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

August 10, 2017

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: BYRON STATION, UNIT NOS, 1 AND 2 – ISSUANCE OF AMENDMENTS REGARDING USE OF TORMIS FOR ASSESSING TORNADO MISSILE PROTECTION (CAC NOS. MF8446 AND MF8447)

Dear Mr. Hanson:

The U.S. Nuclear Regulatory Commission (the Commission) has issued the enclosed Amendment No. 199 to Renewed Facility Operating License No. NPF-37 and Amendment No. 199 to Renewed Facility Operating License No. NPF-66 for the Byron Station, Unit Nos. 1 and 2, respectively. The amendments are in response to your application dated October 7, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16281A174) as supplemented by your letter dated March 20, 2017 (ADAMS Accession No. ML17079A130).

The amendments revise the Updated Final Safety Analysis Report (UFSAR) to identify the TORMIS Computer Code as the methodology used for assessing tornado-generated missile protection of unprotected plant structures, systems and components (SSCs) and to describe the results of the Byron Station site-specific tornado hazard analysis.

A copy of the Safety Evaluation is also enclosed. The Notice of Issuance will be included in the Commission's biweekly *Federal Register* notice.

Sincerely,

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

Docket Nos. STN 50-454 and STN 50-455

Enclosures:
1. Amendment No. 199 to NPF-37
2. Amendment No. 199 to NPF-66
3. Safety Evaluation

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

EXELON GENERATION COMPANY, LLC

DOCKET NO. STN 50-454

BYRON STATION, UNIT NO. 1

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 199
Renewed License No. NPF-37

1. The U.S. Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Exelon Generation Company, LLC (the licensee) dated October 7, 2016, as supplemented by letter dated March 20, 2017, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act) and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, by Amendment No. 199, the Renewed Facility License No. NPF-37 is amended to authorize revision to the Updated Final Safety Analysis Report (UFSAR), as set forth in the application dated October 7, 2016, as supplemented by letter dated

March 20, 2017. The licensee shall update the UFSAR to incorporate the TORMIS Computer Code as the methodology used for assessing tornado-generated missile protection of unprotected plant structures, systems and components (SSCs) and to describe the results of the Byron Station site-specific tornado hazard analysis as described in the licensee's application dated October 7, 2016, as supplemented by letter dated March 20, 2017, and the NRC staff's safety evaluation attached to this amendment, and shall submit the revised description authorized by this amendment with the next update of the UFSAR.

3. This license amendment is effective as of the date of its issuance and shall be implemented within 60 days of the date of issuance. The UFSAR changes shall be filed with the NRC in the next periodic update to the UFSAR scheduled for December 15, 2018.

FOR THE NUCLEAR REGULATORY COMMISSION

David J. Wrona, Chief
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Date of Issuance: August 10, 2017

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

EXELON GENERATION COMPANY, LLC

DOCKET NO. STN 50-455

BYRON STATION, UNIT 2

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 199
Renewed License No. NPF-66

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Exelon Generation Company, LLC (the licensee) dated October 7, 2016, as supplemented by letter dated March 20, 2017, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act) and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, by Amendment No. 199, the Renewed Facility License No. NPF-66 is amended to authorize revision to the Updated Final Safety Analysis Report (UFSAR), as set forth in the application dated October 7, 2016, as supplemented by letter dated

March 20, 2017. The licensee shall update the UFSAR to incorporate the TORMIS Computer Code as the methodology used for assessing tornado-generated missile protection of unprotected plant structures, systems and components (SSCs) and to describe the results of the Byron Station site-specific tornado hazard analysis as described in the licensee's application dated October 7, 2016, as supplemented by letter dated March 20, 2017, and the NRC staff's safety evaluation attached to this amendment, and shall submit the revised description authorized by this amendment with the next update of the UFSAR.

3. This license amendment is effective as of the date of its issuance and shall be implemented within 60 days of the date of issuance. The UFSAR changes shall be filed with the NRC in the next periodic update to the UFSAR scheduled for December 15, 2018.

