is included in the DCD related to train separation and operation of the cross connect valves. No DCD updates will be included for this issue.
b.4 Review the supplied documents and drawings for header temperature and pressure detectors. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417. A markup of the NICWS P&ID is provided with this RAI response illustrating instrument details including header temperature and pressure detectors. Attachment 1 of this RAI response illustrates typical instrumentation locations associated with the CWS. The instrumentation level of detail for DCD Figures 9.2-2a and 9.2-2b-associated with the RCCWS was compared with DCD Figure 9.2-3 for NICWS and found similar. Therefore, GEH considers sufficient information is included in the DCD. No DCD updates will be included for this issue.
b.5 Review the supplied documents and drawings for pump minimum flow	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
recirculation lines. Determine what needs to be included in the DCD.	System Design Specification (SR3-1-P25-SDS-6417). NICWS chiller pump minimum flow recirculation lines are not required because the system design and operation will ensure that the required minimum chilled water pump flow will be maintained under all conditions for both primary and secondary chilled water circuits. As described in the Chilled Water System Design Specification (SR3-P25-SDS-6417), the design flow rate at the NICWS chiller primary and secondary pumps rated head will be specified to ensure that the primary pump will not operate below 85% or above 125% of its best efficiency point. The NICWS includes air-operated bypass control valves, modulated on the basis of the differential pressure across the supply and return lines to regulate the NICWS chilled water supply. This will ensure a flow path is maintained upon isolation of NICWS loads. Each flow path to all interface system heat exchangers is designed to have flow balancing features that may include fixed plate orifices and/or control or manual valves. The CWS is designed to use two-way control valves to regulate the chilled water flow to the AHU and FCU cooling coils that do not utilize a secondary loop pump and mixing valve arrangement. The portions of the NICWS that utilize a secondary pump arrangement include variable speed secondary pumps utilizing an Adjustable Speed Drive and a return line from the coil outlet water to a mixing valve which will mix with the NICWS supply water and adjust the coil supply water to an optimum temperature required for the load. Therefore, sufficient flow will be maintained through each load to satisfy minimum flow requirements. In addition, each CWS chiller package unit includes protection against low chilled water flow.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	DCD Figure 9.2-3, Chilled Water System Simplified Diagram, is updated under revision 6 to illustrate the mixing valve configuration for a secondary loop arrangement and reflect air-operated bypass control valves across the supply and return lines. DCD updates will be included for this issue.
b. 6 Review the supplied documents and drawings for related to the air system interface for the air-operated valves. Review for how train separation is maintained and reliability of this air system arrangement. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). As described in response to b.3 above, DCD subsection 9.2.7.1 states that the CWS is designed so that a single active failure or malfunction of one NICWS train does not affect system functionality. In case of failure, the system automatically generates a train isolation signal. Detail design will ensure valve failure modes will allow achieving this design requirement. As described in the Chilled Water System Design Specification (SR3-1-P25-SDS-6417), air operated valves are specified for the NICWS bypass control valves, NICWS surge tank makeup valve and NICWS user air control valves. The CWS air-operated bypass control valves are modulated on the basis of the differential pressure across the supply and return lines to regulate the NICWS and BOPCWS chilled water supply. The bypass valves also have the ability to be controlled manually from the MCR N-DCIS and the bypass valve fails close. CWS chilled water user air-operated control valves are modulated on the basis of cooling demand from the users. The valves also have the ability to be

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	controlled manually from the MCR. The valves fail open (FO). The CWS surge tank makeup air-operated block valves manually open and close from the MCR N-DCIS. The valve auto-opens when the CWS surge tank level drops to a predetermined low level and auto-closes when a CWS surge tank level rises to a predetermined high level. The CWS surge tank makeup water inlet block valves fail close (FC). NICWS chilled water shall be supplied by both chilled water trains during normal operation with one primary pump and chiller in service on each train and the other primary pump and chiller sets in standby. The number of chillers and primary pumps in operation depend on the total cooling capacity required of the NICWS. The secondary pumps are operated as required to support the cooling load of the associated user. A normally shut manual cross-tie line connects the chilled water supply and return headers of BOPCWS and NICWS. The manual valves may be opened to support maintenance activities. If available, BOPCWS can be used, but no credit is taken in the safe shutdown analysis. As described in DCD subsection 9.3.6.1, the Instrument Air System is designed to ensure that failure of the IAS does not compromise any safety-related system or component nor does it prevent a safe shutdown. Pneumatically operated devices are designed fail-safe and do not require continuous air supply under emergency or abnormal conditions. The importance of non-safety related compressed air supplies was evaluated relative to the criteria for special regulatory treatment of non-safety systems in DCD Tier 2 Appendix 19A. Compressed air supplies and valves, including

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	NICWS valves, were evaluated as described in response to RAI 9.3-32 (MFN - 07-259 dated May 8, 2007) and do not meet the criteria for special regulatory treatment. GEH considers sufficient information is included in the DCD related to train separation and reliability of air systems. The level of detail provided in the CWS System Design Specification is beyond that available in the DCD for similar sections. No DCD updates will be included for this issue.
b. 7 Review the supplied documents and drawings for valve failure modes. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417) and the ESBWR PRA Model (NEDO 33201 Rev 3) with respect to the NICWS valve failure modes. Response to b.6 above provided information regarding NICWS air operated valve operation and failure modes. DCD subsection 9.2.7.1 states that the CWS is designed so that a single active failure or malfunction of one NICWS train does not affect system functionality. In case of failure, the system automatically generates a train isolation signal. Detail design will ensure valve failure modes will allow achieving this design requirement. In the event of a LOCA, CWS automatically performs a containment isolation function by closing its containment isolation valves upon receipt of an isolation signal from the Leak Detection and Isolation System (LD&IS). DCD Table 6.2-39 and Table 6.2-39a, Containment Isolation Valve Information for the Chilled Water System Train A & B, provides valve information including valve type and

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	failure position. the CWS containment isolation valves are solenoid operated ball / gate valves (outboard) normally open / fail shut and air/nitrogen operated globe valve (inboard) normally open / fail shut. The actuator type listed for any valve application is generally based on historical BWR design. Alternate valve-&-operator combinations that provide equivalent functional capability and performance are permissible. The ESBWR Project Design Manual provides guidance for valve specification during system design including consideration of failure mode. GEH considers sufficient information is included in the DCD to resolve this issue related to valve failure mode concerns. This level of detail is beyond that available in the DCD for similar sections. No DCD updates will be included for this issue.
b. 8 Review the supplied documents and drawings for provisions to prevent freezing and damage.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). As described in DCD subsection 9.2.7.5, chiller package protective controls and monitoring instruments indicate high and low oil pressure, condenser pressure, high and <u>low</u> chilled water temperature and flow, high and <u>low</u> condenser water temperature and flow, and unit diagnostics. As described in the Chilled Water System Design Specification (SR3-1-P25-SDS-6417), the chiller package units include individual temperature controls and modulating inlet vanes for capacity control. Each CWS chiller is provided with built-in protection against freezing, high refrigerant pressure, low refrigerant pressure, high discharge temperature, motor overload, lubrication

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	oil failure, and motor high temperature. Freeze protection is not a concern for NICWS piping and components located within heated buildings and structures. Freeze protection features vary on a site-specific basis, depending upon the location of the plant and the site-specific weather conditions. Thus, freeze protection is not part of the ESBWR Standard Plant as described in DCD Tier 2, Subsection 1.2.2.12.16. The ESBWR DCD, Subsection 14.2.8.1.51, specifies an initial test be performed, if applicable, to demonstrate proper operation of freeze protection methods and devices. GEH considers this response sufficient to resolve this issue. No DCD updates will be included for this issue.
b. 9 Review the supplied documents and drawings for how the water in the service water basin.	Not applicable to NICWS. GEH considers this response sufficient to resolve this issue. No DCD updates will be included for this issue.
b.10 Review the supplied documents and drawings for clarification of the water basin.	Not applicable to NICWS. GEH considers this response sufficient to resolve this issue. No DCD updates will be included for this issue.
b.11 Review the supplied documents and drawings for valves with hard seats. .	Valves are usually provided with hard seats to withstand erosion due to water quality issues. CWS water is clean, de-mineralized water treated with corrosion inhibitors and pH adjustment chemicals, introduced into the chilled water through the applicable chemical addition tank, to minimize the corrosion of the CWS piping and components. Therefore, specifying hard seats for CWS

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	valves is not required. GEH considers this response sufficient to resolve this issue. No DCD updates will be included for this issue.
b.12 Review the supplied documents and drawings for related to the detection of gross leakage and related instruments. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). DCD subsection 9.2.7.2 describes that a low level signal in surge tanks (Chilled water leakage exceeding makeup capacity) require the automatic train isolation signal. DCD subsection 9.2.7.5 states that the CWS surge tanks are provided with level controlled demineralized water makeup valves and high/low level alarms in the MCR. As described in the Chilled Water System Design Specification (SR3-1-P25-SDS-6417), the CWS surge tank levels are used to monitor losses of chilled water, and detect inter-system leakage or intrusions into CWS. Low-low surge tank level will alarm in the Control Room. This alarm indicates that system leakage has exceeded makeup water capacity. High-high surge tank level alarms in the Control Room. This alarm indicates that there is inter-system leakage into CWS. The level transmitters in the surge tank standpipes monitor the surge tank levels to ensure that sufficient NPSH is available for pump operation. Surge tanks are designed with sufficient make-up capacity to accommodate design leakage from the system.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	DCD subsections 9.2.7.2 and 9.2.7.5 are updated under revision 6 to provide additional description related to detection of gross leakage. DCD updates will be included for this issue.
b.13 Review the supplied documents and drawings for how the NICWS pumps are protected from large debris that can end up in the service water basin. Determine what needs to be included in the DCD.	This issue is not applicable to the NICWS. CWS is a closed system and CWS water is treated with corrosion inhibitors to minimize the corrosion of the CWS piping and components. Therefore, CWS pumps are not susceptible to failure from large debris during normal operation. GEH considers this response sufficient to resolve this issue. No DCD updates will be included for this issue.
b.14 Review the supplied documents and drawings for nominal screen mesh size.	This issue is not applicable to the CWS since it is a closed system. The CWS is initially filled and maintained with de-mineralized water from the Makeup Water System. CWS water is treated with corrosion inhibitors to minimize the corrosion of the CWS piping and components. Due to high purity CWS water and minimal corrosion expected based on CWS chemistry control, strainers and filters are not specified for this system. GEH considers this response sufficient to resolve this issue. No DCD updates will be included for this issue.
b 15 Review the supplied documents and drawings for high points vents. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). As described in the Chilled Water System Design Specification (SR3-1-P25-

