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

May 19, 2016

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer (CNO)
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: BRAIDWOOD STATION, UNITS 1 AND 2, AND BYRON STATION, UNIT NOS. 1 AND 2, CLOSEOUT OF GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (CAC NOS. MC4667, MC4668, MC4669, AND MC4670)

Dear Mr. Hanson:

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 191, "Assessment of Debris Accumulation on Pressurized Water Reactor Sump Performance."

The stated purpose of GL 2004-02 was focused on demonstrating compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 Section 50.46, "Acceptance Criteria for Emergency Core Cooling Systems (ECCSs) for Light Water Reactors." Specifically, the GL requested addressees to perform an evaluation of the ECCS and containment spray system (CSS) recirculation and, if necessary take additional action to ensure system function, in light of the potential susceptibility of pressurized-water reactor sump screens to blockage during a design-basis accident (DBA) requiring recirculation operation of the ECCS or CSS, and on the potential for additional adverse effects due to debris blockage of flowpaths necessary for ECCS and CSS recirculation and containment drainage.

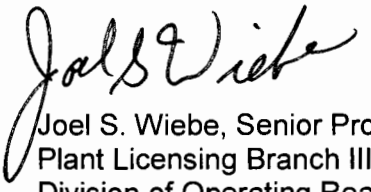
By letter dated March 7, 2005 (ADAMS Accession No. ML050670026), as supplemented by letters dated July 27, 2005 (ADAMS Accession No. ML052140271), September 1, 2005 (ADAMS Accession No. ML052450029), May 31, 2006 (ADAMS Accession No. ML061520299) December 31, 2007 (ADAMS Accession No. ML080280562), July 15, 2008 (ADAMS Accession No. ML081980241), September 19, 2008 (ADAMS Accession No. ML082660245), May 29, 2009 (ADAMS Accession No. ML091520737), October 30, 2015 (ADAMS Accession No. ML15303A408), and April 15, 2016 (ADAMS Accession No. ML16106A219), Exelon Generation Company, LLC (the licensee) provided responses to GL 2004-02 for Braidwood Station, Units 1 and 2 (Braidwood), and Byron Station, Unit Nos. 1 and 2 (Byron).

The NRC staff has completed its review of the licensee responses and supplements associated with the GL 2004-02 for Braidwood and Byron. Based on its review, the NRC staff finds that the information provided demonstrates that debris will not inhibit the ECCS) or the CSS

performance of its intended safety function to assure adequate long term core cooling following a DBA in accordance with 10 CFR 50.46, "Acceptance criteria for ECCSs for light-water nuclear power reactors." Therefore, the NRC staff concludes that the licensee's responses to GL 2004-02 are adequate and considers GL 2004-02 closed for Braidwood and Byron.

Enclosed is the summary of the NRC staff's review. If you have any questions, please call me at 301-415-6606 or via e-mail at Joel.Wiebe@nrc.gov.

Sincerely,



Joel S. Wiebe, Senior Project Manager
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Docket Nos. STN 50-456, STN 50-457,
STN 50-454 and STN 50-455

Enclosure:
NRC review for Braidwood and Byron

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U.S. NUCLEAR REGULATORY COMMISSION (NRC) STAFF REVIEW

OF THE DOCUMENTATION PROVIDED BY

EXELON GENERATION COMPANY, LLC

FOR THE BRAIDWOOD STATION UNITS 1 AND 2 AND

FOR BYRON STATION UNITS 1 AND 2

DOCKET NOS. 50-456, 50-457, 50-454, 50-455

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 cooling 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 an 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 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 long-term core cooling 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), on 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). 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).

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 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. 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 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 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,
- 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

[1] Safety Evaluation by the Office of Nuclear Reactor Regulation, Topical Report (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 Safety Evaluation for Pressurized Water Reactor Owners Group (PWROG) Topical Report (TR), WCAP-16530-NP, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191" (ADAMS Accession No. ML073521072) ; Final Safety Evaluation by the Office of Nuclear Reactor Regulation, Topical Report 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).

Performance," dated July 9, 2012 (ADAMS Accession No. ML121320270). The options are summarized as follows:

- 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 of fiber per fuel assembly.

- 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 14, 2013 (ADAMS Accession No. ML13135A069), Exelon Generation Company, LLC (the licensee) stated that they will pursue Option 1 for the closure of GSI-191 and GL 2004-02 for the Braidwood Station, Units 1 and 2, and Byron Station, Unit Nos. 1 and 2 (Braidwood and Byron).

