UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 8, 2021

Mr. David P. Rhoades
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: R.E. GINNA NUCLEAR POWER PLANT – CLOSEOUT OF GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (EPID L-2017-LRC-0000)

Dear Mr. Rhoades:

The U.S. Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML042360586), dated September 13, 2004, requesting that licensees address the issues raised by Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on PWR [Pressurized Water Reactor] Sump Performance."

By letter dated May 15, 2013 (ADAMS Accession No. ML13141A272), Constellation Energy Nuclear Generation Group (the licensee) stated that they will pursue Option 2 (deterministic) for the closure of GSI-191 and GL 2004-02 for R.E. Ginna Nuclear Power Plant (Ginna). Subsequently, by letter dated April 28, 2021 (ADAMS Accession No. ML21118A007), the licensee determined that they would continue their plan to use the method of deterministic resolution under Option 2.

On July 23, 2019 (ADAMS Package Accession No. ML19203A303), GSI-191 was closed. It was determined that the technical issues identified in GSI-191 were now well understood, and therefore, GSI-191 could be closed. Prior to and in support of closing GSI-191, the NRC staff issued a technical evaluation report on in-vessel downstream effects (ADAMS Accession Nos. ML19178A252 and ML19073A044 (not publicly available, proprietary information)). Following the closure of GSI-191, the NRC staff also issued the review guidance for in-vessel downstream effects, "U.S. Nuclear Regulatory Commission Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of Generic Letter 2004-02 Responses" (ADAMS Accession No. ML19228A011), dated September 4, 2019, to support review of the GL 2004-02 responses.

The NRC staff has reviewed the licensee's responses and supplements associated with GL 2004-02. Based on the evaluations, the NRC staff finds the licensee has provided adequate information as requested by GL 2004-02.

The stated purpose of GL 2004-02 was focused on demonstrating compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46. Specifically, GL 2004-02 requested addressees to perform an evaluation of the emergency core cooling system and containment spray system recirculation and, if necessary, take additional action to ensure system function considering the potential for debris to adversely affect long-term core cooling. The NRC staff finds the information provided by the licensee demonstrates that debris will not inhibit the emergency core cooling system or containment spray system performance following a postulated loss-of-coolant accident. Therefore, the ability of the systems to perform their safety functions, to assure adequate long-term core cooling following a design-basis accident, as required by 10 CFR 50.46, has been demonstrated.

Based on its review, the NRC staff finds the licensee's responses to GL 2004-02 are adequate and considers GL 2004-02 closed for Ginna.

Enclosed is the summary of the NRC staff's review. If you have any questions, please contact me at 301-415-2597 or via e-mail at V.Sreenivas@nrc.gov.

Sincerely,

/RA/

V. Sreenivas, Project Manager
Plant Licensing Branch I
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-244

Enclosure:
NRC Staff Review of GL 2004-02
for Ginna

cc: Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

U.S. NUCLEAR REGULATORY COMMISSION STAFF REVIEW

OF THE DOCUMENTATION PROVIDED BY

CONSTELLATION ENERGY NUCLEAR GENERATION GROUP

FOR R.E. GINNA NUCLEAR POWER PLANT

DOCKET NO. 50-244

CONCERNING RESOLUTION OF GENERIC LETTER 2004-02

POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING

DESIGN-BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS

1.0 INTRODUCTION

A fundamental function of the Emergency Core Cooling System (ECCS) is to recirculate water that has collected at the bottom of the containment through the reactor core following a break in the reactor coolant system (RCS) piping to ensure long-term removal of decay heat from the reactor fuel. Leaks from the RCS, hypothetical scenarios known as loss-of-coolant accidents (LOCAs), are part of every plant's design-basis. Hence, nuclear plants are designed and licensed with the expectation that they are able to remove reactor decay heat following a LOCA to prevent core damage. Long-term core cooling (LTCC) following a LOCA is a basic safety function for nuclear reactors. The recirculation sump provides a water source to the ECCS in a pressurized-water reactor (PWR) once the primary water source has been depleted.

If a LOCA occurs, piping thermal insulation and other materials may be dislodged by the two-phase coolant jet emanating from the broken RCS pipe. This debris may transport, via flows coming from the RCS break or from the containment spray system (CSS), to the pool of water that collects at the bottom of containment following a LOCA. Once transported to the sump pool, the debris could be drawn towards the ECCS sump strainers, which are designed to prevent debris from entering the ECCS and the reactor core. If this debris were to clog the strainers and prevent coolant from entering the reactor core, containment cooling could be lost and result in core damage and containment failure.

It is also possible that some debris would bypass the sump strainer and lodge in the reactor core. This could result in reduced core cooling and potential core damage. If the ECCS strainer were to remain functional, even with core cooling reduced, containment cooling would be maintained, and the containment function would not be adversely affected.

Findings from research and industry operating experience raised questions concerning the adequacy of PWR sump designs. Research findings demonstrated that, compared to other LOCAs, the amount of debris generated by a high-energy line break (HELB) could be greater.

The debris from a HELB could also be finer (and thus more easily transportable) and could be comprised of certain combinations of debris (i.e., fibrous material plus particulate material) that could result in a substantially greater flow restriction than an equivalent amount of either type of debris alone. These research findings prompted the U.S. Nuclear Regulatory Commission (NRC) to open Generic Safety Issue (GSI) - 191, "Assessment of Debris Accumulation on PWR Sump Performance," in 1996. This resulted in new research for PWRs in the late 1990s.

GSI-191 focuses on reasonable assurance that the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46(b)(5) are met. This deterministic rule requires maintaining LTCC after initiation of the ECCS. The objective of GSI-191 is to ensure that post-accident debris blockage will not impede or prevent the operation of the ECCS and CSS in recirculation mode at PWRs during LOCAs or other HELB accidents for which sump recirculation is required. The NRC completed its review of GSI-191 in 2002 and documented the results in a parametric study that concluded that sump clogging at PWRs was a credible concern.

GSI-191 concluded that debris clogging of sump strainers could lead to recirculation system ineffectiveness as a result of a loss of net positive suction head (NPSH) for the ECCS and CSS recirculation pumps. Resolution of GSI-191 involves two distinct but related safety concerns: (1) potential clogging of the sump strainers that results in ECCS and/or CSS pump failure; and (2) potential clogging of flow channels within the reactor vessel because of debris bypass of the sump strainer (in-vessel effects). Clogging at either the strainer or in-vessel channels can result in loss of the long-term cooling safety function.

After completing the technical assessment of GSI-191, the NRC issued Bulletin 03-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML031600259), dated June 9, 2003. The Office of Nuclear Reactor Regulation (NRR) requested and obtained the review and endorsement of the bulletin from the Committee to Review Generic Requirements (CRGR) (ADAMS Accession No. ML031210035), dated August 30, 2003. As a result of the emergent issues discussed in Bulletin 03-01, the NRC staff requested an expedited response from PWR licensees on the status of their compliance of regulatory requirements concerning the ECCS and CSS recirculation functions based on a mechanistic analysis. The NRC staff asked licensees, who chose not to confirm regulatory compliance, to describe any interim compensatory measures that they had implemented or will implement to reduce risk until the analysis could be completed. All PWR licensees responded to Bulletin 03-01. The NRC staff reviewed all licensees' Bulletin 03-01 responses and found them acceptable.

In developing Bulletin 03-01, the NRC staff recognized that it might be necessary for licensees to undertake complex evaluations to determine whether regulatory compliance exists in light of the concerns identified in the bulletin and that the methodology needed to perform these evaluations was not currently available. As a result, that information was not requested in Bulletin 03-01, but licensees were informed that the NRC staff was preparing a Generic Letter (GL) that would request this information. GL 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design-basis Accidents at Pressurized-Water Reactors," dated September 13, 2004 (ADAMS Accession No. ML042360586), was the follow-on information request referenced in Bulletin 03-01. This document set the expectations for resolution of PWR sump performance issues identified in GSI-191, to ensure the reliability of the ECCS and CSS at PWRs. NRR requested and obtained the review and endorsement of the GL from the CRGR (ADAMS Accession No. ML040840034), dated March 23, 2004.

GL 2004-02 requested that addressees perform an evaluation of the ECCS and CSS recirculation functions in light of the information provided in the letter and, if appropriate, take additional actions to ensure system function. Additionally, addressees were requested to submit the information specified in GL 2004-02 to the NRC. The request was based on the identified potential susceptibility of PWR recirculation sump screens to debris blockage during design-basis accidents (DBAs) requiring recirculation operation of ECCS or CSS and on the potential for additional adverse effects due to debris blockage of flow paths necessary for ECCS and CSS recirculation and containment drainage. GL 2004-02 required addressees to provide the NRC a written response in accordance with 10 CFR 50.54(f).