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	SDS-6417), the CWS design is a closed loop system and there is no need for a detailed hydrodynamic analysis. The NICWS includes one surge tank per train provided at the highest point of each NICWS train. The surge tanks are connected to each NICWS train suction header to maintain available static head and adequate NPSH for the primary pumps. The surge tanks remove air and gases coming out of solution for this closed system. The NICWS Train A and Train B have an air separator located before the chilled water primary pump suction headers with a vent to the surge tank of the respective NICWS train. The air separators remove entrained air and route this air to the vented surge tank. DCD Tier 2, Subsection 9.2.7.1 was revised in response to RAI 9.2-15 S01 (MFN Letter 08-178 dated March 8,2008) to describe CWS features to remove air and mitigate water hammer. GEH considers the DCD descriptions related to NICWS high point vents sufficient to resolve this issue. No DCD updates will be included for this issue.
b.16 Review the supplied documents and drawings for DCD consistence between sections related to instruments. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). To the extent that aspects of this question relate to the NICWS, Subsections 9.2.7.2 and 9.2.7.5 address instrumentation and control design performance requirements. GEH considers descriptions related to NICWS instrumentation consistent between DCD sections related to the NICWS. No DCD updates will be

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	included for this issue.
b.17 Review the supplied documents and drawings related to cooldown alignments. DCD Tier 2 Table 9.2-1 needs to indicate which alignment is for a 24 hour cooldown and which is for a 36 hour cooldown to cold shutdown conditions. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). NICWS and BOPCWS heat loads listed in the DCD and used for RCCWS and PSWS heat load calculations are considered bounding with final actual heat loads determined upon completion of HVAC calculations for the Nuclear Island and Turbine Island HVAC systems. There is no specific NICWS alignment specified for the 24 hour or 36 hour cooldown conditions. DCD Table 9.2-11, Chilled Water System Component Design Characteristics listed a CWS chiller heat load of 4850 Kw (16.55 Mbtu/hr) and total system heat load of 19,110 kW (6.5 x 10^7Btu/hr) based on conservative preliminary calculations. This CWS heat load was used as input for TCCWS and RCCWS heat load calculations. GEH considers sufficient information is included in the DCD to determine limiting NICWS heat load conditions. No DCD updates will be included for this issue.
c. Review the supplied documents and drawings for NICWS design related to the minimum net positive suction head (NPSH) for the NICWS pumps (needs to be satisfied for all postulated conditions, including vortex formation considerations.) The system description indicates that the NICWS pumps have	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417). As described in response to c above for the RCCWS, Chilled Water System Equipment Sizing calculations will determine the NPSHR for the CWS pumps as an activity under detailed design. The CWS pumps will be sized for a Total Discharge Head (TDH) (primary and secondary pumps) equal to the minimum

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
sufficient available NPSH due to the surge tank. However, the specific NPSH requirements for the NICWS pumps; the minimum required water level that is necessary to satisfy NPSH requirements and the basis for this determination and limiting assumptions that were used (e.g., water level, maximum temperature, maximum flow rate, number of pumps operating, vortex effects). Determine how the combined license (COL) applicants will know to periodically confirm that adequate levels exist. Determine what needs to be included in the DCD.	NPSH plus the frictional head resistance under worst case flow conditions. Significant margin will be applied to account for pipe fittings and unknown routing, pipe aging and increased fouling in accordance with standard design specifications considering URD recommendations. To the extent that aspects of this question relate to the NICWS, the CWS includes surge tanks to maintain NPSH for the pumps and to maintain system pressure above vapor pressure to mitigate voiding as described in response to RAI 9.2-15S01 (MFN LTR 08-178 dated March 8, 2008). The tanks are located above the highest system point and the use of sloped piping minimizes the potential for air binding. Makeup to the CWS inventory is from the Makeup Water System through an automatic level control valve to the surge tanks as described in DCD, Tier 2, Subsection 9.2.7.2. GEH considers sufficient information is included in the DCD to resolve this issue related to NICWS pump NPSHR. No DCD updates will be included for this issue.
d.1 Review the supplied documents and drawings for the amount of back leakage through the pump check valves.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417) with respect to design operation and layout features associated with the CWS pump discharge check valves to prevent excessive back leakage and line voiding. Each primary and secondary pump discharge line is provided with a check valve to prevent backflow through the pump. Preoperational startup testing described in DCD section 14.2.8.1.24 will verify proper operation of system

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	valves, including timing, under expected operating conditions. Maintenance, test and operating procedures will include provisions for regular inspection, testing and maintenance of valves to prevent leakage that can cause void formation during periods of standby. CWS pump test and integrated flow tests will ensure discharge check valve leakage will not impact pump or system flow performance requirements. As described in DCD Tier 2, Appendix 19A.8, all RTNSS systems are in the scope of the Design Reliability Assurance Program, as directed by DCD Tier 2 Chapter 17, which will be incorporated into the Maintenance Rule Program. Performance monitoring of RTNSS components is required by the Maintenance Rule. DCD Figure 9.2-3, Chilled Water System Simplified Diagram is updated under revision 6 to reflect the pump check valves located downstream of the primary and secondary pumps (as applicable). GEH considers sufficient information is provided in this response to resolve this issue. DCD updates will be included for this issue.
d. 2 Review the supplied documents and drawings for how proper operation of the automatic air release/vacuum valves.	CWS is a closed system and does not require air release/vacuum values due to minimal air ingestion and the system design hydraulic gradient. Therefore, this issue is not applicable to the CWS. As described in the Chilled Water System Design Specification (SR3-1-P25-SDS-6417), the CWS design includes one surge tank per train (total of three) provided at the highest point of each NICWS train and the BOPCWS train. The surge tanks are connected to each NICWS train and BOPCWS suction header. The surge tanks will remove air and gases coming out of solution for this closed system.

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	The BOPCWS and NICWS Train A and Train B have an air separator (total of three) located before the chilled water primary pump suction headers with a vent to the surge tank of the respective NICWS train or BOPCWS. The air separators remove entrained air and route this air to the vented surge tank. DCD Tier 2, Subsection 9.2.7.1 was revised in response to RAI 9.2-15 S01 (MFN Letter 08-178 dated March 8,2008) to describe CWS features to remove air and mitigate water hammer. GEH considers sufficient information is included in the DCD to resolve this issue related to system air binding and venting. No DCD updates will be included for this issue.
d. 3 Review the supplied documents and drawings for valve actuation/stroke times.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417) with respect to valve actuation and stroke times. As described in response to d.1 above, preoperational startup testing (DCD Tier 2 subsection 14.2.8.1.24) will verify proper operation of system valves, including timing, under expected operating conditions. Maintenance, test and operating procedures will include provisions for regular inspection, testing and maintenance of valves to prevent degradation over time. As described in DCD Tier 2, Appendix 19A.8, all RTNSS systems are in the scope of the Design Reliability Assurance Program, as directed by DCD Tier 2 Chapter 17, which will be incorporated into the Maintenance Rule Program. Performance