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	ML050670026	Initial Response to GL
June 3, 2005	ML051520515	1st NRC RAI
July 27, 2005	ML052140271	Licensee Response to RAI
September 1, 2005	ML052450029	Supplemental Information
February 9, 2006	ML060390378	2nd NRC RAI
May 31, 2006	ML061520299	Supplemental Information
December 31, 2007	ML080280562	Supplemental Information
July 15, 2008	ML081980241	Completion of Activities
July 24, 2008	ML081930604	1st NRC Sump Structural Analysis RAI and No Further Questions Letter
September 19, 2008	ML082660245	Licensee Response to RAI
April 15, 2009	ML090960135	2nd NRC Sump Structural Analysis RAI

May 29, 2009	ML091520131	Licensee Response to RAI
May 14, 2013	ML13135A069	Path Forward for Resolution
October 30, 2015	ML15303A408	Licensee Response to In-vessel Down Stream Effects
April 15, 2016	ML16106A219	Supplemental Information

The NRC staff reviewed the licensee's responses through December 31, 2007, and by letter dated July 24, 2008 (ADAMS Accession No. ML081930604), concluded that the NRC staff had no further questions regarding the licensee's completion of corrective actions for GL 2004-02, with the exception of structural issues concerning the new sump strainer, and the demonstration that in-vessel downstream effects issues are resolved. The NRC staff's conclusion is based on the very low debris loading at Byron and Braidwood, as discussed in the licensee's RAI responses, and supplemental information.

2.0 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's original review of Section 3k, Sump Structural Analysis, of the licensee's December 31, 2007, submittal, led to the conclusion that the licensee did not adequately address the information requested by the Revised Content Guide for GL 2004-02 Item 2(d)(vii).

In its submittal, the licensee stated that an analysis was performed for the ECCS sump strainer components using ANSYS finite element program software. The licensee stated the design requirements for the ECCS sump strainer ensured structural integrity for the following loads: the dead weight of the strainer, full debris loading, differential pressure, and seismic load for operating basis earthquake and safe-shutdown earthquake events, and the load combinations were provided. The licensee provided the stress ratios for the main sump components, which is a comparison of the maximum design stress to the allowable stress limits. All of the results were less than one, with the exception of 'Strut Head 1,' for which the licensee provided an acceptable explanation. The submittal further noted that the trash rack is outside the zone of influence for all applicable design basis high-energy line breaks (HELB) and; therefore, dynamic loads were not considered in the structural analysis. The licensee noted that backflushing was not incorporated into the strainer design.

The NRC staff review of the licensee's submittal identified several issues. Specifically, the licensee's submittal failed to identify which edition of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) was used for the strainer structural analysis, and no results were provided for the structural qualification of the trash rack. There were also discrepancies in the written evaluation as to which loadings apply to which structures, and contradictory statements were made regarding the inclusion of hydrodynamic loads or masses. Additionally, the licensee did not properly evaluate the dynamic effects due to a high-energy line break within a 10-diameter radius of the existing plant piping. To address these issues, by letter dated July 24, 2008, the NRC issued five RAIs.

In its response, dated September 19, 2008, the licensee identified the edition of the ASME Code used to support their structural evaluations and provided a tabulated summary of the stress ratios for the trash rack structures. The licensee also clarified its comments regarding the structural integrity of the trash rack and identified which loads are applicable to the strainer and the trash rack. The licensee analyzed the jet force impacts on the trash rack using simplified methods described in the updated final safety analysis report and demonstrated that no load would be imposed on the trash racks. The licensee also noted that the interaction between the strainer and the water inside the sump pit was not relevant due to the small volume of the sump. Therefore, hydrodynamic loads did not need to be considered.

The NRC staff reviewed the RAI responses and found them acceptable, except for the response regarding the hydrodynamic loads. Several components (notably Strut Head 1), had such high stress ratios that even a small hydrodynamic loading value could have an impact on the acceptability of particular strainer components. To address this, the NRC issued a follow-up RAI by letter dated April 15, 2009, to which the licensee responded by letter dated May 29, 2009. In its response, the licensee explained that the loads used in the analysis of the components in question were very conservatively estimated. Based on the conservative methods used to analyze the components, adequate margin exists to account for any increase in loading due to hydrodynamic forces. Based on the RAI response, the NRC staff determined that the licensee had provided sufficient information to justify the omission of the hydrodynamic loading in the licensee's structural analyses.