FOR THE NUCLEAR REGULATORY COMMISSION

David J. Wrona, Chief
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Date of Issuance: August 10, 2017

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 199 TO RENEWED FACILITY OPERATING LICENSE NO. NPF-37 AND AMENDMENT NO. 199 TO RENEWED FACILITY OPERATING LICENSE NO. NPF-66

EXELON GENERATION COMPANY, LLC

BYRON STATION, UNIT NOS. 1 AND 2

DOCKET NOS. STN 50-454 AND STN 50-455

1.0 INTRODUCTION

By letter dated October 7, 2016 (Agencywide Document Access and Management System (ADAMS Accession No. ML16281A174), as supplemented by letter dated March 20, 2017 (ADAMS Accession No. ML17079A130), Exelon Generating Company, LLC (EGC, the licensee), submitted a request to the U.S. Nuclear Regulatory Commission (NRC or Commission) to revise the Byron Station (Byron), Unit Nos. 1 and 2, licensing bases for protection from tornado-generated Missiles. Specifically, the proposed changes would revise the Updated Final Safety Analysis Report (UFSAR) to identify the TORMIS computer code (TORMIS) as the methodology used for assessing tornado-generated missile protection of unprotected plant structures, systems and components (SSCs) and to describe the results of the Byron site-specific tornado hazard analysis.

The March 20, 2017, supplement contained clarifying information and did not change the NRC staff's initial proposed finding of no significant hazards consideration published in the *Federal Register* dated December 6, 2016 (81 FR 87969).

2.0 REGULATORY EVALUATION

The NRC requires that nuclear power plants be designed to withstand the effects of natural phenomena, including tornado and high-wind-generated missiles, so as not to adversely impact the health and safety of the public in accordance with the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix A, General Design Criterion (GDC) 2, "Design Bases for Protection against Natural Phenomena," and GDC 4, "Environmental and Dynamic Effects Design Bases." Methods acceptable to the NRC to comply with these regulations are described in Regulatory Guides (RG) 1.117, "Tornado Design Classification," Revision 1, April 1978, and NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants," Section 3.5.1.4, "Missiles Generated by Natural Phenomena," and Section 3.5.2, "Structures, Systems, and Components to be Protected from Externally-Generated Missiles," Revision 2, July 1981.

The SRP, Sections 3.5.1.4 and 3.5.2, contain the current acceptance criteria governing tornado missile protection. These criteria generally specify that SSCs that are important to safety be provided with sufficient, positive tornado missile protection (i.e., barriers) to withstand the maximum credible tornado threat. The appendix to RG 1.117, lists the types of SSCs that should be protected from design basis tornadoes. However, SRP Section 3.5.1.4 permits relaxation of the above deterministic criteria if it can be demonstrated that the frequency of damage to unprotected essential safety-related features is sufficiently small.

To use this probabilistic criterion, the Electric Power Research Institute (EPRI) developed the tornado missile probabilistic methodology described in two topical reports, EPRI NP-768 and NP-769, "Tornado Missile Risk Analysis and Appendices," issued May 1978, and EPRI NP-2005, "Tornado Missile Risk Evaluation Methodology," Volumes I and II, issued August 1981.[1] These topical reports document the TORMIS methodology. The TORMIS methodology employs Monte Carlo random sampling techniques to assess the frequency of tornado missile strikes that will cause unacceptable damage to safety-related plant equipment.

The NRC staff issued a safety evaluation report (SER), dated October 26, 1983 (ADAMS Accession No. ML080870291), which concludes that the TORMIS methodology can be used in lieu of the deterministic methodology when assessing the need for positive tornado missile protection for specific safety-related plant features in accordance with the criteria of SRP Section 3.5.1.4. The staff further concluded that the methodology had limitations for its use and that licensees must consider five plant-specific points and provide appropriate information regarding its use. These five points are discussed and evaluated in Section 3.0 of this safety evaluation (SE).