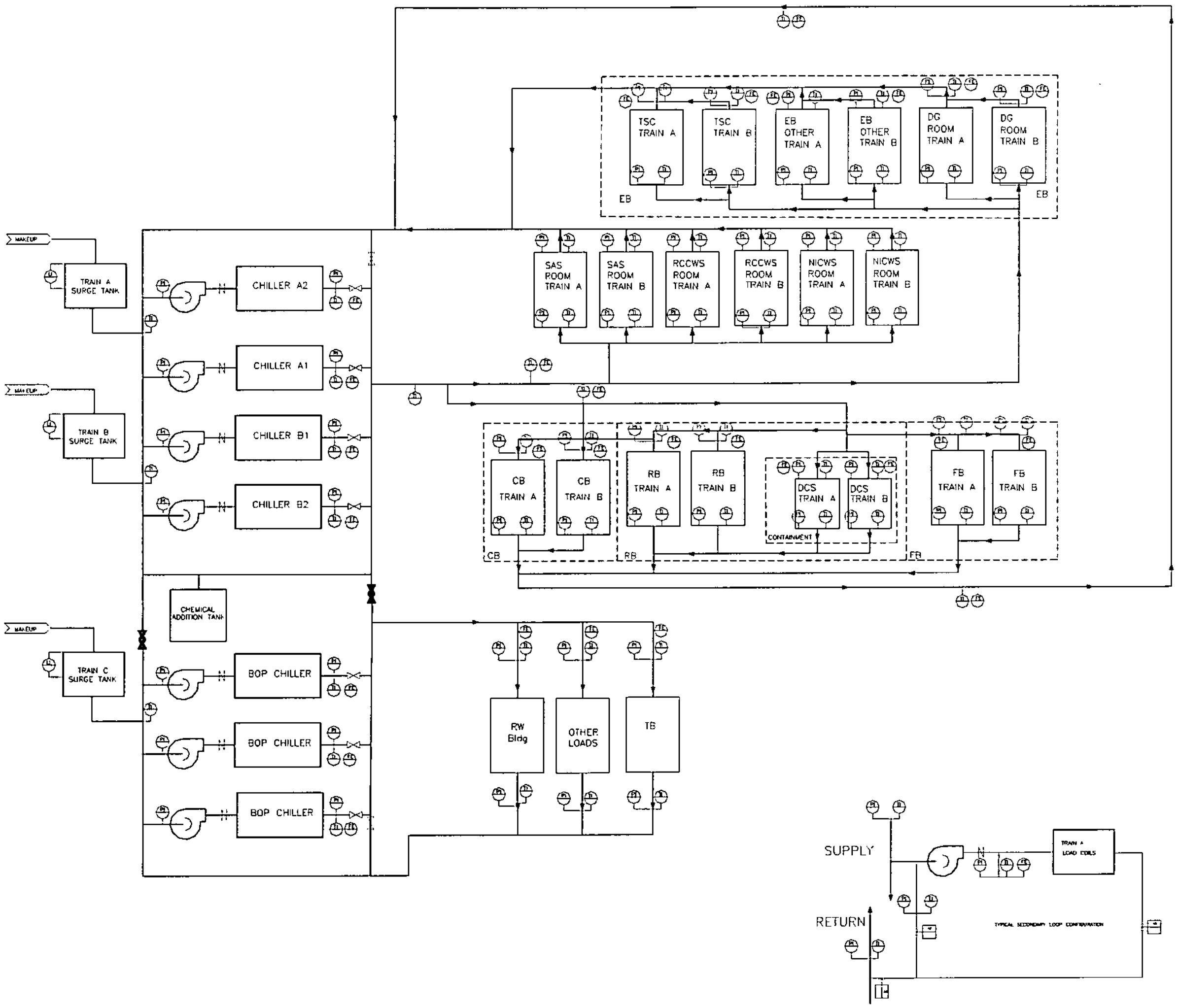
Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	monitoring of RTNSS components is required by the Maintenance Rule. The ESBWR Project Design Manual provides guidance for valve actuation/stroke time development during system design to prevent water hammer and control instability while minimizing operation of pumps below minimum flow while the valves stroke open to establish system flowpaths. GEH considers sufficient information is included in the DCD to resolve this issue related to valve actuation/stroke time concerns. This level of detail is beyond that available in the DCD for similar sections. No DCD updates will be included for this issue.
d. 4 Review the supplied documents and drawings for related to waterhammer. Review that the initial test program will demonstrate that any startup of the standby loop or actuation following a loss of power will not result in a significant waterhammer event. Determine what needs to be included in the DCD.	The NRC reviewed the preliminary Phase 1 Design piping diagrams associated with Engineering Change SR3-1-ECA-0036, Optimization of the Chilled Water System (P25). In addition, the NRC reviewed the Chilled Water System Design Specification (SR3-1-P25-SDS-6417) with respect to the mitigation of water hammer. The initial test program for the CWS described in DCD Tier 2 subsection 14.2.8.24 demonstrates proper operation of system valves, including timing, under expected operating conditions; and proper operation of pumps and motors in all design operating modes. This includes startup of a standby loop or actuation following a loss of power with proper operation ensuring that water hammer does not occur. In response to RAI 9.2-11-S04, GEH revised ESBWR DCD Tier 2, subsection 13.5.2, to ensure operating and maintenance procedures developed for RTNSS systems will address water hammer. In addition, testing, inspection, or

Table 2 – RAI 9.2-24 Audit Items and GEH Response

RAI 9.2-24 NRC Audit Items, NICWS	GEH Response to Audit Findings/Comments, NICWS
	quality assurance programs will verify design features intended to prevent or mitigate water hammer. As described in response to b.15 above, NICWS is a closed cycle cooling water system and does not require a detailed hydrodynamic analysis. As described in the Chilled Water System Design Specification (SR3-1-P25-SDS-6417), vents are located in all high points and function to properly vent air while filling the piping system with water. This ensures that the system is completely filled with water and that there are no air pockets that will reduce the chance for water hammer after a pump start. System valve opening and closing times are selected to minimize water hammer effects. Design features to preclude or mitigate water hammer in the NICWS are described in the ESBWR DCD, Tier 2, subsection 9.2.7. The CWS meets the intent of the acceptance criteria of GDC 4 for normal operation, maintenance, and testing. The CWS meets the intent of the acceptance criteria of GDC 4 with respect to dynamic effects associated with water hammer. The potential for water hammer is mitigated through the use of various system design and layout features, such as high point vents, valve cycle times, and surge tanks. Additionally, CWS operation and maintenance procedures incorporate necessary steps, such as proper line filling, to avoid water hammer. Information was added to DCD Revision 5, as explained in GEH's response to RAI 9.2.15, S01 (MFN Letter 08-178 dated March 8, 2008- Resolved)). GEH considers sufficient information is included in the DCD to resolve this issue related to water hammer concerns. No DCD updates will be included for this issue.

ATTACHMENT 1, TYPICAL Chilled Water System Instrumentation



4. INTERFACE MATERIAL

An applicant for a combined license (COL) that references the ESBWR certified design must provide design features or characteristics that comply with the interface requirements for the plant design and inspections, tests, analyses, and acceptance criteria (ITAAC) for the site-specific portion of the facility design, in accordance with 10 CFR 52.79 (c).

Tier 1 interfaces were identified for the conceptual design portion of the Plant Service Water System for the certified design.

4.1 PLANT SERVICE WATER SYSTEM

Design Description

The Plant Service Water System (PSWS) is the heat sink for the Reactor Component Cooling Water System (RCCWS). PSWS does not perform any safety-related function. There is no interface with any safety-related component. The PSWS provides the non-safety related functions to support the post-72 hour cooling for RCCWS. The PSWS system must have the volume of water necessary to accommodate losses due to evaporation, drift, etc. without make-up for seven days using the most limiting condition of operation as defined by the PRA model. The volume maintained must also ensure that the PSWS pumps have sufficient available net positive suction head at the pump suction location for the lowest probable water level of the heat sink. The most limiting condition equates to 2.02×10^7 MJ (1.92×10^{10} BTU) over a period of seven days.

The PSWS cooling towers and basins are not within the scope of the certified design. A specific design for this portion of the PSWS shall be selected for any facility, which has adopted the certified design. The plant-specific portion of the PSWS shall meet the interface requirements defined below.

Interface Requirements

The interface requirements are necessary for supporting the post-72-hour cooling function of the PSWS. The volume of water shall be sufficient such that no active makeup shall be necessary ~~The PSWS is required~~ to remove 2.02×10^7 MJ (1.92×10^{10} BTU) over a period of ~~7~~ seven days~~, without active makeup~~. Additionally, the PSWS pumps must have sufficient available net positive suction head at the pump suction location for the lowest probable water level of the heat sink. Consequently, verification of compliance with the interface requirements shall be achieved by inspections, tests, and analyses that are similar to those provided for the certified design. The combined license applicant referencing the certified design shall develop these inspections, tests, and analyses, together with their associated acceptance criteria.

4.2 OFFSITE POWER

Design Description

The offsite portion of the Preferred Power Supply (PPS) consists of at least two electrical circuits and associated equipment that are used to interconnect the offsite transmission system with the plant main generator and the onsite portions of the PPS. The PPS consists of the normal preferred and alternate preferred power sources and includes those portions of the offsite power designs with allowance for increase in system friction loss and impeller wear. The design of the heat rejection facilities and PSWS pumps have sufficient available net positive suction head (NPSH) under worst case conditions. Basin water level is monitored to ensure sufficient NPSH at design flow is provided to the PSWS pumps.

The pumps in each train are powered from redundant electrical buses. During a LOPP, the pumps are powered from the two nonsafety-related standby diesel-generators.

~~Where needed, v~~Valves are provided with hard seats to withstand erosion where required based on site water quality analysis (COL 9.2.1-1). The valves are arranged for ease of maintenance, repair, and in-service inspection. During a LOPP, the motor-operated valves are powered from the two, nonsafety-related standby diesel-generators.

The AHS provided for each PSWS train is a separate, multi-celled, 100% capacity mechanical draft cooling tower, with the fans in the tower from each train supplied by one of the two redundant electrical buses. During a LOPP, the fans are powered from the two, nonsafety-related standby diesel-generators. Each tower cell has an adjustable-speed, reversible motor fan unit that can be controlled for cold weather conditions to prevent freezing in the basin. A full flow bypass is provided to return water directly to the PSWS basin to allow ease of cold weather startup. Mechanical and electrical isolation allows maintenance on one tower, including complete disassembly, during full power operation. The Station Water System provides makeup for blowdown, drift, and evaporation losses from the basin. Refer to Subsection 9.2.10 for Station Water System discussion. The COL Applicant will determine material selection, including valve hard seat material, and provide provisions to preclude long-term corrosion and fouling of the PSWS based on site water quality analysis (COL 9.2.1-1-A).

In the event of a LOPP, the PSWS supports the RCCWS in bringing the plant to cold shutdown condition in 36 hours assuming the most limiting single active or a passive component failure.

The ESBWR Standard Plant PSWS design heat loads are shown in Table 9.2-1. The PSWS component design characteristics are shown in Table 9.2-2.

The PSWS design detects and alarms in the MCR any potential gross leakage and permits the isolation of any such leak in a sufficiently short period of time to preclude extensive plant damage.

Means are provided to detect leakage into the PSWS from the RCCWS, which may contain low levels of radioactivity.

The potential for water hammer is mitigated through the use of various system design and layout features, such as automatic air release/vacuum valves installed at high points in system piping and at the pump discharge, proper valve actuation times to minimize water hammer, procedural requirements ensuring proper line filling prior to system operation and after maintenance operations, and the use of a check valve at each pump discharge to prevent backflow into the pump.

The above conceptual design information for the heat rejection facilities of the PSWS will be replaced with site-specific design information in the COLA FSAR.

Operation

The PSWS operates during startup, normal power operation, hot standby, cooldown, shutdown/refueling, and LOPP.

During normal power operation, the cross-tie valves in the PSWS pump discharge header are open, allowing two of the four 50% capacity PSWS pumps to supply water to both PSWS trains. Heat removed from the RCCWS and TCCWS is rejected to the normal power heat sink or to the auxiliary heat sink.

Operation of any two of the four PSWS pumps is sufficient for the design heat load removal in any normal operating mode. During normal and LOPP cooldown mode three pumps can be used for operational convenience to bring the plant to cold shutdown condition in 24 hours.

During a LOPP, the running PSWS pumps restart automatically using power supplied by the nonsafety-related standby diesel-generators.