NRC Staff Conclusion:

Based on the above, the NRC staff concludes that the licensee's structural analysis of the Braidwood and Byron replacement sump strainers is adequate and reasonable assurance exists that the sump strainer assemblies will remain structurally adequate under normal and abnormal loading conditions such that the assemblies will be able to perform their intended design functions. The NRC staff considers this item closed for GL 2004-02.

3.0 DOWNSTREAM EFFECTS - FUEL AND VESSEL

The objective of the downstream effects review, 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 long-term core cooling.

Initial NRC Staff Review:

The initial NRC staff review is based on documentation provided by the licensee through December 31, 2007.

In the December 31, 2007, submittal, the licensee stated that it performed an evaluation of the effects of ECCS sump strainer bypassed debris on post-LOCA long-term core cooling using the guidance in WCAP-16793-NP, Revision 0. The evaluation showed that long-term core cooling can be achieved and the maximum fuel clad temperature, after the initial core quench, can be maintained below 800 degrees Fahrenheit (°F). However, the licensee acknowledged that the NRC staff had not issued a final SE on WCAP-16793-NP, Revision 0, and, therefore, committed to submitting a final response in November 2015, following of receipt of the final NRC SE.

By letter July 24, 2008, the NRC staff expressed reasonable assurance that the likelihood of unacceptable in-vessel debris impact for Byron and Braidwood is very low because of the low debris loading at all four units. However, because the GL 2004-02 response referred to and relied on a TR for which the NRC had not yet issued an SE, the NRC deferred issuance of a closure letter to Byron and Braidwood for GL 2004-02 until uncertainties regarding the issues with WCAP-16793-NP were reduced. Further, the NRC stated that the licensee could wait for the issues to be resolved through the WCAP process or could demonstrate that in-vessel downstream effects issues were resolved for Byron and Braidwood by demonstrating, without reference to WCAP-16793 or the NRC staff SE, that in-vessel downstream effects were addressed for Byron and Braidwood.

Final NRC Staff Review:

By letter dated October 30, 2015, the licensee submitted a revised GL 2004-02 in-vessel downstream effects resolution for Byron and Braidwood. By letter dated April 15, 2016, the licensee submitted a revision to the October 30, 2015, submittal. The final NRC staff review is based on the licensee's October 30, 2015, and April 15, 2016, submittals.

Evaluation Criteria

On April 8, 2013, the NRC staff issued an SE (ADAMS Accession No. ML13084A154) on TR WCAP-16793-NP, Revision 2, finding the TR an acceptable model for assessing the effects of sump strainer bypassed fibrous, particulate, and chemical debris on core cooling in PWRs. The TR guidance and acceptance bases were developed through analyses and flow testing using representative fuel assemblies and ECCS flow rates. In order to demonstrate adequate core cooling capability, the TR, the limitations and conditions section of the NRC SE of the TR, and the GL 2004-02 response to the content guide (ADAMS Accession No. ML073110278) require certain actions of the licensee. These requirements and the licensee's actions for meeting these requirements are described herein.

The GL 2004-02 response content guide required the response to item (n), "Downstream Effects - Fuel and Vessel" to confirm that the licensee's evaluation is consistent with, or bounded by, the industry generic guidance contained in TR WCAP-16793-NP, as modified by the NRC staff's conditions and limitations stated in the NRC SE on that document. Also, the response shall briefly summarize the application of the WCAP evaluation methods and include the following information:

a) The available driving head and ECCS flow rate used in the evaluation of the hot-leg break LOCA scenario,

b) The type(s) of fuel and inlet filters installed in the plant,

c) The results of the LOCADM calculation, including the predicted peak clad temperature,

d) The amount of fiber (in grams per fuel assembly) that is assumed to reach the core inlet after a LOCA,

e) The method(s) used to estimate the quantity and size distribution of the fibrous debris that would pass through the ECCS sump strainer and reach the core inlet after a LOCA and,

f) A description of any deviations from, or exceptions to the WCAP or the NRC SE for the WCAP.