By letter dated May 28, 2004 (ADAMS Package Accession No. ML041550661), the Nuclear Energy Institute (NEI) submitted a report describing a methodology for use by PWRs in the evaluation of containment sump performance. The NEI requested that the NRC review the methodology. The methodology was intended to allow licensees to address and resolve GSI-191 issues in an expeditious manner through a process that starts with a conservative baseline evaluation. The baseline evaluation serves to guide the analyst and provide a method for quick identification and evaluation of design features and processes that significantly affect the potential for adverse containment sump blockage for a given plant design. The baseline evaluation also facilitates the evaluation of potential modifications that can enhance the capability of the design to address sump debris blockage concerns and uncertainties and supports resolution of GSI-191. The report offers additional guidance that can be used to modify the conservative baseline evaluation results through revision to analytical methods or through modification to the plant design or operation.

By letter dated December 6, 2004 (ADAMS Accession No. ML043280641), the NRC issued an evaluation of the NEI methodology. The NRC staff concluded that the methodology, as approved in accordance with the NRC staff safety evaluation (SE), provides an acceptable overall guidance methodology for the plant-specific evaluation of the ECCS or CSS sump performance following postulated DBAs.

In response to the NRC staff SE conclusions on NEI 04-07 "Pressurized Water Reactor Sump Performance Evaluation Methodology" (ADAMS Accession Nos. ML050550138 and ML050550156), the Pressurized Water Reactor Owners Group (PWROG) sponsored the development of the following Westinghouse Commercial Atomic Power (WCAP) Topical Reports (TRs):

- TR-WCAP-16406-P-A, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," Revision 1 (not publicly available), to address the effects of debris on piping systems and components.

- TR-WCAP-16530-NP-A, "Evaluation of Post-accident Chemical Effects in Containment Sump Fluids to Support GSI-191," issued March 2008 (ADAMS Accession No. ML081150379), to provide a consistent approach for plants to evaluate the chemical effects that may occur post-accident in containment sump fluids.

- TR-WCAP-16793-NP-A, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid," Revision 2 issued July 2013 (ADAMS Accession No. ML13239A114), to address the effects of debris on the reactor core.

The NRC staff reviewed the TRs and found them acceptable to use (as qualified by the limitations and conditions stated in the respective safety evaluations (SEs)).[1] A more detailed evaluation of how the TRs were used by the licensee is contained in the evaluations below.

After the NRC staff evaluation of licensee responses to GL 2004-02, the NRC staff found that there was a misunderstanding between the industry and the NRC on the level of detail necessary to respond to GL 2004-02. The NRC staff in concert with stakeholders developed a content guide for responding to requests for additional information (RAIs) concerning GL 2004-02. By letter dated August 15, 2007 (ADAMS Accession No. ML071060091), the NRC issued the content guide describing the necessary information to be submitted to allow the NRC staff to verify that each licensee's analyses, testing, and corrective actions associated with GL 2004-02 are adequate to demonstrate that the ECCS and CSS will perform their intended function following any DBA. By letter dated November 21, 2007 (ADAMS Package Accession No. ML073110389), the NRC issued a revised content guide.

The content guide described the following information needed to be submitted to the NRC:

- corrective actions for GL 2004-02,
- break selection,
- debris generation/zone of influence (ZOI) (excluding coatings),
- debris characteristics,
- latent debris,
- debris transport,
- head loss and vortexing,
- net positive suction head (NPSH),
- coatings evaluation,
- debris source term,
- screen modification package,
- sump structural analysis,
- upstream effects,
- downstream effects – components and systems,
- downstream effects – fuel and vessel,
- chemical effects, and
- licensing basis

Based on the interactions with stakeholders and the results of the industry testing, the NRC staff in 2012 developed three options to resolve GSI-191. These options were documented and proposed to the Commission in SECY-12-0093, "Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance," dated July 9, 2012 (ADAMS Package Accession No. ML121320270). The options are summarized as follows:

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1 SE by the Office of NRR, TR WCAP-16406-P, Revision 1, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," Pressurized Water Reactors Owners Group Project No. 694 (ADAMS Accession No. ML073520295); Final SE for PWROG TR, WCAP-16530-NP, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191" (ADAMS Accession No. ML073521072) ; Final SE by the Office of Nuclear Reactor Regulation, TR WCAP-16793-NP, Revision 2, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid," Pressurized Water Reactor Owners Group Project No. 694 (ADAMS Accession No. ML13084A154).

- Option 1 would require licensees to demonstrate compliance with 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," through approved models and test methods. These will be low fiber plants with less than 15 grams (g) of fiber per fuel assembly (FA) (g/FA).

- Option 2 requires implementation of additional mitigating measures and allows additional time for licensees to resolve issues through further industry testing or use of a risk informed approach.

    - Option 2 Deterministic: Industry to perform more testing and analysis and submit the results for NRC review and approval (in-vessel only).

    - Option 2 Risk Informed: Use the South Texas Project pilot approach currently under review with NRR staff.

- Option 3 involves separating the regulatory treatment of the sump strainer and in-vessel effects.

The options allowed industry alternative approaches for resolving GSI-191. The Commission issued a Staff Requirement Memorandum on December 14, 2012 (ADAMS Accession No. ML12349A378), approving all three options for closure of GSI-191.

By letter dated May 15, 2013 (ADAMS Accession No. ML13141A272), Constellation Energy Nuclear Generation Group (the licensee) stated that they will pursue Option 2 (deterministic) for the closure of GSI-191 and GL 2004-02 for R.E. Ginna Nuclear Power Plant (Ginna).

On July 23, 2019 (ADAMS Package Accession No. ML19203A303), GI-191 was closed. It was determined that the technical issues identified in GI-191 were now well understood and therefore GI-191 could be closed. Prior to and in support of closing the GI, NRR staff issued a technical evaluation report on in-vessel downstream effects (IVDEs) (ADAMS Accession Nos. ML19178A252 and ML19073A044 (non-public version)). Following the closure of the GI, NRR staff also issued review guidance for IVDEs to support review of the GL 2004-02 responses "NRC Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of Generic Letter 2004-02 Responses" (ADAMS Accession No. ML19228A011).

The following is a list of documentation provided by the licensee in response to GL 2004-02:

RESPONSES TO GL 2004-02		
DOCUMENT DATE	ACCESSION NUMBER	DOCUMENT
March 7, 2005	ML050730147	Initial Response to GL
June 2, 2005	ML051530230	1st NRC RAI
July 15, 2005	ML052020171	Licensee Response to RAI
August 31, 2005	ML052510414	Supplemental Information
February 9, 2006	ML060380256	2nd NRC RAI
June 29, 2006	ML061880205	Licensee Response to RAI
February 29, 2008	ML080710041	Supplemental Information
July 25, 2008	ML082100452	Supplemental Information

January 7, 2009	ML083300109	3rd NRC RAI
June 2, 2009	ML091590265	Licensee Response to RAI
December 4, 2009	ML093290264	4th NRC RAI
April 6, 2010	ML101020069	Licensee Response to RAI
October 26, 2010	ML103050148	Supplemental Information
May 15, 2013	ML13141A272	Resolution Path
April 28, 2021	ML21118A007	Final Supplemental Response

The NRC staff reviewed the information provided by the licensee in response to GL 2004-02 and all RAIs. The following is a summary of the NRC staff review.

2.0 GENERAL DESCRIPTION OF CORRECTIVE ACTIONS FOR THE RESOLUTION OF GL-2004-02

GL 2004-02 Requested Information Item 2(b) requested a general description of and implementation schedule for all corrective actions. The following is a list of corrective actions completed by the licensee at Ginna in support of the resolution of GL 2004-02:

- Evaluation of sump performance using the guidance of NEI 04-07.
- Ex-vessel downstream effects evaluation using the TR-WCAP-16406-P-A, Revision 1 methodology.
- Containment walkdowns to sample and characterize latent debris, including other debris sources, e.g., labels, tags, containment liner seals, etc.
- As-built verification walkdowns of insulation in containment.
- Replaced original sump screen of simple geometry with complex geometry strainers. Increased strainer area from about 110 square feet (ft^2) to 4,087 ft^2.
- Installed debris interceptors beneath and alongside sump strainer modules to provide pre-filtering of debris for back side of strainer modules.
- NPSH and debris bed de-aeration analyses.
- Installed stainless steel Sure-Hold bands, on 6” centers, to all calcium silicate (Cal-Sil) insulation within or near the steam generator and pressurizer cubicles.