9.2.1.3 Safety Evaluation

The PSWS has no safety-related function. Failure of the system does not compromise any safety-related system or component, nor does it prevent safe shutdown of the plant.

9.2.1.4 Testing and Inspection Requirements

Initial testing of the system includes performance testing of the heat rejection facilities and pumps for conformance with design heat loads, water flows, and heat transfer capabilities. An integrity test is performed on the system upon completion of construction. This initial testing of the system includes demonstrating that PSWS supplies adequate cooling water flow rate to the RCCWS and TCCWS heat exchangers.

Additional testing details of PSWS are described in Subsection 14.2.8.1.51.

Provision is made for periodic inspection of components to ensure the capability and integrity of the system. The pumps are tested in accordance with standards of the Hydraulic Institute ANSI/HI 2.6 (M108). Testing is performed to simulate the various modes of operation to the greatest extent practical.

Motor-operated valves are tested and inspected to ensure plant availability.

9.2.1.5 Instrumentation Requirements

The PSWS is operated and monitored from the MCR. The PSWS can also be operated from the remote shutdown panels.

With one PSWS pump operating, the respective standby pump starts automatically on detection of low system pressure signal in that train, loss of electric power to the operating pump, or operating pump trip signal.

Starting a PSWS pump automatically opens a flow path through the RCCWS and TCCWS heat exchangers. The PSWS pump will trip if the pump discharge valve fails to open ensuring minimum flow conditions are maintained.

The pump discharge strainers have remote manual override features for their automatic cleaning cycle. Pressure drop across the strainer is indicated in the MCR and a high-pressure drop is annunciated in the control room.

Supply and return header temperatures and supply header pressure are indicated in the MCR.

Each TCCWS and RCCWS heat exchanger has a pressure differential transmitter to indicate the pressure drop across the heat exchangers. In addition, a discharge flow transmitter is placed after each RCCWS and TCCWS heat exchanger. Flow elements and transmitters in the PSWS provide monitoring of system flow in the MCR and can be used to assist in leak detection.

This PSWS instrumentation conforms with GDC 13. Refer to Subsection 3.1.2 for a general discussion of the GDC.

9.2.1.6 COL Information

9.2.1-1-A Material Selection

The COL Applicant will determine material selection, including valve hard seat material, and provide provisions to preclude long-term corrosion and fouling of the PSWS based on site water quality analysis (Subsection 9.2.1.2).

9.2.1.7 References

9.2.1-1 Regulatory Guide 1.29 "Seismic Design Classification"

9.2.1-2 ANSI/HI 2.6 (M108) American National Standard for Vertical Pump Tests

9.2.2 Reactor Component Cooling Water System

9.2.2.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Reactor Component Cooling Water System (RCCWS) does not perform any safety-related function. Therefore, the RCCWS has no safety design basis.

The RCCWS has RTNSS functions as described in Appendix 19A, which provides the level of oversight and additional requirements to meet the RTNSS functions. Performance of RTNSS functions is assured by applying the defense-in-depth principles of redundancy and physical separation to ensure adequate reliability and availability as described in Subsection 19A.8.3.

The RCCWS meets the requirements of GDC 2 as it pertains to Position C.2 of Reg. Guide 1.29. The RCCWS also meets the intent of GDC 2 as it pertains to Position C.1 of Reg. Guide 1.29.

The RCCWS meets the intent of the acceptance criteria of GDC 4 for normal operation, maintenance, and testing. The RCCWS meets the intent of the acceptance criteria of GDC 4 with respect to dynamic effects associated with water hammer. The RCCWS has high point vents and operation and maintenance procedures assure sufficient measures are taken to avoid water hammer. The RCCWS also meets the intent of the acceptance criteria of GDC 4 for other dynamic effects, including the effects of missiles, jet impingement, pipe whipping, and discharging fluids, as clarified by the following design considerations:

- Pipe routing;

In the event of LOPP, the RCCWS supports the FAPCS and the RWCU/SDC in bringing the plant to cold shutdown condition in 36 hours if necessary assuming the most limiting single active failure. In addition, RCCWS provides cooling water to the Standby Onsite AC Power System Diesel Generators.

Each RCCWS train consists of parallel pumps, parallel heat exchangers, one surge tank, connecting piping, and instrumentation. Both trains share a chemical addition tank. The two trains are normally connected by crosstie piping during operation for flexibility, but may be isolated for individual train operation or maintenance of either train.

The pumps in each train discharge through check valves and butterfly valves to a common header leading to the RCCWS heat exchangers' header. Crosstie lines between each train are provided at the pump suction and discharge headers; and downstream of the Diesel Generators' cooling water supplies. There shall be two automatic train separation signals used to close the cross-tie valves, detection of unbalanced flow and a LOPP event. The heat exchanger outlet isolation valves are provided. The heat exchanger flow control valves, bypass temperature control valves, and cross-tie isolation valves are pneumatically operated.

RCCWS cooling water is supplied to the following major users:

- Chilled Water System (CWS) Nuclear Island chiller-condenser (Subsection 9.2.7)
- RWCU/SDC non-regenerative heat exchanger (Subsection 5.4.8)
- FAPCS heat exchanger (Subsection 9.1.3)
- Standby Onsite AC Power Supply Diesel Generators (Subsection 9.5.5)

The flow paths to heat exchangers and coolers are provided with flow balancing features that may be fixed orifice plates and/or control or manual valves, which can also be used for isolation. The major heat exchangers and coolers have motor-operated isolation valves for operator convenience.

The RCCWS pumps and heat exchangers are located in the Turbine Building. Table 9.2-4 shows the characteristics of the RCCWS pumps and heat exchangers.

The pumps in each train are powered from separate buses. During a LOPP, the pumps are powered from the two nonsafety-related standby diesel-generators.

The RCCWS utilizes plate type heat exchangers. Leakage through holes or cracks in the plates is not considered credible based on industry experience with plate type heat exchangers. In addition, the heat exchangers are designed such that any gasket leakage from either RCCWS or PSWS drains to the Equipment and Floor Drain System. This design mitigates cross-contamination of either RCCWS or PSWS. Pressure and air relief valves are provided as necessary.

Surge tanks provide a constant pump suction head and allow for thermal expansion of the RCCWS inventory. The tanks are located above the highest point in the system. Makeup to the RCCWS inventory is from the Makeup Water System (MWS) through an automatic level control valve. A manual valve provides a backup source of makeup from the Fire Protection System.

System Operation

The RCCWS operates during startup, normal power operation, hot standby, normal cooldown, shutdown/refueling, and LOPP.

RCCWS pump and heat exchanger configuration during each operational mode is shown in Table 9.2-5.

RCCWS heat exchanger operation is coordinated with PSWS flow. RCCWS cooling water flow through a RCCWS heat exchanger is only allowed if there is a corresponding PSWS water flow to absorb the heat load.

9.2.2.3 Safety Evaluation

The RCCWS has no safety-related function. Failure of the system does not compromise any safety-related system or component, nor does it prevent a safe shutdown of the plant.

There is no interface with the safety-related electrical system.

9.2.2.4 Testing and Inspection Requirements

All major components are tested and inspected as separate components prior to installation and as an integrated system after installation to ensure design performance. Additional testing details of RCCWS are described in Subsection 14.2.8.1.21.

Provision is made for periodic inspection of major components to ensure the continued capability and integrity of the system. Indicators are provided for vital parameters required for testing and inspection. Provisions for grab sampling of RCCWS cooling water are provided for chemical and radiological analyses.

9.2.2.5 Instrumentation Requirements

The RCCWS is operated and monitored from the Main Control Room (MCR). Major system parameters (loop flow rate, heat exchanger outlet temperature and pressure) are indicated in the MCR. Low pump discharge header pressure, high or low head tank level, and excessive makeup valve opening time are alarmed/annunciated in the MCR.

Temperature, pressure and level indicators provide additional component performance information.

The RCCWS heat exchanger isolation valves operate in coordination with the corresponding PSWS flow. Failure of a RCCWS pump automatically starts the standby pump. Failure of one of the electrical buses automatically starts the standby pump(s) in the unaffected train.

RCCWS radiation monitors are provided for monitoring radiation levels and alerting the plant operator of abnormal radiation levels.

This RCCWS instrumentation conforms to GDC 13. Refer to Subsection 3.1.2 for a general discussion of the GDC.

The RCCWS surge tank levels are used to monitor losses of cooling water, and detect intersystem leakage intrusions into RCCWS. The level transmitters in the surge tank standpipes in combination with low-low surge tank level automatically initiate a train shut down. A train shutdown signal will trip off all pumps in the train and close all isolation, bypass, and flow control valves.

9.2.2.6 COL Information

None

9.2.2.7 References

None

9.2.3 Makeup Water System

9.2.3.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Makeup Water System (MWS) is a nonsafety-related system, and has no safety design basis other than provision for safety-related containment penetrations and isolation valves. The MWS meets GDC 2, as it relates to meeting the guidance of Regulatory Guide (RG) 1.29. The applicable sections of RG 1.29 include Position C.1 for safety-related portions and Position C.2 for nonsafety-related portions. The seismic and quality group classifications are identified in Table 3.2-1. The MWS meets GDC 5 for shared systems and components important to safety. The MWS Standard Plant design does not share any SSC with any other unit.

As discussed below, if available, the MWS can be used to provide makeup water to the Isolation Condenser / Passive Containment Cooling (IC/PCCS) pools following an anticipated operational occurrence (AOO) or any abnormal event. However, this MWS function is not assumed or modeled in any safety analysis.

Power Generation Design Bases

The MWS is designed to supply demineralized water to the equipment and components shown in Table 9.2-6, and meets the water quality requirements shown in Tables 9.2-7 and 9.2-8.

The system provides the following design functions:

- Remove dissolved minerals, organics, and other impurities;
- Transfer Makeup Water throughout the entire plant; and
- Provide 7 day capacity of makeup water demand during normal power generation.