By letter dated October 30, 2015, the licensee stated that all units at Byron and Braidwood meet the requirements of 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," based on approved models for analyses, strainer head loss testing, and its analysis of in-vessel downstream effects. As the WCAP-16793-NP, Revision 2, methodology represents an NRC-approved model, successful completion of the in-vessel downstream effects analysis in accordance with the WCAP and associated SE shows compliance with 10 CFR 50.46 as it relates to in-vessel downstream effects. The licensee updated its in-vessel evaluation by letter dated April 15, 2016. This letter confirmed that the Byron and Braidwood units meet the NRC-approved acceptance criteria for in-vessel debris. Some of the values provided in the October 2015, letter, were changed slightly. This section reflects the updated values.

The licensee determined the amount of fiber that could bypass their ECCS strainer using the methods allowed in the NRC staff SE for WCAP-16793, Revision 2. The SE allows licensees to determine the quantity of strainer bypass for their strainer by using the results of strainer testing conducted on a strainer of the same manufacture and same perforation size as the plant strainer. If necessary, the results are to be prorated to the plant's strainer area, approach velocity, debris types, and debris quantities. The licensee compared bypass results obtained specifically for Byron and Braidwood, but collected using techniques not fully acceptable to the NRC, to results obtained for plants with similar strainers and post-accident conditions. The licensee corrected the results to the results previously accepted by the NRC for the other plants and included conservatism in the evaluation. The licensee's calculations found that the in-vessel debris loading for the plants is less than the limit defined in the staff SE for WCAP-16793, Rev. 2 and that all other limitation and conditions of the staff SE are met. Therefore, the debris amount is acceptable.

The licensee performed a plant-specific evaluation of the maximum fuel clad temperature and deposit thickness for Byron and Braidwood using WCAP-16793-NP, Revision 2, and the associated NRC SE for that document. The evaluation results are:

1. The maximum calculated cladding temperature is less than 620 °F. This is less than the WCAP-recommended maximum cladding temperature of 800 °F.

2. The total deposition thickness is less than 0.018 inches (18 mils). This is less than the WCAP recommended total debris deposition thickness of 0.050 inch (50 mils).

Also, in the letter dated October 30, 2015, the licensee satisfactorily demonstrated compliance with the 14 limitations and conditions (L&Cs) of the NRC SE for WCAP-16793-NP-A, Revision 2. The April 15, 2016 letter confirmed that the L&Cs continue to be met.

Based on the above information, the licensee has documented that all the Byron and Braidwood units meet the requirements specified in WCAP-16793-NP, Revision 2, and the specifications, limitations, and conditions listed in the associated NRC SE.

NRC Staff Conclusion:

The NRC staff reviewed the description of the analyses, strainer bypass testing, and compliance with the L&Cs of the SE, as described in the licensee's GL 2004-02 response to Item (n) and finds that the licensee's response addressing in-vessel downstream effects for all units at Byron and Braidwood satisfies the requirements stated in TR WCAP-16793-NP-A, Revision 2 and the NRC SE for that document. Therefore, the NRC staff concludes that the licensee has adequately addressed the potential effects of ECCS sump strainer bypassed debris on core cooling at Byron and Braidwood. The NRC staff considers this item closed for GL 2004-02.

4.0 CONCLUSION

The NRC staff has performed a thorough review of all of the licensee's responses and RAI supplements to GL 2004-02. The NRC staff conclusions associated with in-vessel downstream effects is documented above. Based on the above evaluation, and the NRC June 1, 2009, letter 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 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 ECCS or CSS from performing their intended functions in accordance 10 CFR 50.46 to assure adequate long-term core cooling following a design basis accident.

Therefore, the NRC staff concludes that the licensee's responses to GL 2004-02 are adequate and considers GL 2004-02 closed for the Byron Unit Nos. 1 and 2, and Braidwood, Units 1 and 2.

Principle Contributor: S. Smith
Date of issuance: May 19, 2016

performance of its intended safety function to assure adequate long term core cooling following a DBA in accordance with 10 CFR 50.46, "Acceptance criteria for ECCSs for light-water nuclear power reactors." Therefore, the NRC staff concludes that the licensee's responses to GL 2004-02 are adequate and considers GL 2004-02 closed for Braidwood and Byron.

Enclosed is the summary of the NRC staff's review. If you have any questions, please call me at 301-415-6606 or via e-mail at Joel.Wiebe@nrc.gov.

Sincerely,

/RA/

Joel S. Wiebe, Senior Project Manager
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-456, STN 50-457,
STN 50-454 and STN 50-455

Enclosure:
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DATE	05/11/16	05/11/16	04/28/16	05/13/16	05/19/16

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