Based on the information provided by the licensee, the NRC staff considers this item closed for GL 2004-02.

3.0 BREAK SELECTION

The objective of the break selection process is to identify the break size and location that present the greatest challenge to post accident sump performance. The term ZOI used in this section refers to the spherical zone representing the volume of space affected by the ruptured piping.

NRC STAFF REVIEW:

The licensee used the NEI 04-07 guidance for break selection with one exception that the break was not moved incrementally along the pipe to determine the location which resulted in the maximum debris generation. The process was simplified to pick the break locations based on the location of potential debris sources with respect to potential break locations. In general, all fibrous debris within a compartment is considered to be destroyed by the limiting break within that compartment. Different breaks within a compartment result in a larger amount of fibrous and Cal-Sil/asbestos debris. However, the Ginna analysis combined the source term from breaks that produced the limiting amount of fibrous debris and particulate debris to ensure a conservative debris load was evaluated. In addition to the above, secondary breaks were not considered because they do not require recirculation within the design basis.

The staff noted that it was clear that the break selection had not been moved systematically to ensure that the maximum amounts of coatings, particulate, and fibrous debris had been destroyed. However, the ZOIs were large enough that almost all potential sources within the compartment in which the break was located were rendered into debris. Therefore, the NRC staff found this treatment of break selection acceptable. The amount of debris from each break is very large such that even a fraction of the debris could result in a challenge to the strainer's ability to prevent high head losses.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. The break location analysis completed by the licensee is in accordance with the content guide and the Guidance Report (GR)/SE while using an acceptable method to determine break locations to analyze for maximum debris generation results. Therefore, the NRC staff concludes that the break selection evaluation for Ginna is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02 for Ginna.

4.0 DEBRIS GENERATION/ZONE OF INFLUENCE (EXCLUDING COATINGS)

The objective of the debris generation/ZOI evaluation is to determine the limiting amounts and combinations of debris that can occur from the postulated breaks in the RCS.

NRC STAFF REVIEW:

The initial NRC staff review is based on documentation provided by the licensee through June 2, 2009.

The NRC staff found that the Ginna debris generation evaluation generally followed approved guidance. The licensee used the GR Section 4.2.2.1.1 ZOI refinement of debris-specific spherical ZOI. The licensee assumed the GR/SE default ZOI of 2.0D for Transco reflective metal insulation (RMI) and default ZOI of 11.7D for Temp-Mat. The licensee used a ZOI of 6.4D for stainless steel clad Cal-Sil while the GR/SE allows a default ZOI of 5.45D. However, the licensee indicated that it also had Cal-Sil/asbestos insulation. The asbestos was treated as Cal-Sil in the evaluation. The licensee indicated that because the material properties were similar and the Ginna information did not distinguish between Cal-Sil and Asbestos in most cases, the same destruction pressure/ZOI of 6.4D was assumed for the insulation listed and described as Cal-Sil/Asbestos or Cal-Sil (w/asbestos). The licensee also indicated that the insulation on the loop/vessel supports in the primary shield wall penetrations are asbestos, but the break case debris source term listings show no contribution from asbestos only so these locations may well be outside a 6.4D ZOI. The licensee assumed a ZOI of 17.0D for Transco Thermal-Wrap with the justification that it was a low-density fiberglass product constructed very similar to Nukon and could be expected to have a destruction pressure and thus ZOI similar to the GR/SE default of 17.0D for Nukon. The licensee referenced the GR/SE Section 3.4.3.2 for a statement recognizing this similarity.

The licensee stated that there is 118 ft^2 of strainer surface area that can be attributed as sacrificial area to accommodate debris such as masking tape, labels, and tags. The 2008 refueling outage walk down identified this type of debris as tape and stickers, signs and placards, and containment liner insulation jacket sealant. These were quantified as a total of 114 ft^2. With 100 percent transport and strainer surface impact this would still be less than the 118 ft^2 of sacrificial strainer surface.

NRC STAFF CONCLUSION:

For the debris generation/ZOI review area, the licensee provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris generation/ZOI evaluation for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

5.0 DEBRIS CHARACTERISTICS

The objective of the debris characteristics determination process is to establish a conservative debris characteristics profile for use in determining the transportability of debris and its contribution to strainer head loss.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through April 6, 2010.

The debris characterizations originally used by Ginna are generally considered to be best estimate rather than conservative. In many cases the licensee used debris characteristics that align with approved guidance. For Thermal-Wrap, the licensee referenced a proprietary Alion size distribution based on jet destruction testing of fibrous insulation. This method assigns debris characteristics based on the distance from the jet to the target. Insulation closer to the jet source, is rendered into finer sizes due to the higher pressure while that more distant receives less damage. This methodology has been accepted by the NRC staff as a refinement to the approved guidance in the GR and SE. A similar methodology was used for Temp-Mat.

A similar treatment of Cal-Sil is potentially non-conservative, since this size distribution used by the licensee is based on the Ontario Power Generation (OPG) testing that was done on relatively long targets that were not fully exposed to the full destruction pressure during testing. A compensating measure taken by the licensee is to use a larger (6.4D vs. 5.4D) ZOI than recommended in the NRC staff approved guidance. The licensee also combines source terms from breaks with limiting amounts of debris. That is, the evaluation always assumes the maximum amount of Cal-Sil combined with the maximum amounts of other debris. The NRC staff requested the licensee to provide information to verify that the Ginna Cal-Sil was installed in a similar configuration to that tested by OPG and that the plant insulation was manufactured such that its properties are comparable to that used in the testing.

The licensee's initial response provided sufficient information to address the aspect of this question associated with the insulation manufacturing processes for the plant and test materials so that the NRC staff could conclude that the materials would behave similarly under the influence of a jet and after being damaged. However, the NRC staff was not able to conclude that the physical installation in the plant was bounded by the tested configuration and therefore requested additional information regarding the jacketing and banding. The licensee responded that stainless steel banding will be installed on all Cal-Sil insulation within the ZOI for any limiting break location that meets or exceeds that installed in the OPG testing. The licensee also provided an evaluation to show that the stainless steel jacketing at Ginna is equivalent to or more robust than the aluminum jacket used in the OPG tests. Therefore, the NRC staff found that the Ginna insulation will be at least as robust as the configuration tested by OPG and considered this issue closed.

NRC STAFF CONCLUSION:

For the debris characteristics review area, the licensee provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris characteristics evaluation for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

6.0 LATENT DEBRIS

The objective of the latent debris evaluation process is to provide a reasonable approximation of the amount and types of latent debris (e.g., miscellaneous fiber, dust, dirt) existing within the containment and its potential impact on sump screen head loss.

NRC STAFF REVIEW:

The licensee presented the results of the latent debris source term analyses which were conducted using methods approved by the NRC. Four debris samples were taken on each of 12 surface types, both horizontal and vertical, to determine the latent debris mass density within containment. The total latent debris mass, when extrapolated to the entire containment building, was 77 pounds-mass (lbm). The licensee used a value of 100 lbm for the containment latent debris source term to provide margin for the calculations. A value larger than the total amount of tags, label, and other miscellaneous debris identified during a 2008 walk-down (114 ft^2) was used as sacrificial area.

NRC STAFF CONCLUSION:

For the latent debris review area, the licensee used staff approved methods and provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the latent debris evaluation for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

7.0 DEBRIS TRANSPORT

The objective of the debris transport evaluation process is to estimate the fraction of debris that would be transported from debris sources within containment to the sump suction strainers.

NRC STAFF REVIEW:

The initial NRC staff review is based on documentation provided by the licensee through October 26, 2010.

The Round 1 review of the February 2008 supplemental response determined that there was insufficient information to perform a true plant-specific review. Therefore, one RAI was proposed that essentially requested that the licensee provide a description of the transport analysis that conforms to the requests of the content guide. The June 2, 2009, supplemental response included this information. However, there were a large number of remaining concerns with the information provided, due primarily to assumptions the licensee made that are not consistent with the approved guidance and for which adequate justification was not provided. As a result, several more specific RAIs were generated by the NRC staff. These RAIs and the responses are summarized below.