9.2.3.2 System Description

The MWS consists of two subsystems: (1) the demineralization subsystem and (2) the storage and transfer subsystem. The demineralization subsystem is a conceptual design that is dependent on the site-specific water quality of the available source water. The storage and transfer subsystem is a standard design applicable to any site. The makeup water transfer pumps and the demineralization subsystem are sized to meet the demineralized water needs of all operation conditions except for shutdown/refueling/startup. During the shutdown/refueling/startup mode, the increases in plant water consumption may require use of a temporary demineralization

- The chiller units are packaged designs, including centrifugal compressor, condenser, evaporator, refrigerant piping, relief valve, instrumentation, pump out unit, oil heater, refrigerant, controls, and control panel. The compressor inlet guide vanes are modulated by the chiller leaving water temperature to regulate the chillers output capacity ; and
- The chiller units are capable of operating at partial capacity; varying from less than 25% to 100%.

The surge tanks provide a constant pump suction head and allow for thermal expansion/contraction of the chilled water inventory. Surge tanks are designed with sufficient make-up capacity to accommodate design leakage from the system. Surge tanks also provide NPSH to the CWS pumps and maintain system pressure above vapor pressure to mitigate voiding. The tanks are located a minimum of three feet above the highest system point and the use of sloped piping minimizes the potential for air binding. Makeup to the chilled water inventory is from the Makeup Water System through an automatic level control valve to the surge tanks.

The CWS component design characteristics are listed in Table 9.2-11. The CWS simplified diagram is shown in Figure 9.2-3.

Detailed NICWS Description

The NICWS consists of two 100% capacity trains (Train A and Train B), with redundancy and independence for active components. Each NICWS train consists of parallel pumps, parallel chillers, one surge tank, an air separator, startup strainer, active valves, and instrumentation. Chilled water is supplied from either train to a common header that distributes chilled water to the NICWS loads throughout the facility via a single piping distribution loop. Individual chillers and pumps are isolable for maintenance and repair. A chemical feed tank is installed in parallel with the loads for corrosion inhibitor addition to the chilled water. Each train is powered from separate buses.The following units are cooled by the NICWS:

- Fuel Building HVAC air handling units;
- Control Building HVAC air handling units;
- Reactor Building HVAC air handling units;
- Drywell Air Coolers;
- RCCWS equipment room HVAC fan coil units in Turbine Building;
- Service air compressors room HVAC fan coil units in Turbine Building;
- NICWS chillers room HVAC fan coil units in Turbine Building;
- Diesel Generator Control Equipment Room;
- Technical Support Center in Electrical Building; and
- Electrical Building HVAC air handling units.

The NICWS condensers are cooled by the RCCWS.

9.2.7.4 Testing and Inspection Requirements

Initial testing of the system includes performance testing of the chillers, pumps and coils for conformance with design heat loads, water flows, and heat transfer capabilities. An integrity test is performed on the system upon completion.

Provision is made for periodic inspection of major components to ensure the capability and integrity of the system. Local display devices are provided to indicate all vital parameters during testing and inspections.

The pumps are tested in accordance with standards of the Hydraulic Institute ANSI/HI 1.6 (M104).

The functional capabilities of the containment isolation valves are testable in-place in accordance with the inservice inspection requirements. Periodic leak testing of the containment isolation valves is prescribed in the Technical Specifications (refer to DCD Chapter 16) and described in Subsection 6.2.6.

Samples of chilled water may be obtained for chemical analyses. System design ensures that the chilled water does not become radioactive during normal operation.

9.2.7.5 Instrumentation Requirements

The CWS status indications, control instrumentation, alarms and annunciators are located in the MCR to provide the operator sufficient data for remote operation of standby units. The plant-wide multiplexing system provides data communication and control.

The chillers and pumps automatically startup and shutdown according to chilled water flow required by the plant. They can also be manually started from the MCR or from the local chiller control panels. The local control panels display the active component operating status and system parameters including flows, temperatures, and pressures.

Chiller package protective controls and monitoring instruments indicate high and low oil pressure, condenser pressure, high and low chilled water temperature and flow, high and low condenser water temperature and flow, and unit diagnostics.

A CWS standby chiller unit starts automatically upon failure of an operating unit. Loss of chilled water or RCCWS/TCCWS cooling water flow automatically stops the chiller unit and associated chilled water recirculating pump.

The chilled water temperature is automatically controlled.

Protective interlocks prevent chiller start if there is no flow through the evaporator or if the RCCWS/TCCWS flow through the NICWS/BOPCWS condenser is out of range. An anti-recycle timer prevents successive compressor starts.

CWS system containment penetration line isolation valves automatically close on a containment isolation signal to control the NICWS flow into and out of the containment (refer to Subsection 6.2.4).

The surge tanks are provided with level controlled demineralized water makeup valves and high/low level alarms in the MCR. The CWS surge tank levels are used to monitor losses of chilled water, and detect inter-system leakage or intrusions into CWS. Low-low surge tank level will alarm in the Control Room. This alarm indicates that system leakage has exceeded makeup water capacity. High-high surge tank level alarms in the Control Room. This alarm indicates that there is inter-system leakage into CWS. The level transmitters in the surge tank standpipes monitor the surge tank levels to ensure that sufficient NPSH is available for pump operation.

This CWS instrumentation conforms to GDC 13. Refer to Subsection 3.1.2 for a general discussion of the GDC.

9.2.7.6 COL Information

None

9.2.7.7 References

9.2.7-1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.(ASHRAE) Standard 30, Methods of Testing Liquid-Chilling Packages

9.2.7-2 ANSI/HI 1.6 (M104), Centrifugal Tests

9.2.8 Turbine Component Cooling Water System

9.2.8.1 Design Bases

Safety (10 CFR 50.2) Design Bases

The Turbine Component Cooling Water System (TCCWS) does not perform or ensure any safety-related function, and thus, has no safety design basis.

There are no connections between the TCCWS and any safety-related systems.

Power Generation Design Bases

The TCCWS provides cooling water to all turbine island auxiliary equipment listed in Table 9.2-12.

During power operation, the TCCWS operates to provide a continuous supply of cooling water to the turbine island auxiliary equipment.

The TCCWS is designed to permit the maintenance of any single active component without interruption of the cooling function.

Makeup to the TCCWS is designed to permit continuous system operation with design failure leakage and to permit expeditious post-maintenance system refill.

The TCCWS includes an atmospheric surge tank located such that the water level in the tank is above any other component in the system.

The TCCWS utilizes plate and frame type heat exchangers. This design mitigates cross-contamination between TCCWS and the PSWS.

9.2.8.2 System Description

Summary Description

The TCCWS is a single loop system and consists of one surge tank, one chemical addition tank, pumps, heat exchangers connected in parallel, associated coolers, piping, valves, controls, and

Table 9.2-1
PSWS Heat Loads

Normal Operation		
Trains A and B		
RCCW System:	33.8 MW	1.15×10^8 Btu/hr
TCCW System:	45.6 MW	1.56×10^8 Btu/hr
Total Trains A and B:	79.4 MW	2.71×10^8 Btu/hr
Normal Cooldown[1]		
Trains A and B		
RCCW System:	90.9 MW	3.10×10^8 Btu/hr
TCCW System:	21 MW	7.17×10^7 Btu/hr
Total Trains A and B:	111.9 MW	3.82×10^8 Btu/hr
Single Train Failure Cooldown[2]		
Train A or B		
RCCW System	59.8 MW	2.04×10^8 Btu/hr
TCCW System	21 MW	7.17×10^7 Btu/hr
Total Train A or B	80.8 MW	2.75×10^8 Btu/hr
LOPP Operation		
Single Train Failure, 2 PSWS Pumps	74.8 MW	2.55×10^8 Btu/hr
Both Trains, 3 PSWS Pumps	120.8 MW	4.12×10^8 Btu/hr

Note 1: Normal Shutdown Cooling such that the reactor coolant temperature is reduced to 60°C (140°F) in 24 hours.

Note 2: Design Limiting Condition - Reach cold shutdown conditions of 93.3°C (200°F) in 36 hours.

Table 9.2-2

PSWS Component Design Characteristics

PSWS Pumps	
Type	Vertical, wet-pit, centrifugal turbine
Quantity	4
Capacity Each	1.262 m^3/s (20,000 gpm)
Plant Service Water System[1]	
Flow (NPHS or AHS)	2.524 m^3/s (40,000 gpm)
PSWS Cooling Towers and Basins	
Type[2]	Mechanical draft, multi-cell, redundant adjustable speed, reversible fans
Quantity[2]	2
Heat Load Each[3]	~~90~~ 83.5 MW (2.85~~3.07 x 10~~^{8} BTU/hr)
Flow Rate (Water) Each	2.524 m^3/s (40000 gpm)
Ambient Wet Bulb Temperature[2]	27.8°C (82°F)
Approach Temperature[2,]	3.3°C (6°F)
Cold Leg Temperature	31.1°C (88°F)
Strainers	
Type	Automatic cleaning, basket
Quantity	4

1 – PSWS required to remove 2.02 X 10^7 MJ (1.92 X 10^{10} BTU) for period of 7 days without active makeup

2 – Conceptual Design Information

3 – Minimum heat load cooling towers need to be able to reject

Table 9.2-3

RCCWS Nominal Heat Loads

Normal Operation		
Nominal Heat Load Contributions		
RWCU/SDC:	9.6 MW	32.8 MBtu/hr
FAPCS:	9.6 MW	32.8 MBtu/hr
CWS:	12.3 MW	41.9 MBtu/hr
Diesel Generator	0 MW	0 MBtu/hr
Other:	2.3 MW	7.8 MBtu/hr
Total Trains A & B:	33.8 MW	115 MBtu/hr
Normal Cooldown [2]		
Nominal Heat Load Contributions (Train A)		
RWCU/SDCS:	28 MW	95.6 MBtu/hr
FAPCS:	9.6 MW	32.8 MBtu/hr
CWS:	12.3 MW [1]	41.9 MBtu/hr
Other	1.9 MW	6.5 MBtu/hr
Diesel Generator A	0 MW	0 MBtu/hr
Total Train A:	51.8 MW	177 MBtu/hr
Nominal Heat Load Contributions (Train B)		
RWCU/SDC:	28 MW	95.6 MBtu/hr
FAPCS	9.6 MW	32.8 MBtu/hr
Diesel Generator B	0 MW	0 MBtu/hr
Other:	1.5 MW	5.1 MBtu/hr
Total Train B:	39.1 MW	133 MBtu/hr
Total Train A&B:	90.9 MW	310 MBtu/hr

Table 9.2-3

RCCWS Nominal Heat Loads (Continued)

Single Failure Cooldown w/ LOPP[3]		
Nominal Heat Load Contributions (Train A or B)		
RWCU/SDC:	36 MW	123 MBtu/hr
FAPCS:	9.6 MW	32.8 MBtu/hr
CWS:	12.3 MW	41.9 MBtu/hr
Diesel Generator	15 MW	51.1 MBtu/hr
Other:	1.9 MW	6.5 MBtu/hr
Total Train A or B:	74.8 MW	255.2 MBtu/hr

1 [1]–Total CWS Heat Load shown is applicable to Train A or B, or shared between the two trains.