On June 16, 2008, the NRC issued Regulatory Issue Summary (RIS) 2008-14, "Use of TORMIS Computer Code for Assessment of Tornado Missile Protection," (ADAMS Accession No. ML080230578). This RIS addresses: (1) the NRC staff position on the use of TORMIS for assessing nuclear power plant tornado missile protection, (2) issues identified in previous license amendment requests to use TORMIS, and (3) information needed in license amendment applications using TORMIS. As specified in RIS 2008-14, the TORMIS methodology is approved for situations where: (1) a licensee identifies existing plant SSCs that do not comply with the current licensing basis for positive tornado missile protection of the plant and (2) it would require costly modifications to bring the plant into compliance with the current licensing basis. The TORMIS methodology is not approved for justification of existing missile barrier removal, either temporarily or permanently.

Although the TORMIS methodology utilizes acceptance criteria for the frequency of tornado-induced loss of system function, the NRC approval for implementation of TORMIS is not a risk informed approach. As such, approval of TORMIS allows an alternate method for meeting regulatory guidance under very specific circumstances with respect to the evaluation of specific plant features where additional costly tornado missile protective barriers or alternate systems are under consideration. A licensee may submit a license amendment application utilizing a risk-informed change process consistent with the guidelines of RG 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk Informed Decision on Plant-Specific Changes to the Licensing Basis." If a risk-informed process was proposed, it would have to meet the five key principles of risk-informed regulation described in RG 1.174.

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[1]Available from Electric Power Research Institute, 3420 Hillview Avenue, Palo Alto, California 94304

In its application dated October 7, 2016, the license states that the Byron Station TORMIS analysis utilizes a probabilistic approach performed in accordance with the guidance described in the NRC TORMIS SER dated October 26, 1983, as clarified by RIS 2008-14, "Use of TORMIS Computer Code for Assessment of Tornado Missile Protection," dated June 16, 2008. Based on the licensee's statement, the NRC does not consider the licensee's request a risk-informed application and, therefore, the NRC will not use the guidance in RG 1.174 for this evaluation.

3.0 TECHNICAL EVALUATION

3.1 Background

NRC Inspection Report (IR), dated November 5, 2009 (ADAMS Accession No. ML093100141), identified a non-cited violation (NCV) at Byron for failure to protect the various components listed in the IR. Subsequently, NRC IR dated July 21, 2015 (ADAMS Accession No. ML15203A042), identified another NCV for failure to evaluate the adverse effects of the licensee changing the essential service water cooling tower (SXCT) tornado analysis as described in the UFSAR. In addition, the IR identified that the licensee used TORMIS in an operability evaluation to evaluate the failure to protect the components but had not obtained NRC approval for the use of TORMIS, as stated in RIS 2008-14. On May 25, 2016, EGC issued Event Notification Report No. 51958[2], "Discovery of Non-Conforming Conditions during Tornado Hazards Analysis," which documents non-conforming conditions in the plant design such that specific technical specification (TS) equipment on both units is considered to be inadequately protected from tornado missiles. To resolve the above concerns and close out the Operability Evaluation, the licensee is pursuing NRC approval to utilize the TORMIS methodology for assessing tornado-generated missile protection of Byron SSCs.

As explained above, the NRC staff's approval of the licensee's application using TORMIS is subject to the appropriate resolution of the five specific concerns identified in the NRC TORMIS SER dated October 26, 1983. These specific concerns are related to the assumptions used in the input parameters for the analysis (e.g., locations and numbers of potential missiles presented at a specific site, wind speed, wind speed near the ground, etc.). The staff reviewed the submittal with respect to: (1) the five specific concerns related to the NRC approval of the TORMIS methodology, and (2) the acceptability of the TORMIS analysis for calculating the appropriate missile mean strike and damage probabilities and of the TORMIS results against the guidance provided in the SER on EPRI TORMIS methodology and RIS 2008-14.

The Byron TORMIS results provide estimated probabilities of tornado missile hits and damage to modeled targets. There were 153 individual unprotected safety-significant targets modeled in the Byron TORMIS as identified in the licensee's application dated October 7, 2016, Attachment 1-1, Table 1, "TORMIS Results by Individual TORMIS Target." The licensee considered systems or portions of systems such as SXCT, air intake louver on ultimate heat sink (UHS) electrical room, diesel auxiliary feed pump exhaust, power operated relief valves (PORV) and main steam safety valve (MSSV) tailpipe, UHS rooms, and refueling water storage tank (RWST) hatch. Of particular note, only the SXCT fans and cells that survive a tornado strike will be credited for UHS cooling as opposed to the original licensing basis that assumed all the unprotected SXCT fans are damaged by tornado-generated missiles.