The NRC staff questioned the amount of holdup credited on gratings during the blowdown phase of transport. The licensee stated that no credit is taken for debris capture on grating below the postulated break location. There is no grating beneath the breaks. The licensee did credit some holdup of debris when sources are above the break and above gratings. The licensee provided information to show that the assumed holdups are reasonable. The NRC staff reviewed the licensee's response and found it acceptable. The staff's basis for acceptance is as follows: (1) the amount of credit for small piece hold up is only 3 percent which has minimal effect on the evaluation, (2) large pieces generated above the break and above nearly continuous grating will have difficulty reaching the containment pool, (3) the NRC staff recognizes that inertial capture and other hold up mechanisms will exist for small pieces of debris that are not typically credited in licensee transport evaluations and these capture mechanisms are expected to exceed 3 percent, (4) the NRC staff considers holdup credit for debris that is generated above gratings to be consistent with existing test results as opposed to hold up of debris generated below and first blown up through gratings (especially for large pieces), and (5) there is no debris assumed to be held up beneath the break that could be washed down or eroded by break flow.

The NRC staff questioned that 5 percent of the small fiberglass debris blown upward would be trapped due to changes in flow direction. The staff determined that much of the debris considered to be trapped due to inertial capture could eventually wash down to the sump pool. The licensee responded that the small fiberglass debris was not assumed to be retained for the full 30-day sump mission time. The licensee explained the conservatisms in the model and the lack of credit for other realistic holdup mechanisms. The NRC staff reviewed the licensee's response and found it acceptable since the licensee clarified that 30-day hold up credit was not being taken in the evaluation.

The NRC staff questioned the methodology used to determine transport of small fibrous debris pieces on the operating deck level. The licensee calculated 0 percent transport on the upper level of the operating deck, and 40 percent transport on the lower level of the operating deck. The staff considered several aspects of the licensee's methodology to be unacceptable and asked specifically about each of the potentially non-conservative assumptions. The staff requested the licensee to provide additional justification, or else modify the approach used to determine the transport percentages across the operating deck, in response to the issues noted above. The licensee provided a detailed response to address the NRC staff questions. However, in the end, the licensee decided to revise its transport analysis to remove credit for small fiberglass debris retention in upper containment. The NRC staff found the updated assumption acceptable.

The NRC staff questioned the assumptions made by the licensee with respect to post-LOCA debris erosion. The staff asked the licensee the following questions: In particular, the NRC staff was concerned that the assumption of 10 percent fibrous debris erosion in the containment pool was not justified by testing. The staff specifically questioned whether the erosion assumption was applicable to debris that was predicted to settle on the operating deck because the flow velocities on the deck, during containment spray operation, were predicted to be relatively high which could cause additional erosion. The staff was also concerned that the effects of erosion of debris trapped on gratings could be greater than assumed by the licensee. The licensee responded that they are a participant in an industry erosion test program that the NRC reviewed and considered appropriate. For the other issues, the licensee revised the analysis to remove credit for settlement of fiber on the operating deck and clarified no debris is held up on gratings below the break location. These last two issues are also subjects of other questions discussed herein. The NRC staff reviewed the licensee's responses and found them acceptable.

The NRC staff questioned whether the head loss testing performed for Ginna adequately represented the erosion of small and large debris because a significant amount of debris added to each test settled onto the test flume floor. It appeared that a significant part of the settled debris was potentially erodible. The staff found that any debris that is included in testing because the transport analysis determined that it would arrive at the strainer should be accounted for in the test result. That is, the debris should either become part of the debris bed, or if it would actually settle, be assumed to erode and the erosion products become part of the debris bed. The licensee responded that the transport of large pieces of Temp-Mat was maximized analytically by assuming transport via floatation. The licensee stated that the large pieces of Temp-Mat are incapable of entering the strainer pockets. The licensee stated that at worst, the debris pieces could block the pocket openings, but that the containment velocities would be too low to hold the debris against the openings. The licensee also stated that the majority of the settled debris was large debris that had reached the open face of the strainer and extended in a pile about 3 feet long. Erosion of this debris was not explicitly considered. The licensee stated that head loss did not continually increase over the 5-day test period. The licensee concluded that increases in NPSH margin would more than offset erosion effects. However, the licensee concluded the discussion by stating that Ginna will perform additional head loss testing and will account for the potential for erosion of debris settled in front of the strainer. The NRC staff reviewed the licensee's responses and found that the arguments regarding the ability of large pieces of fibrous debris to affect strainer head loss to be reasonable. The staff did not consider the licensee's technical arguments regarding erosion of the settled debris to be justified because the head loss test flume was not capable of modeling erosion under actual plant conditions. However, the NRC staff considered the licensee's plans for performing additional testing that accounts for the potential erosion of debris settled in front of the strainer as an acceptable method to resolve the RAI. The staff reviewed additional information provided by the licensee regarding an updated transport analysis and head loss testing based on the new analysis. The testing included appropriate amounts of fine debris to account for the potential erosion of debris that was assumed to transport to the strainer but settled during testing. Therefore, this issue has been appropriately addressed.

The NRC staff questioned the assumption that any debris washed to the refueling cavity would be held up in the refueling cavity or reactor cavity rather than reaching an active portion of the containment pool. The staff asked the licensee to clarify whether filling of the inactive volumes prior to the termination of the containment sprays could occur for any post-LOCA scenarios, resulting in a portion of the debris assumed to wash to the inactive volumes reaching the active containment pool instead. The licensee responded by clarifying the washdown evaluation and providing details on how transportable debris from upper containment was apportioned along various washdown paths to the containment pool. The licensee originally assumed that fines washed into the reactor cavity sump would be unable to transport to the strainers; however, because drainage from the refueling canal continues to fill the reactor cavity sump, resulting in flow from the reactor cavity sump to the containment pool, the licensee conservatively assumed that fines did not settle and increased the percentage of fines transporting to the strainer by 0.8 percent. The NRC staff reviewed the licensee's response and found it acceptable. The licensee's response demonstrated that it is reasonable to credit the inactive reactor cavity sump with hold up for small and large piece debris washed down from the refueling canal, even if this inactive sump is already filled with water.

The NRC staff questioned the licensee's credit for the settlement of fine debris. The staff requested the licensee to provide the quantities of fine debris assumed to settle during recirculation. The staff requested the licensee to demonstrate that the credit taken for fine debris settling is technically justified. The licensee provided a technical response to justify the settling credit, but ultimately decided to revise the transport analysis to eliminate credit for settling of fines. The NRC staff reviewed the licensee's response and found it acceptable because the credit for settling was eliminated. The staff did not accept the licensee's technical responses to the settling issue. The staff found that the licensee's decision not to credit settlement of fine debris removes these uncertainties from the licensee's analysis and provides an acceptable basis to consider the question resolved.

The NRC staff questioned whether the same debris transport metrics were used for Thermal Wrap and Temp-Mat and requested that the licensee provide the transport metrics used for Temp-Mat. The licensee responded that all Temp-Mat large and small pieces in the active recirculation pool were assumed to float and therefore transport 100 percent. The only transport metric that was the same for Temp-Mat and Thermal-Wrap was the TKE required to keep individual Temp-Mat and Thermal-Wrap fibers in suspension. The NRC staff reviewed the licensee's response and found it acceptable.

<u>NRC STAFF CONCLUSION</u>:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the debris transport has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris transport evaluation for Ginna is acceptable. The NRC staff considers this area closed for GL 2004-02.

8.0 HEAD LOSS AND VORTEXING

The objectives of the head loss and vortexing evaluations are to calculate head loss across the sump strainer and to evaluate the susceptibility of the strainer to vortex formation.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through October 26, 2010.

The licensee's approach to reducing strainer head loss is to install a relatively large Control Components, Inc. (CCI) strainer. The first tests of the CCI strainer were conducted without chemical effects. These tests reportedly resulted in low head losses. However, it is likely that the tests were completed using non-prototypical debris preparation and introduction techniques. The original chemical effects testing completed by CCI for Ginna resulted in unacceptably high head losses. This testing used a CCI chemical injection method which the submittal states is overly conservative by a factor of four when compared to the WCAP-16530 (staff approved) methodology. Therefore, Ginna retested the strainer using a WCAP chemical effects protocol. Ginna performed an additional round of testing to address NRC staff questions regarding the test methodology used. The issues identified by the NRC staff, and eventually resolved by retesting, are discussed below.

In order to better understand the test methodology used by CCI for testing their strainers the NRC staff visited the CCI test facility and found their strainer testing, including application of the WCAP-16530 methodology, to be acceptable. The staff was not able to determine whether the methodologies accepted by the NRC staff were in effect when the early Ginna testing was performed. Therefore, the NRC staff asked several questions regarding the test methodology and parts of the evaluation of the test results used in the second set of tests run for the strainer.