2 Normal Shutdown Cooling such that the reactor coolant temperature is reduced to 60°C (140°F) in 24 hours.

3 Design Limiting Condition - Reach cold shutdown conditions of 93.3°C (200°F) in 36 hours.

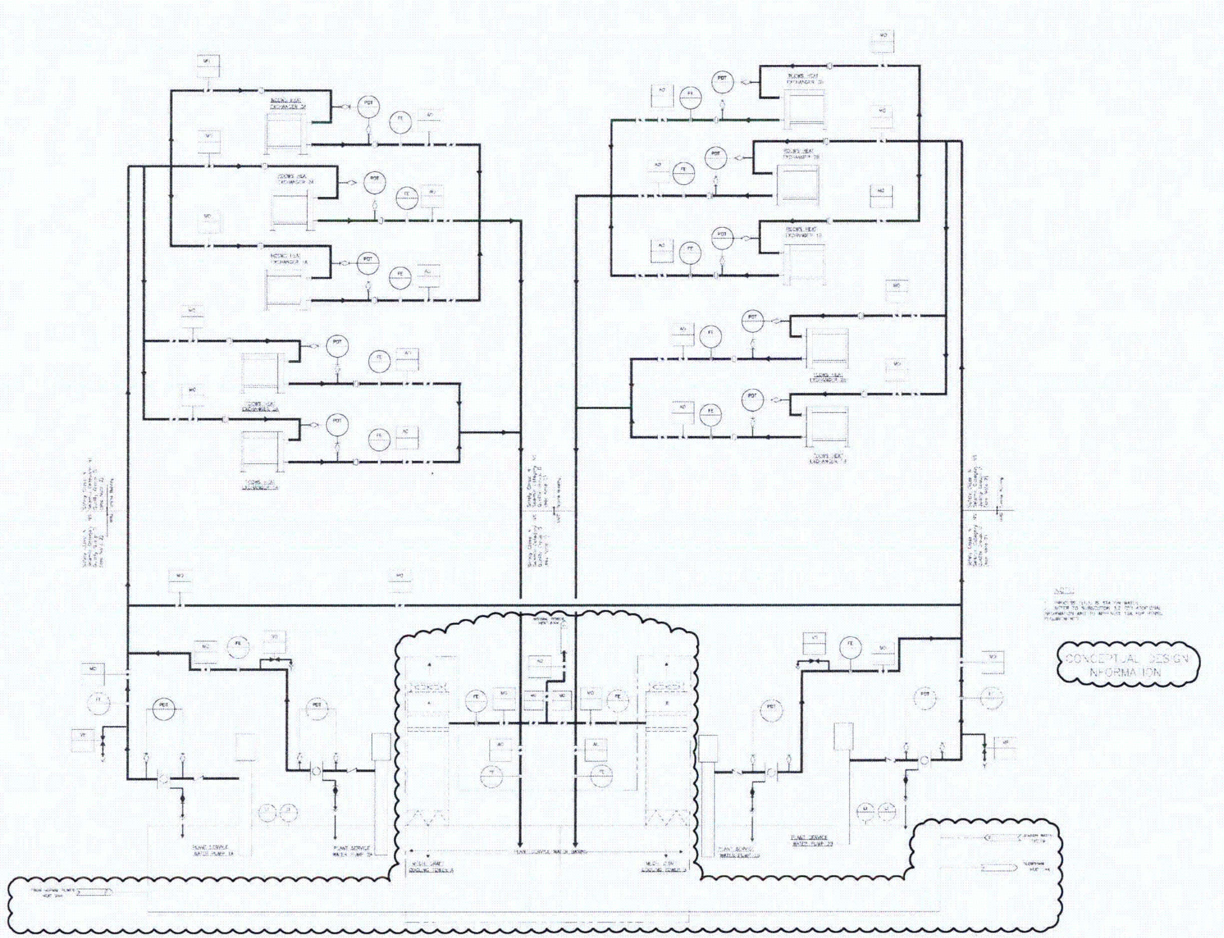
Table 9.2-5

RCCWS Configuration by Mode

Operation Mode	No. Train A Pumps Used	No. Train B Pumps Used	No. Train A HX Used	No. Train B HX Used	Total No. Pumps Used	Total No. HX Used	Total Cooling Water Flow
Normal Operation	1	1	1	1	2	2	2,700 m^3/hr (11,888 gpm)
Normal Cooldown[1]	2	2	2	2	4	4	5,400 m^3/hr (23,775 gpm)
Cooldown w/ Single Failure of Train A	0	2	0	2	2	2	2,700 m^3/hr (11,888gpm)
Cooldown w/ Single Failure of Train B	2	0	2	0	2	2	2,700 m^3/hr (11,888gpm)
Cooldown w/ Single Failure of Train A w/ LOPP[2]	0	3	0	3	3	3	4,050 m^3/hr (17,832 gpm)
Cooldown w/ Single Failure of Train B w/ LOPP	3	0	3	0	3	3	4,050 m^3/hr (17,832 gpm)
Normal Cooldown w/ LOPP[2]	3	3	3	3	6	6	8,100 m^3/hr (35,663 gpm)