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[2] Available on the USNRC public web site at https://www.nrc.gov/reading-rm/doc-collections/event-status/event/2016/20160526en.html#en51958

The NRC staff's position, as outlined in NRC memorandum from Harold R. Denton to Victor Stello, "Position on the Use of Probabilistic Risk Assessment in Tornado Missile Protection Licensing Actions" (ADAMS Accession No. ML080870287), is that the guidance of SRP, Section 2.2.3, "Evaluation of Potential Accidents" (ADAMS Accession No. ML070460336), is applicable to tornado missiles. This guidance, which is used in probabilistic tornado missile reviews, states that an expected rate of occurrence of potential exposures in excess of the 10 CFR Part 100 guidelines of approximately 1.0E-06 per year is acceptable if, when combined with reasonable qualitative arguments, the risk can be expected to be lower.

As noted in the Byron TORMIS results, the individual units damage frequency meet the acceptance criterion of 1.0E-06 per year.

3.2 Implementation of the TORMIS Methodology

The NRC TORMIS SER dated October 26, 1983, approving the TORMIS methodology, identifies that licensees using the methodology are to consider and address five points in their applications. The NRC's evaluation of the licensee's responses with respect to these five points is described below:

(1) Data on tornado characteristics should be employed for both broad regions and small areas around the site. The most conservative values should be used in the analysis or justification provided for those values selected.

Section 2.3.1.2.2 of the Byron UFSAR (ADAMS Accession No. ML16357A516) states that the probability of a tornado occurring within the one-degree square in which the Byron site is located is 21.0 E-04 per year. The licensee, in its application dated October 7, 2016, uses a mean annual frequency of 3.58E-04 tornadoes per square mile per year.

In its e-mail dated January 19, 2017 (ADAMS Accession No. ML17019A202), the NRC staff in the request for additional information (RAI) 1 questioned differences in tornado frequency values found in the UFSAR and the licensee's application dated October 7, 2016. In response, the licensee noted that the UFSAR, Section 2.3.1.2.2, "Tornadoes and Severe Winds," estimated mean tornado probability values of 21.0 E-04 per year has units of "tornadoes per year" as opposed to the "tornadoes per year per square mile" used in the TORMIS analysis. Using the UFSAR "1-degree square" annual tornado frequency values and the UFSAR area for the 1-degree square of approximate 3470 square miles, the equivalent occurrence rate for tornadoes expressed in units of "tornadoes per year per square mile" is 6.05E-04 tornadoes per year per square mile. A correction for annual reporting trend in TORMIS results in a value of 3.58E-04 mean annual tornado frequency per square mile. The licensee further clarified that the UFSAR values are averages with very large uncertainties resulting from a few years of data. The TORMIS application tornado occurrence rate uses significantly more data (1950-2013) over a much larger area, which reduces the uncertainty associated with determining the tornado occurrence rate. It also uses both broad and small regions to select a homogenous sub-region around the station. The licensee concludes that the differences in the UFSAR and TORMIS occurrence rates are reasonable given the significant differences in the periods of record, quality of data used, and consideration of small area events. As indicated by the licensee, the TORMIS tornado hazard curve is conservative when compared to NUREG/CR-4461 (ADAMS Accession No. ML070810400), for defining the design-basis tornado for a nuclear power plant.

Based on the licensee's use of the most recent data, derived with more emphasis on reporting and verification of tornadoes which results in higher quality data, the NRC staff concludes that the tornado characteristics used in the application are acceptable.

(2) The EPRI study proposes a modified tornado classification, F'-scale, for which the velocity ranges are lower by as much as 25-percent than the velocity ranges originally proposed in the Fujita, F-scale. Insufficient documentation was provided in the studies in support of the reduced F'-scale. The F-scale tornado classifications should therefore be used in order to obtain conservative results.