The licensee provided a third supplemental response that addressed the NRC staff's questions regarding the testing and head loss evaluation methodology. In general, the information provided was adequate to answer the NRC staff's questions. Based on the response, the NRC staff was able to determine that the updated testing was conducted in accordance with approved guidance. However, the review of the RAI responses did raise some additional questions that are discussed below.

The NRC staff requested additional information regarding the temperature assumptions for the clean strainer head loss (CSHL) calculation. The CSHL calculation appeared to be conducted at a temperature that could result in non-conservative head losses under some conditions. The licensee provided additional details on how the CSHL was calculated and provided graphical depictions of how strainer head loss, including CSHL changes with sump temperature. The sump temperatures considered included the range of temperatures expected during sump recirculation. The NRC staff reviewed the licensee's response and found that the range of temperatures considered for the strainer head loss calculation, including CSHL was adequate. The licensee demonstrated that as sump temperature decreases, pump NPSH margin increases at a rate faster than strainer head loss. The increase in NPSH margin is due to subcooling of the sump fluid. The licensee noted that head loss testing would be reperformed and that updated strainer head loss calculations would be performed based on the new testing. The updated head loss testing was performed, and the results provided to the NRC. The test results were similar to those conducted previously and were bounded by the previous results. Therefore, the previous calculations regarding total head loss are still valid. The staff found the response acceptable because the licensee provided information that justified that the full range of post-LOCA sump temperatures was considered in their head loss evaluation.

The NRC staff requested additional information regarding the potential for deaeration of the coolant as it passes through the debris bed and any effect this deaeration may have on pump

NPSH. The licensee provided additional information regarding the potential for the deaeration of fluid as it passes through the debris bed. The licensee stated that an evaluation for the potential of deaeration was performed using very conservative inputs and that the largest calculated void fraction downstream of the strainer was very small. The licensee evaluated the results of the void fraction calculation against the Regulatory Guide 1.82 guidance for required NPSH penalty and determined that the penalty would be insignificant. The NRC staff reviewed the licensee's response and agreed that the calculation for fluid deaeration that was performed by the licensee was conducted using conservative inputs and that the effect of the calculated void fraction on pump operation would be negligible.

The NRC staff requested additional information regarding the temperature assumptions for the debris head loss calculation. The licensee provided a head loss value for a "minimum sump temperature" of 195 degrees Fahrenheit (°F). It was not clear whether the higher head losses that could occur at lower temperatures were adequately evaluated. The licensee provided additional details on how the strainer head loss was calculated and provided tables of how strainer head loss, including debris head loss and CSHL, changes with sump temperature. The sump temperatures considered included the range of temperatures expected during sump recirculation. The NRC staff reviewed the licensee's response and found that the range of temperatures considered for the strainer head loss calculation, including debris head loss was adequate. The licensee demonstrated that as sump temperature decreases, pump NPSH margin increases at a rate faster than strainer head loss. The increase in NPSH margin is due to subcooling of the sump fluid. The licensee noted that head loss testing would be reperformed and that updated strainer head loss calculations would be performed based on the new testing. Results of the testing and head loss calculation were provided to the NRC and the NRC staff found the results acceptable and bounded by earlier testing. The staff found the response to the initial RAI acceptable based on the information provided by the licensee that shows that the full range of post-LOCA sump temperatures were evaluated.

The NRC staff requested additional information regarding the debris surrogate used for Cal-Sil. The licensee supplemental response stated that some of the Cal-Sil was represented by zinc dust. Because Cal-Sil is known to cause high head losses compared to many other types of debris, the use of an alternate debris surrogate may be non-conservative. The licensee provided additional information stating that additional head loss testing will be performed and that the correct amount of Cal-Sil will be used as a surrogate in that testing. The licensee performed updated testing that used an appropriate surrogate for Cal-Sil. This is acceptable since an appropriate surrogate for Cal-Sil was used.

NRC STAFF CONCLUSION:

Based on the test results provided by the licensee, the NRC staff concludes that the head loss portion of the analysis has been completed adequately. Testing and analysis was conducted using staff approved guidance. The other information provided by the licensee, either previously or in the recent submittals, provide adequate documentation that the strainer will perform its function during any required recirculation operation. For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has overall been addressed conservatively or prototypically.

Therefore, the NRC staff concludes that the head loss and vortexing evaluation for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

9.0 NET POSITIVE SUCTION HEAD

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a LOCA considering a spectrum of break sizes.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through April 6, 2010. The staff found that the licensee provided the information requested by staff guidance and that the licensee responses showed that the NPSH evaluation was conducted in accordance with the guidance.

During its review the NRC staff determined that additional information regarding the NPSH evaluation was required before a conclusion regarding its adequacy could be reached because the information received in the first response did not address all areas required. The NRC staff requested that the licensee provide information on various flow rates, flow resistances, and margins for various operating scenarios. The NRC staff also requested additional information regarding the potential for holdup of fluid in various locations including the refueling cavity and the accumulators. In its updated supplemental response, the licensee provided the information requested in staff guidance documents. The staff found most of the responses to be acceptable once a complete response was made by the licensee.

The only area that the NRC staff found to require more information was related to the credit for accumulator volume for all scenarios. Therefore, the NRC staff requested the licensee to provide a basis for concluding that, for all small-break LOCAs (including breaks at elevated locations such as the pressurizer); the water level in containment will be prototypical or conservative with respect to its importance to strainer submergence, deaeration, and vortexing. The licensee stated that the minimum water level calculation was revised to address potential non-conservatisms associated with differences in the effects of various LOCA break sizes. The licensee stated that the large break LOCA level was calculated to be 3.8 feet. For small breaks, the licensee determined that a minimum level of 3.39 feet could exist. The licensee stated that the analysis now considers cases where the accumulators were not credited, as well as cases that considered elevated breaks that would lead to refill of the entire RCS (e.g., line break at top of pressurizer). The licensee analyzed the smaller breaks of 2”, 3”, and 4” at several different points in the accident sequence, including (1) at recirculation, (2) during depressurization, (3) after RCS refill, and (4) after RCS is refilled and depressurized.

The NRC staff found that the licensee performed additional analysis to incorporate the effects discussed in the NRC staff’s request into the minimum water level calculation. The licensee stated that the existing minimum water level assumptions now account for the issues that the NRC staff raised. Therefore, the NRC staff considers this item to be addressed.

NRC STAFF CONCLUSION:

For the NPSH area, the licensee has provided information such that the NRC staff has reasonable assurance that it has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the NPSH evaluation for Ginna is acceptable. The NRC staff considers this area closed for GL 2004-02.

10.0 COATINGS EVALUATION

The objective of the coatings evaluation section is to determine the plant-specific ZOI and debris characteristics for coatings for use in determining the eventual contribution of coatings to overall head loss at the sump screen.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through June 2, 2009. The guidance documents used for the review include the "Revised Guidance Regarding Coatings Zone of Influence For Review of Final Licensee Responses to Generic Letter 2004-02" (ADAMS Accession No. ML100960495) and Regulatory Guide 1.82, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident."

For head loss testing, a 10D ZOI was used to calculate the quantity of coatings debris generated. The 10D ZOI is based on the NRC staff position described in the NRC SE of NEI 04-07. The licensee also analyzed a 5D ZOI for debris generation and transport analysis based on WCAP-16568-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified/Acceptable Coatings" (ADAMS Accession No. ML061990594). The staff finds the application of WCAP-16568-P and a ZOI of 5D for qualified epoxy acceptable for Ginna. Therefore, the use of a 10D ZOI for testing results in a conservative quantity of coating debris. All coatings in the ZOI are assumed to fail as fine particulate. The NRC staff found the licensee's treatment of coatings debris within the ZOI acceptable.

The licensee treated degraded qualified coatings debris as chips. The technical justification for treating the epoxy coating as chips is based on a Keeler and Long Report, "TXU Paint Chip Characterization" (ADAMS Accession No. ML081770357). This acceptable to the NRC staff since the Keeler and Long Report is accepted in the NRC review guidance. Additional margin was included for the coatings due to the potential failure of degraded qualified coatings. It was assumed that 5 percent of the total concrete surface area below the intermediate deck and inside the inner shield wall would fail as degraded qualified coatings.

During head loss testing with coatings debris treated as particulate the licensee did not observe a thin bed. In additional testing, the licensee introduced paint chips of a size equivalent to the area of the sump screen openings to maximize head loss for strainer testing. This is acceptable based on the NRC SE.