1. Normal Shutdown Cooling such that the reactor coolant temperature is reduced to 60°C (140°F) in 24 hours.

2. Design Limiting Condition - Reach cold shutdown conditions of 93.3°C (200°F) in 36 hours.


CONCEPTUAL DESIGN INFORMATION

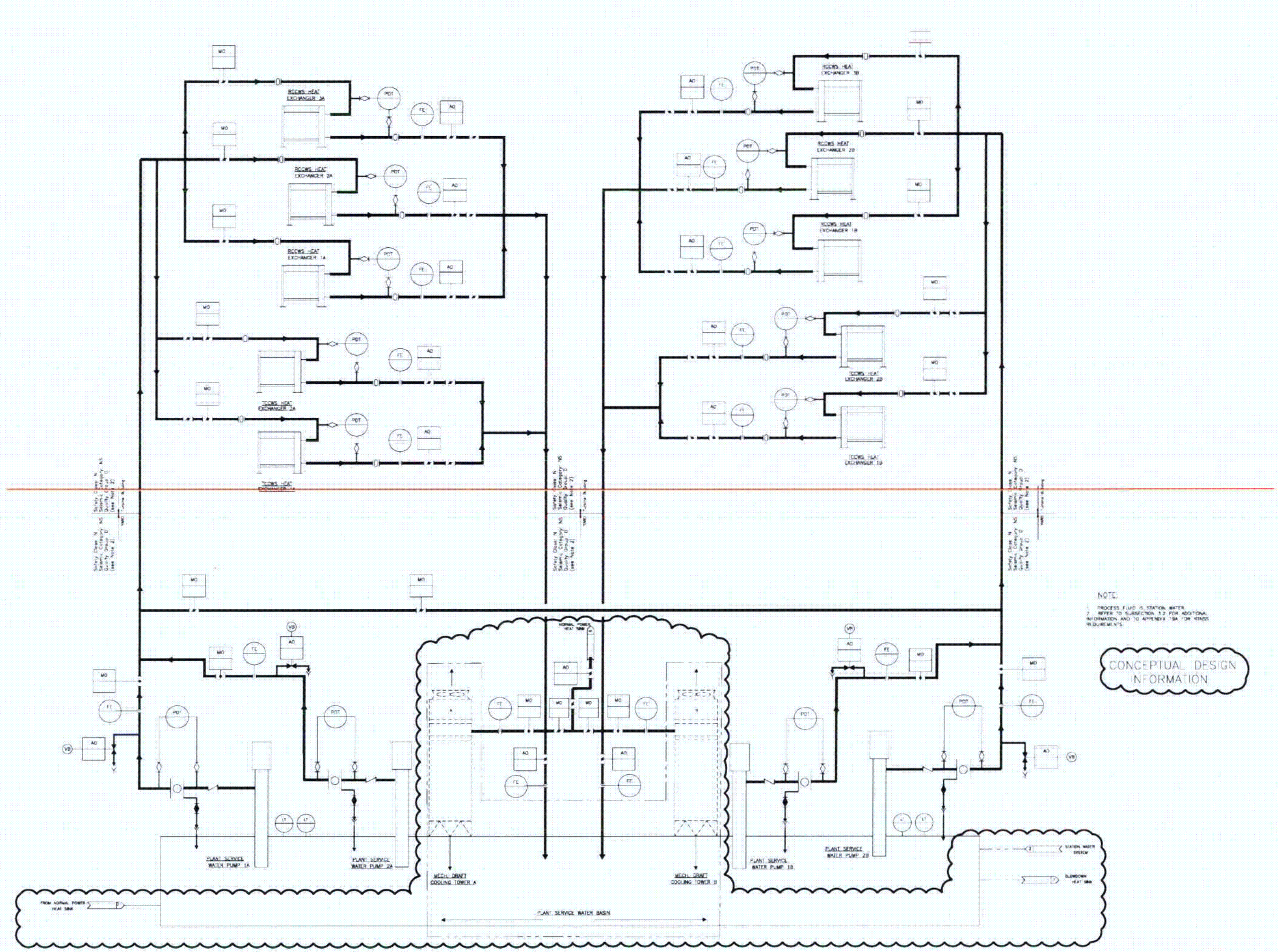
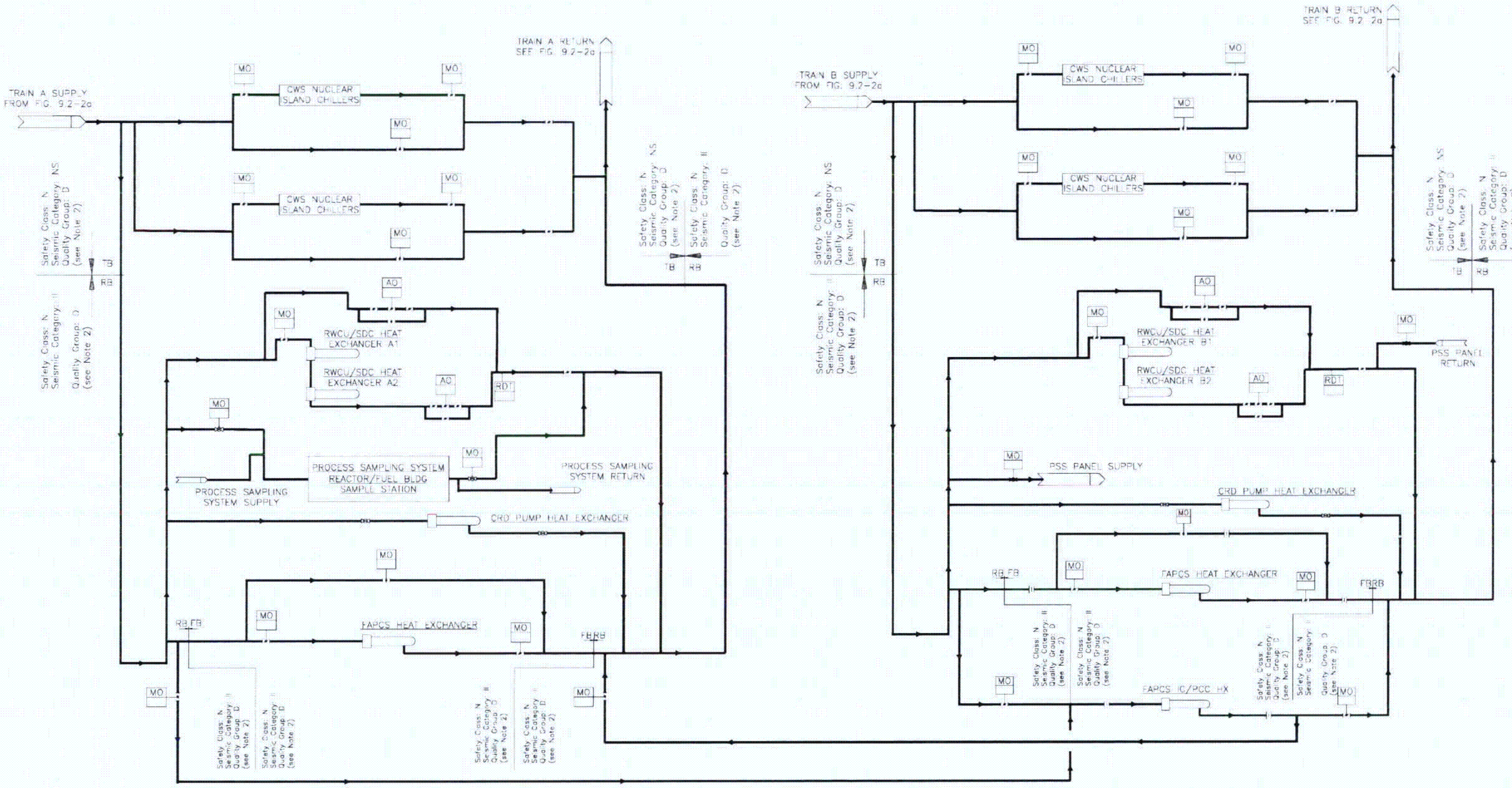
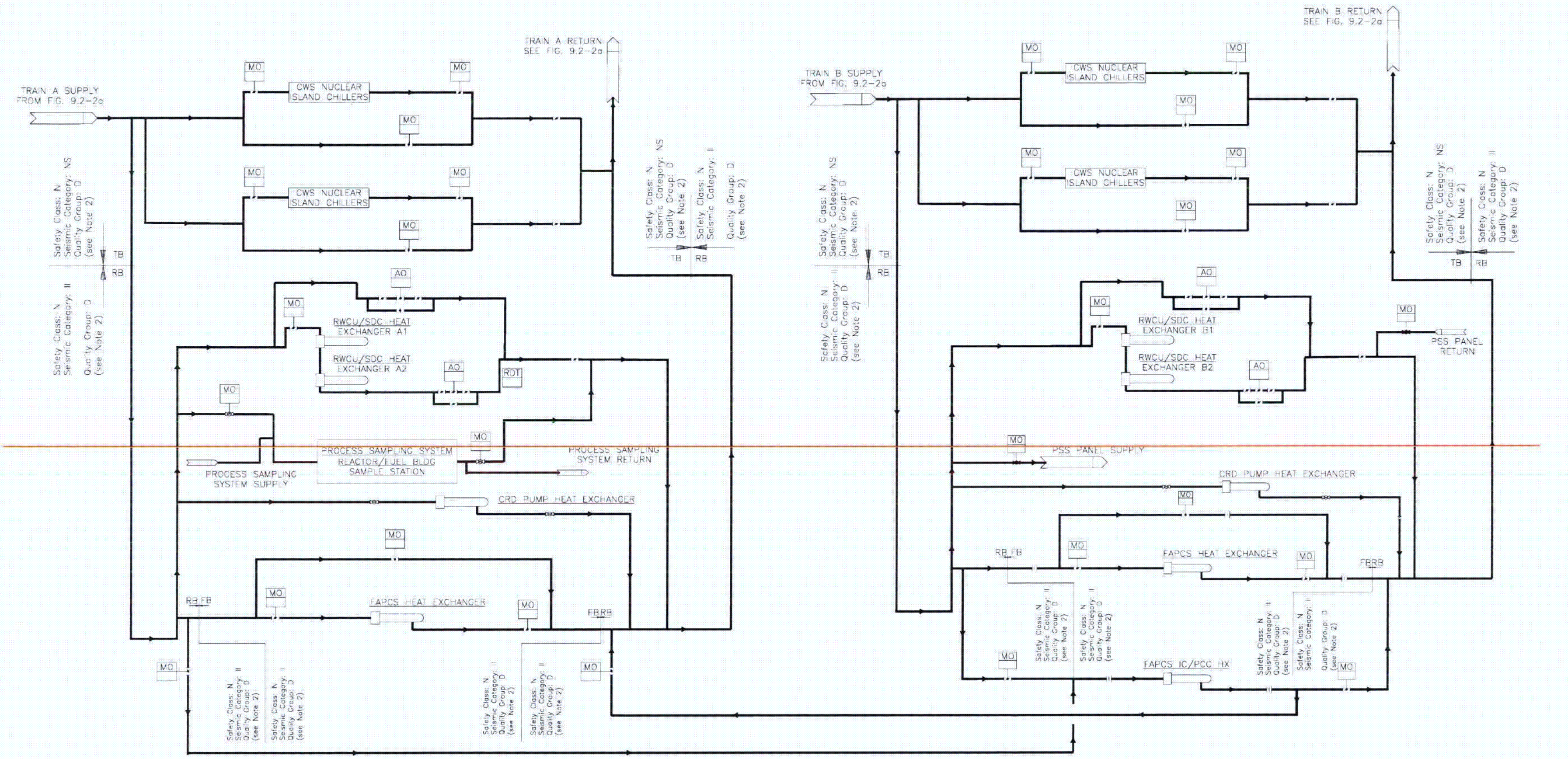


Figure 9.2-1. Plant Service Water System Simplified Diagram



NOTES:

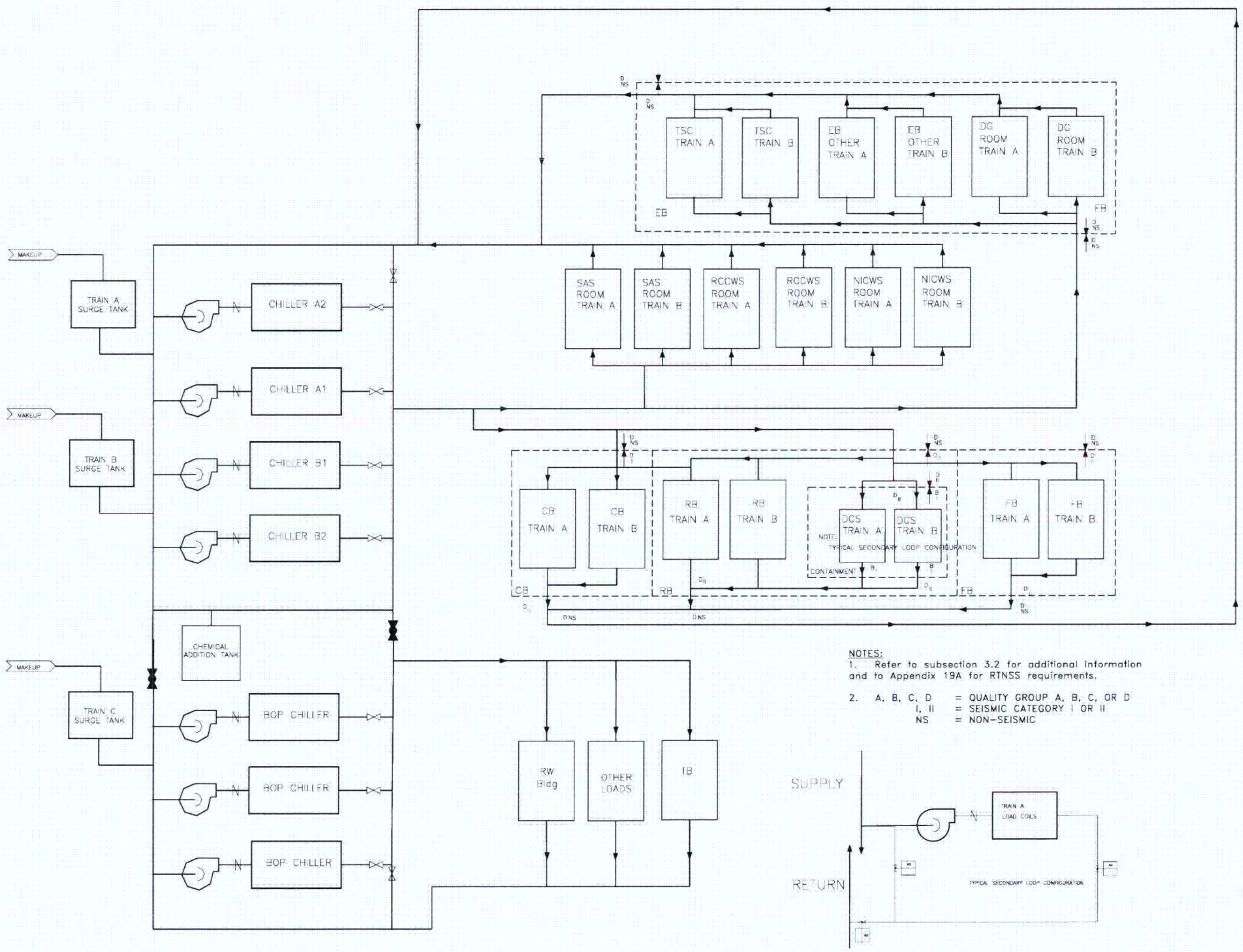
1. MISCELLANEOUS COOLERS NOT SHOWN ON THE P&ID INCLUDE RWCU/SDS PUMP COOLERS, FAPCS PUMP COOLERS, SAS AIR COMPRESSORS AND OTHER MINOR COOLERS AS REQUIRED.
2. REFER TO SUBSECTION 3.2 FOR ADDITIONAL INFORMATION AND TO APPENDIX 19A FOR RTNSS REQUIREMENTS.
3. PROCESS FLUID IS DEMINERALIZED WATER.
4. RADIATION DETECTION EQUIPMENT IS PART OF THE PRMS SYSTEM.



NOTES:

1. MISCELLANEOUS COOLERS NOT SHOWN ON THE P&ID INCLUDE RWCU/SDS PUMP COOLERS, FAPCS PUMP COOLERS, SAS AIR COMPRESSORS AND OTHER MINOR COOLERS AS REQUIRED.
2. REFER TO SUBSECTION 3.2 FOR ADDITIONAL INFORMATION AND TO APPENDIX 19A FOR RTNSS REQUIREMENTS.
3. PROCESS FLUID IS DEMINERALIZED WATER.
4. RADIATION DETECTION EQUIPMENT IS PART OF THE PRMS SYSTEM.

Figure 9.2-2.b Reactor Component Cooling Water System


MAKEUP
TRAIN A SURGE TANK
CHILLER A2
CHILLER A1
MAKEUP
TRAIN B SURGE TANK
CHILLER B1
CHILLER B2
CHEMICAL ADDITION TANK
MAKEUP
TRAIN C SURGE TANK
BOP CHILLER
BOP CHILLER
BOP CHILLER
TSC TRAIN A
TSC TRAIN B
EB OTHER TRAIN A
EB OTHER TRAIN B
DG ROOM TRAIN A
DG ROOM TRAIN B
EB
FB
SAS ROOM TRAIN A
SAS ROOM TRAIN B
RCCWS ROOM TRAIN A
RCCWS ROOM TRAIN B
NICWS ROOM TRAIN A
NICWS ROOM TRAIN B
CB TRAIN A
CB TRAIN B
RB TRAIN A
RB TRAIN B
DCS TRAIN A
DCS TRAIN B
NOTE: TYPICAL SECONDARY LOOP CONFIGURATION
CONTAINMENT
FB TRAIN A
FB TRAIN B
CB
RB
FB
RW Bldg
OTHER LOADS
TB
NOTES:
1. Refer to subsection 3.2 for additional information and to Appendix 19A for RTNSS requirements.
2. A, B, C, D = QUALITY GROUP A, B, C, OR D
I, II = SEISMIC CATEGORY I OR II
NS = NON-SEISMIC
SUPPLY
RETURN
TRAIN A LOAD COILS
TYPICAL SECONDARY LOOP CONFIGURATION

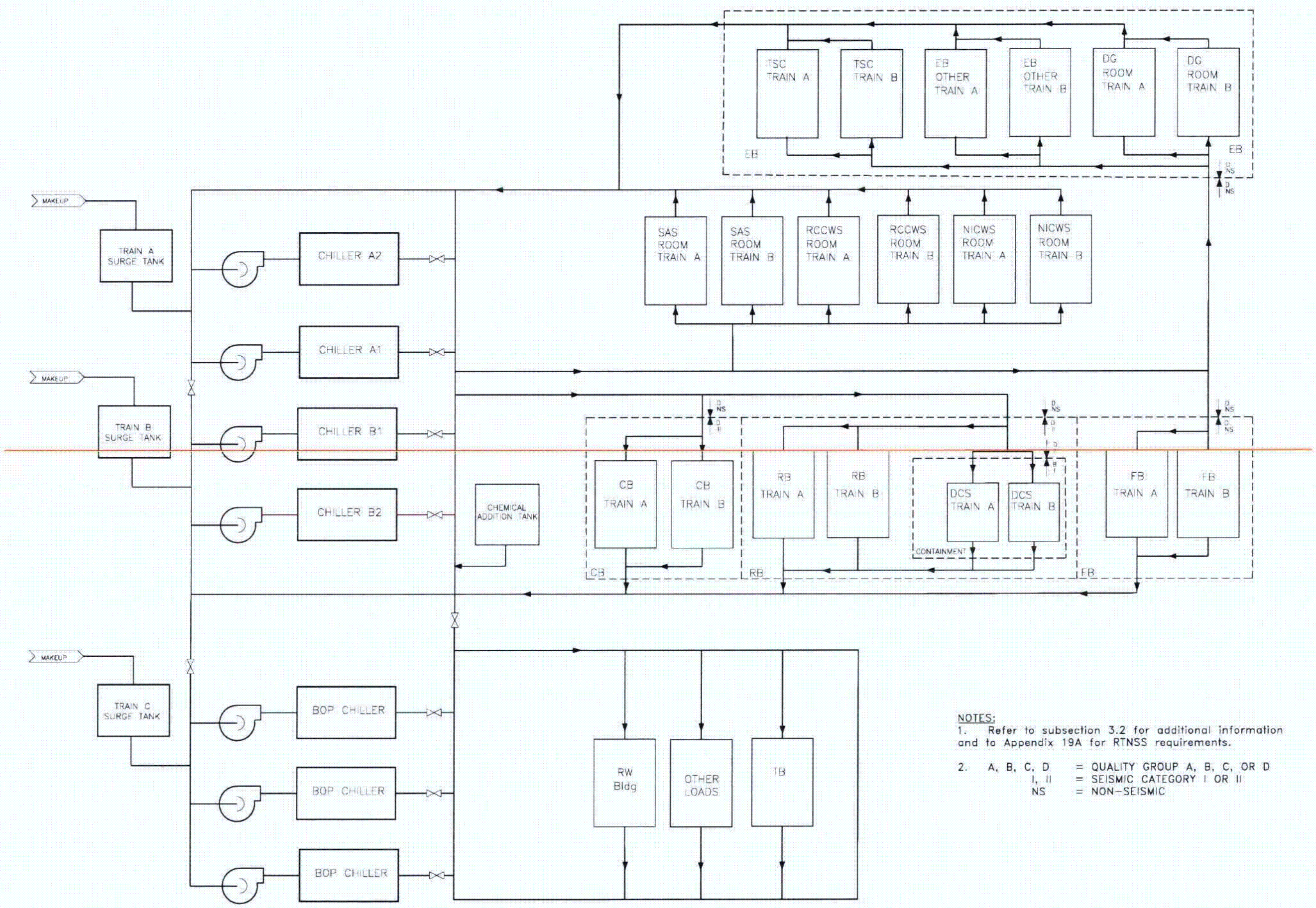


Figure 9.2-3. Chilled Water System Simplified Diagram

- Proper operation of system valves including automatic air release/vacuum valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;
- Acceptable pump suction under the most limiting design flow conditions;
- Proper operation of motorized self cleaning strainers;
- Proper system flow paths and flow rates, including pump capacity and discharge head;
- Proper pump motor start sequence and margin to actuation of protective devices;
- Proper operation of interlocks and equipment protective devices in pump, motor and valve controls;
- Proper operation of freeze protection methods and devices, if applicable; and
- Acceptability of pump/motor vibration levels and system piping movements during both transient and steady state operation.

The heat exchangers, which serve as interface with the RCCWS and TCCWS, are considered part of those systems and are tested as such. However, due to insufficient heat loads during the preoperational test phase, the heat exchanger performance verification is deferred until the startup phase.

14.2.8.1.52 Turbine Component Cooling Water System Preoperational Test

Purpose

The objective of this test is to verify proper operation of the TCCWS and its ability to supply design quantities of cooling water, at the specified temperatures, to designated plant loads.

Prerequisites

The construction tests have been successfully completed and the SCG has reviewed the test procedure and approved the initiation of testing. Electric power, PSWS, instrument air, and other required supporting systems shall be available, as needed, for the specified testing configurations. The cooled components shall be operating to the extent practical during heat exchanger performance evaluation.

General Test Methods and Acceptance Criteria

Performance shall be observed and recorded during a series of individual component and integrated system tests to demonstrate the following:

- Proper operation of instrumentation and equipment in appropriate design combinations of logic and instrument channel trip;
- Proper functioning of instrumentation and alarms used to monitor system operation and availability;
- Proper operation of system valves, including timing, under expected operating conditions;
- Proper operation of pumps and motors in all design operating modes;