The surrogate coatings debris used for head loss testing were zinc dust, stone flour, and paint chips. The materials used for testing are acceptable to the NRC staff. The quantity of surrogate coatings debris was conservatively increased for testing in comparison to the quantities calculated in the licensee's analysis.

Ginna has implemented a new containment coatings assessment procedure to go along with the current performance of coating assessments every refueling outage. The new procedure was developed using Electric Power Research Institute guidelines and Ginna's current licensing basis. This procedure outlines roles and responsibilities in performing, reporting on, and approving containment coatings condition assessments. The staff finds the licensee's coating assessment program acceptable and consistent with staff expectations.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the coatings evaluation for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

11.0 DEBRIS SOURCE TERM

The objective of the debris source term section is to identify any significant design and operational measures taken to control or reduce the plant debris source term to prevent potential adverse effects on the ECCS and CSS recirculation functions.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through June 2, 2009.

The licensee described programmatic and process controls that it has in place to prevent the entry of foreign materials into the containment area. A review of plant procedures, programs, and design requirements was performed in an attempt to diagnose potential vulnerabilities that could impact analyzed containment or recirculation function criteria.

The addition of materials to containment is controlled through an administrative process in which change impacts are evaluated for each design change. Every material added, removed, or changed is evaluated as a potential source of debris that could be generated during a LOCA. Similarly, quantities of aluminum in containment that are added, removed, or changed are evaluated for impact.

The updated final safety analysis report (UFSAR) Chapter 6, specifically, Section 6.1, lists the materials of construction in the Ginna containment. This specification is considered the master document for determining the acceptability of materials for use in containment for preventing changes to the debris source term.

Technical Specification SR 3.5.2.7 states the minimum periodicity for visual inspection of the containment sump area and makes it a licensing basis-level requirement. The sump must be inspected every 24 months for foreign material and debris.

A foreign material exclusion (FME) program contains guidance specifically addressing FME concerns in areas like the containment sump and the Spent Fuel Pool. It classifies the containment sump as a special foreign materials exclusion area and requires an FME Project Plan for any entry into the sump. The requirements of this instruction are stringent with regard to standards but allow flexibility for adapting an FME Project Plan for any kind of maintenance evolution.

A containment storage and closeout inspection is executed prior to closing out the containment sump prior to the end of the outage. It provides specific guidance on what must be done at each mode change as the plant transitions from Mode 5 to Mode 1, and incorporates all the requirements of the Technical Specifications, providing direction for verification that equipment storage and cleanliness requirements are maintained inside containment.

A database exists which, as of September 2004, listed all the insulation in the containment loop area, including associated components, amounts, insulation type, and associated reference drawings.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has overall been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris source term evaluation for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

12.0 SCREEN MODIFICATION PACKAGE

The objective of the screen modification package section is to provide a basic description of the sump screen modification.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through June 2, 2009.

The licensee provided a basic description of the major features of the new sump strainers. They are CCI “pocket” or “cassette” design with 16 modules arranged on the containment floor. The strainer has an effective surface area of approximately 4,089 ft^2 with 1/16 inch diameter perforations and incorporates debris interceptor plates to minimize larger/heavier debris transport to one side of most of the strainer modules. The clean strainer module tested head loss is 0.004 feet of water. The calculated strainer internals flow loss at the bounding flow rate of 2,300 gpm and 68 °F is 0.117 feet of water. Total CSHL to the sump pit residual heat removal suction lines is 0.121 feet of water. At 2,300 gpm the average approach velocity to a 4,089 ft^2 surface area would be about 0.0013 feet per second. The strainers would be submerged by 7 inches at the minimum LOCA containment recirculation pool level. The strainer components are constructed from stainless steel.

NRC STAFF CONCLUSION:

For the screen modification package review area, the licensee provided information such that the NRC staff has confidence in the design of the strainer. Therefore, the NRC staff concludes that the screen modification package information provided for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

13.0 SUMP STRUCTURAL ANALYSIS

The objective of the sump structural analysis section is to verify the structural adequacy of the sump strainer including seismic loads and loads due to differential pressure, missiles, and jet forces.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through June 2, 2009.

The licensee provided the design inputs to determine the sump strainer structural loads. The NRC staff asked questions in several areas regarding the structural analysis. The staff reviewed the initial inputs and those which were provided in response to staff questions and found them acceptable.

The NRC staff asked for the design inputs that were used to determine the structural loading on the strainer. The licensee provided the requested information and the NRC staff found it acceptable because the inputs conform to similar inputs for this type of analysis.

The NRC staff requested, and the licensee provided the load combinations for the sump strainer structural analysis. These load combinations were found to be acceptable because they included the normal operating and accident load conditions pertinent to sump strainer structural analysis.

The NRC staff requested, and the licensee provided the edition of the American Society of Mechanical Engineers (ASME) code that was used in the sump strainer analysis. The licensee stated that ASME Section III, Subsection NF, 2001 Edition and ASME Section II, Part D, 2001 Edition, were used for the Analysis. The staff found the use of these codes acceptable because the ASME Code is part of the licensing basis of this plant.

The NRC staff questioned how the dynamic analysis of the strainer was performed. The licensee stated that equivalent static analysis, based on the ANSYS structural analysis code, was used for the dynamic analysis of the strainer components. The staff found this response acceptable because this method of analysis and the ANSYS code conform to current industry practice and have been accepted by the NRC staff for structural analysis application.

The NRC staff requested that the licensee provide details regarding the loading and load combination on the strainer in table format so that the NRC staff could validate that allowable limits were not exceeded. The licensee provided tables showing the loading conditions and load combinations, the calculated high stresses in various strainer components and the corresponding ASME code allowable stresses. The staff evaluated these results and found them acceptable because the calculated stresses were all below the allowable stresses.

The NRC staff questioned whether the strainer could be damaged due to pipe whip, missiles, or jet impingement. The licensee stated that the sump strainers are sufficiently separated from all high energy lines inside containment and are protected by robust concrete walls and barriers, such that the sump strainers will not be subjected to HELB dynamic effects such as jet impingement, pipe whip, or missile impacts. The staff found this response acceptable because the measures taken to protect the sump strainers from HELB effects conform to the current licensing basis for this plant.

The NRC staff questioned whether the strainer had been evaluated to determine whether reverse flow or back-flushing could overstress any of the strainer components. The licensee stated that a back-flushing strategy has not been credited for the Ginna sump strainers, and therefore no reverse flow was considered for the sump strainers structural analysis.

<u>NRC STAFF CONCLUSION</u>:

Based on the above, the NRC staff concludes that the licensee's structural analysis of the sump strainers is adequate because it was conducted in accordance with standard industry guidance and contains associated conservatisms. Reasonable assurance exists that the strainer assembly will remain structurally adequate under normal and abnormal loading conditions such that it can perform its intended design functions. Therefore, the NRC staff concludes that the sump structural analysis for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

14.0 UPSTREAM EFFECTS

The objective of the upstream effects assessment is to evaluate the flow paths upstream of the containment sump for holdup of inventory, which could reduce flow to the sump.

NRC STAFF REVIEW:

The NRC staff review is based upon documentation provided by the licensee through June 2, 2009.

An evaluation of the flow paths necessary to return water to the recirculation sump strainers was performed in accordance with the recommendations contained in NEI 04-07. This evaluation determined that, with the exception of containment spray holdup in the reactor cavity, all water return flow paths have sufficiently large openings to prevent the holdup of significant quantities of water that could challenge the containment sump minimum water level analysis.

As part of the recirculation pool water level calculation, holdup volumes were calculated for all containment spray return pathways that would cause a reduction in the volume of water returning to the sump. This calculation assumed that the volume of containment spray flow credited in the recirculation pool water level would be reduced by holdup of some inventory in the reactor cavity.

The required containment flow paths for return of water to the sump were evaluated for their ability to pass debris laden water. No flow path is obstructed by any physical barrier, such as a gate, curb, or wall. There is a six-inch curb around the sump; however, that is not a choke point. The curb is not a barrier that will impede flow to the strainer. The width of each flow path, created by the physical features of the containment basement walls, stairways, and components, was evaluated based on its ability to pass the volume of large or intact insulation debris, as determined by the Debris Generation and Debris Transport Analyses.

The most restrictive flow paths at the sump elevation provide a minimum of 3 feet of clearance, as determined by walk downs and system drawings. As a result, no single choke point exists. Additionally, for each break location, there are two primary flow paths in opposite directions to the containment sump location. Each primary flow path has multiple secondary flow paths providing additional assurance that water will reach the sump.

The staff requested that the licensee provide the basis for concluding that the refueling cavity drain(s) would not become blocked with debris. Staff asked if large pieces of debris could be blown into the upper containment by pipe breaks occurring in the lower containment, and subsequently drop into the cavity. In the case that partial/total blockage of the drains might occur, staff asked if water hold-up calculations used in the computation of NPSH margin account for the lost (held-up) water resulting from debris blockage.

The licensee stated that the refueling canal drain becoming blocked is not a credible scenario. All debris and water introduced into the refueling canal, regardless of subsequent flow path, ends up residing in an inactive cavity. The amount of water that would be held in the refueling cavity would be relatively small as the containment sprays are the only source of water to this area and they are terminated upon switchover to recirculation (57 minutes after Safety Injection Actuation Sequence). The sump water level calculation already assumes that all water reaching the refueling canal is held up.

The staff requested the licensee to provide the basis for concluding that the ratio of refueling cavity area to basement floor area is conservative for determining how much water will drain into the cavity. The staff asked whether spray drainage landing on other surfaces at or above the elevation of the refueling cavity, but not directly over the refueling cavity could drain into the refueling cavity. The licensee stated that none of the water landing outside of the cavity will transport to the cavity because there is a curb surrounding the refueling cavity preventing flow into it. Calculations show that the height of the water on the containment operating floor does not exceed the height of the curb. Water landing on the operating deck flows through grating and stairways to lower elevations. There are no other mechanisms for spray flow to enter the refueling cavity. Therefore, it is conservative to assume that the water landing in the cavity (by ratio to the containment cross-sectional area) is the total volume of water held up by the cavity.

The staff asked the licensee to provide the volume of water assumed to be held up in the refueling cavity whether blocked, partially blocked, or open. The licensee stated that the volume of containment spray water entering the refueling cavity is 17,932 gallons, of which 4,149 gallons flows to and is held up in the reactor cavity. Therefore, the volume of containment spray that is held up in the refueling cavity is 13,783 gallons. This entire volume is assumed to be held-up and assumed not to drain to the active recirculation pool.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has overall been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the upstream effects evaluation for Ginna is acceptable. The NRC staff considers this item closed for GL 2004-02.

15.0 DOWNSTREAM EFFECTS - COMPONENTS AND SYSTEMS

The objective of the downstream effects, components and systems section is to evaluate the effects of debris carried downstream of the containment sump screen on the function of the ECCS and CSS in terms of potential wear of components and blockage of flow streams.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through June 2, 2009.

The licensee’s GL 2004-02 supplemental response contains a summary description of the methods used by the licensee to evaluate the downstream effects of debris that bypass the ECCS sump strainers. The licensee followed the methods prescribed in WCAP-16406-P, “Evaluation of Downstream Sump Debris Effects in Support of GSI-1 91.” The scope of the calculations was to evaluate the impact of debris entrained in the recirculated fluid systems on downstream components.

The licensee evaluated the valves in the post-LOCA recirculation flow path for plugging and unacceptable wear using the criteria in WCAP-16406 and concluded that none of the ECCS and CSS valves were subject to plugging or unacceptable wear.

The licensee evaluated the ECCS and CSS pumps for effects of ingested debris on hydraulic performance, mechanical shaft seal performance, and mechanical (vibration) performance and concluded that the pumps would perform satisfactorily through their mission times.

The licensee evaluated the ECCS heat exchangers, orifices, and spray nozzles in the post LOCA recirculation flow path for plugging and concluded that the narrowest flow passages in these components is significantly larger than the holes in the sump strainer and, therefore, blockage of flow would not occur. The licensee also evaluated these components for erosive wear and determined that wear over the 30-day mission time would be insufficient to affect the system performance.

The NRC asked a clarification question to ensure that the licensee used the latest staff approved guidance for this area. The licensee confirmed that it performed ex-vessel downstream effects calculations and analyses in accordance with the methods prescribed in WCAP-16406-P, Revision 1, and the associated NRC SE, including limitations and conditions.

NRC STAFF CONCLUSION:

For the ex-vessel downstream effects review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has overall been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the licensee's evaluation of this area is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02.

16.0 DOWNSTREAM EFFECTS - FUEL AND VESSEL

The objective of the downstream effects, fuel and vessel section, is to evaluate the effects that debris carried downstream of the containment sump screen and into the reactor vessel has on LTCC.

NRC STAFF REVIEW:

The final NRC staff review is based on information submitted by the licensee through April 28, 2021.

Ginna followed the PWROG effort documented in WCAP-17788-P, "Comprehensive Analysis and Test Program for GSI-191 Closure" (ADAMS Package Accession No. ML15210A667) and has verified that the amount of debris that could be delivered to the reactor vessel during a design basis event does not compromise LTCC. Ginna is a two loop upper plenum injection plant. Ginna verified that the amount of debris introduced to the core is less than the NRC staff accepted limit and that the boric acid precipitation mitigation measures are taken prior to 24 hours to prevent debris concentration in the core. Ginna's in-vessel debris loading prediction, debris load acceptance criteria, and boric acid precipitation measures are discussed in the following paragraphs.

The licensee stated the predicted fiber debris that could bypass the sump strainer is 71 g/FA. The licensee stated that this was updated from the 62 g/FA previously communicated to the

NRC. This increased debris load was the result of reducing the sump strainer efficiency to account for the possibility of small fibers that may penetrate the fine mesh bypass strainer during testing and updating the methodology to the Westinghouse analytical method for predicting strainer fiber penetration for downstream effect. The licensee stated that its current 71 g/FA debris load is less than the acceptance limit in WCAP-17788 and that there is margin to accommodate future discoveries that may increase the current 71 g/FA debris load.

The licensee stated that timely re-establishment of cold leg injection mitigates postulated blockage from boric acid precipitation. The licensee confirmed that cold leg injection was re-established consistent with WCAP-17788 guidance. Cold leg injection would be re-aligned after 4 hours from start of sump recirculation and well less than the 24-hour limit. The licensee concluded that establishing cold leg recirculation between 4 and 24 hours ensures that debris does not concentrate in the core as a result of boric acid precipitation.

NRC STAFF CONCLUSIONS:

For the in-vessel downstream effects review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has overall been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the licensee's evaluation of this area is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02.

17.0 CHEMICAL EFFECTS

The objective of the chemical effects section is to evaluate the effects that chemical precipitates have on head loss.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee (ADAMS Accession Nos. ML080710041, ML082100452, ML091590265) as well as the updated plant specific path and schedule resolution of GL 2004-02 supplement submitted on May 15, 2013 (ADAMS Accession No. ML13141A272). The reference documents used for this review include the SE of WCAP-16530-NP-A (ADAMS Accession No. ML081150379) and "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Plant Specific Chemical Effects Evaluations", dated March 2008 (ADAMS Accession No. ML080380214).

The licensee uses sodium hydroxide for post-LOCA pool pH control in Ginna. The licensee replaced their containment ECCS sump strainer with a "pocket type" passive strainer design, manufactured and tested by CCI. The strainer surface area increased from approximately 600 ft^2 to approximately 4,000 ft^2.

The licensee's plant-specific debris generation and transportation analysis determined that the debris sources for Ginna included stainless steel RMI, Cal-Sil/Asbestos, asbestos, fibrous insulation (temp-mat and thermal wrap), phenolic paint, inorganic zinc paint, and latent debris (fiber, particulate dirt, & dust).

The licensee's first supplemental response described their first chemical effects tests conducted in November 2007 at the CCI multi-functional test loop in Winterthur, Switzerland. The testing resulted in higher than expected head loss test results. The licensee's investigations into the cause of the high head loss concluded that the test methods used by the strainer vendor, CCI, were overly conservative. CCI's method of simulating chemical effects involved injecting chemicals into the test loop fluid that was representative of the containment recirculation pool. The licensee concluded the chemical injection method generated significantly more precipitates than intended. Therefore, the licensee considered the test to be flawed and planned a new series of chemical effects tests.

The licensee submitted a second supplemental letter which included new chemical effects test results for Ginna. The licensee's updated chemical effects test was based on the WCAP-16530-NP-A methodology. The licensee's results from the WCAP-16530-NP-A chemical model with the Ginna specific inputs showed that the expected precipitate would be sodium aluminum silicate. The licensee concluded that Ginna would not form aluminum oxyhydroxide precipitate due to relatively high quantities of silicon, which preferentially form sodium aluminum silicate.

The NRC staff has accepted the WCAP-16530-NP-A approach for calculating the quantity of precipitate to add to strainer testing. Although the NRC staff did not agree that the model predictions for relative amounts of aluminum oxyhydroxide and sodium aluminum silicate precipitate are accurate, the NRC staff finds the model prediction for aluminum precipitates to be conservative. The NRC staff found that the WCAP-16530-NP-A predicted amounts of precipitate were applied acceptably for Ginna since all aluminum is assumed to precipitate and small quantities of each precipitate are effective at producing significant head loss across a fiber bed.

The additional strainer tests for Ginna were performed in accordance with NRC staff guidance. The chemical effects portion was completed in February 2008. The chemical precipitate formation procedures were developed by CCI and Westinghouse. The licensee followed the methods and processes described in WCAP-16530-NP-A for the formation of sodium aluminate silicate precipitate surrogate.

The licensee used the worst-case debris loading determined through debris generation and transport analyses to determine the quantities of precipitates that could form. Therefore, the chemical effects testing debris loading used had the greatest quantity of each debris type from all break cases to ensure a bounding conservative result.

Bench top tests were conducted prior to chemical precipitate testing to confirm the settling rate of the precipitate met the WCAP-16530-NP-A requirements. The chemical precipitates settlement met the WCAP-16530-NP-A acceptance criteria. The chemical effects precipitate quantity used in the testing was a scaled quantity, based on the amount calculated via WCAP-16530-NP-A methodology. The total quantity of sodium aluminum silicate used in the testing was scaled from the 71.3 kilograms (kgs) calculated. The chemical precipitate surrogate of sodium aluminum silicate was prepared outside the test loop in a mixing tank and transferred to the test loop by way of a transfer pump, as described in WCAP-16530-NP-A.

The fiber and particulate debris were added to the test loop in a manner consistent with the NRC guidance on thin bed formation and full debris load testing. The worst-case full debris head loss (including chemicals) was determined to be 0.99 feet water column (corrected to the minimum design temperature of 195 °F).

The second supplemental response letter did not provide sufficient information in the chemical effects area. Therefore, the NRC staff issued RAIs as described below.

The NRC staff requested that the licensee provide the containment spray pH values used as input for the WCAP-16530-NP-A chemical spreadsheet from the time that sodium hydroxide is injected into the containment spray until an equilibrium pH value is reached. The licensee responded that they used a containment spray pH value of 9.76 as input to the WCAP-16530-NP-A chemical spreadsheet. This pH value was applied for the entire period in which containment spray is active.

The NRC requested that the licensee clarify whether aluminum corrosion inhibition by silica was credited. Also, if silica inhibition credit was used to reduce the amount of aluminum containing precipitate, the NRC asked the licensee to provide the sources of the silicates, the dissolved silicate concentration and time to reach that concentration, discuss whether other breaks that produce less Cal-Sil were considered, and provide the quantity of aluminum precipitate reduction credited in the head loss test. The licensee responded that testing was originally designed to credit inhibition resulting in a reduction from 81 to 71.3 kg of dissolved aluminum. However, the licensee later made modifications to the assumptions for aluminum in containment (reduced margin that was originally reserved as contingency). Those analytical changes allowed the licensee to justify the 71.3 kg of aluminum without crediting silica inhibition.

The NRC requested that the licensee describe the analysis that was performed and the basis for concluding that four times the predicted amount of chemical precipitate formed in the CCI test loop during the initial (injected chemical) head loss tests conducted for Ginna. The staff also asked the licensee to describe why the precipitate that formed in the test loop was not representative of what could form in the sump pool following a LOCA. The licensee stated that their review and an independent review concluded that the original test procedure and chemical additions were flawed, resulting in excessive chemical precipitation that would not be expected in the plant environment. A summary of the licensee's independent review is provided below:

- Excess calcium was added to the test loop, resulting in calcium precipitation formation.
- The order and combination of the chemicals added to the test loop was not representative of the containment environment, which lead to the formation of aluminum hydroxide.
- Boric acid was added to the test loop before any of the fiber and particulate debris. Sodium hydroxide buffer was not added to the test loop until the end of the test. This allowed for uncontrolled interactions in the test loop.

The NRC staff visited the CCI test facilities on two different occasions (September 2006 and April 2008) to observe testing and have discussions with the CCI technical staff (ADAMS Accession Nos. ML070170235 and ML081400706). The NRC staff questioned the chemical addition process and its influence on how chemical precipitates formed. Therefore, the NRC sponsored tests at Argonne National Laboratory (ANL). Testing performed at ANL showed that the chemical addition process can influence the amount of precipitate that forms and the head loss that results from the precipitate. The NRC staff discussed these test results in an NRC staff presentation at a public meeting on GSI-191 in 2007 (ADAMS Accession No. ML072980669). As a result, the NRC staff decided to review the use of the CCI precipitation method on a case-by-case basis, since there may be differences in the precipitation process depending on plant-specific pH, buffer, and plant materials. In the case of the original Ginna tests, the NRC staff agrees that the chemical injection method can result in over-conservative head loss if high aluminum concentrations result in the formation of large particle sizes.

The licensee's control of precipitation using CCI in-situ precipitate formation method is no longer relevant to the analysis for Ginna since that test was superseded with chemical effects head loss testing using WCAP-16530-NP-A baseline methodology.

The NRC staff evaluated all the licensee's RAI responses and concludes that the July 25, 2008, chemical effects analysis provided by the licensee is acceptable. The chemical effects portion of the head loss testing is acceptable since the licensee followed the WCAP-16530-NP-A baseline methodology with the pre-mixed WCAP precipitate. This method has been previously approved by the NRC staff.

NRC STAFF CONCLUSION:

For the chemical effects area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that chemical effects have been addressed conservatively or prototypically for Ginna. Therefore, the NRC staff concludes that the chemical effects evaluation for Ginna is acceptable. The NRC staff considers this area closed for GL 2004-02.

18.0 LICENSING BASIS

The objective of the licensing basis section is to provide information regarding any changes to the plant licensing basis due to the changes associated with GL 2004-02.

The licensee committed to provide the NRC with conformation that all Cal-Sil insulation within the ZOI of the most limiting break location conforms to the standards established for the OPG testing, i.e., insulation banding spaced no more than 6" apart. The Cal-Sil insulation banding modification was completed during the fall 2012 refueling outage. All Cal-Sil insulation within or near the steam generator and pressurizer cubicles is banded with a band spacing less than 6".

The licensee committed to change the UFSAR in accordance with 10 CFR 50.71(e) to reflect the changes to the plant in support of the resolution to GL 2004-02. In addition, the licensee stated that changes would be made to the UFSAR describing the new licensing basis to reflect the revised debris loading as it affects ECCS and CSS sump strainer performance and in-vessel effects, including the following:

- Break Selection
- Debris Generation
- Latent Debris
- Debris Transport
- Head Loss
- Additional Design Considerations

NRC STAFF CONCLUSION:

Based on the licensee's commitment, the NRC has confidence that the licensee will affect the appropriate changes to the Ginna UFSAR, in accordance with 10 CFR 50.71(e), that will reflect the changes to the licensing basis as a result of corrective actions made to address GL 2004-02. Therefore, the NRC considers this item closed for GL 2004-02.

19.0 CONCLUSION

The NRC staff has performed a thorough review of the licensee's responses and RAI supplements to GL 2004-02. The NRC staff conclusions are documented above. Based on the above evaluations the NRC staff finds the licensee has provided adequate information as requested by GL 2004-02.

The stated purpose of GL 2004-02 was focused on demonstrating compliance with 10 CFR 50.46. Specifically, the GL requested addressees to perform an evaluation of the ECCS and CSS recirculation and, if necessary, take additional action to ensure system function in light of the potential for debris to adversely affect LTCC. The NRC staff finds the information provided by the licensee demonstrates that debris will not inhibit the ECCS or CSS performance following a postulated LOCA. Therefore, the ability of the systems to perform their safety functions, to assure adequate LTCC following a design-basis accident, as required by 10 CFR 50.46, has been demonstrated.

Therefore, the NRC staff finds the licensee's responses to GL 2004-02 are adequate and considers GL 2004-02 closed for the R.E. Ginna Nuclear Power Plant.

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A. Russell

Date: October 8, 2021

SUBJECT: R.E. GINNA NUCLEAR POWER PLANT – CLOSEOUT OF GENERIC LETTER 2004 02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (EPID L-2017-LRC-0000) DATED OCTOBER 8, 2021

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