The licensee stated that the original Enhanced Fujita (EF) scale wind speeds were utilized in the Byron analysis. The hazard curve developed for the Bryon analysis does not utilize either the SER specified Fujita F'-scale nor the SER prohibited, modified, Fujita F'-scale. Instead, the analysis utilizes the EF scale wind speeds as per NUREG/CR-4461, Revision 2. Although the 1983 NRC SER called for the use of the Fujita F'-scale of tornado intensity for assigning tornado wind speeds to each intensity category (FI-F5), the NRC subsequently adopted the EF scale in the positions of NRC RG 1.76, Revision 1, that are based on NUREG/CR-4461, Revision 2.

While the Byron TORMIS analysis used the EF-Scale, UFSAR Section 2.3.1.2.2 defines the current licensing basis windspeed for the Byron Station, with the rotational velocity equal to 290 miles per hour (mph) and maximum translational velocity equal to 70 mph. In its e-mail dated January 19, 2017, the NRC staff in RAI 4 questioned the basis for use of the EF-scale in the TORMIS analysis. As specified in its March 20, 2017, response, the licensee stated that, "The use of the EF scale wind speeds is limited to evaluation of unprotected equipment using TORMIS. There is no intent to update the entire licensing basis to utilize the latest revision of RG 1.76." The licensee added a statement to UFSAR, Section 3.5.5.a, to identify the limitation on EF-scale use to TORMIS simulations only. Based on limitations of use and consistency with current NRC guidance, the staff concludes that the use of the EF scale is acceptable for analyzing SSC's within this TORMIS application.

(3) Reductions in tornado wind speed near the ground due to surface friction effects are not sufficiently documented on the EPRI study. Such reductions were not consistently accounted for when estimating tornado wind speeds at 33 feet above grade on the basis of observed damage at lower elevations. Therefore, the user should calculate the effects of assuming velocity profiles with ratios Vo (speed at ground level)/ V33 (speed at 33 foot elevation) higher than that in the EPRI study. Discussion of the sensitivity of the results to changes in the modeling of the tornado wind speed profile near the ground should be provided.

To address the reductions in tornado missile speed near the ground due to surface friction effects that are not sufficiently documented in the EPRI study, the licensee stated that the TORMIS rotational velocity Profile 3 was used. This profile has increased wind speeds over the TORMIS Profile 5 values used in the 1981 EPRI TORMIS reports. A sensitivity study was conducted by running the original EPRI profiles and comparing the results. The comparison showed that differences in results were negligible for missile hit. Some sensitivity was observed for targets with very low damage frequencies (i.e., <1.0E-08); however, differences were negligible when aggregated over the target groups. The use of Profile 3 with higher near-ground wind speeds is conservative when compared to Profile 5. Therefore, the NRC staff concludes that the licensee's use of TORMIS rotational velocity Profile 3 to address the reductions in tornado missile speed near the ground is reasonable and acceptable.

(4) The assumptions concerning the locations and numbers of potential missiles presented at a specific site are not well established in the EPRI studies. However, the EPRI methodology allows site-specific information on missile availability to be incorporated in the risk calculation. Therefore, users should provide sufficient information to justify the assumed missile density based on site-specific missile sources and dominant tornado paths of travel.

The licensee performed a walkdown of the Byron site during a plant outage which identified an increase in the number of potential missiles at the site. The survey walkdown uses a systematic, documented process to provide input on what missiles are in each missile zone, the minimum and maximum injection heights for all missiles by missile type, the building characteristics for structures in the missile zone, and pictures of the missiles and buildings surveyed. The mean number of potential missiles simulated for EF5 tornadoes was 238,874, including structural failure missile sources. Missile sources were catalogued and modeled to a distance of approximately 2,500 feet. The NRC staff finds that 238,874 potential missiles is an acceptable number of missiles based on the systematic walkdown used to develop the number. In comparison, the NRC notes that some other plants use 25,000 to 74,000 potential missiles.

(5) Once the EPRI methodology has been chosen, justification should be provided for any deviations from the calculational approach.

The licensee stated that the TORMIS code, a legacy FORTRAN computer code, has been updated to modern computers. The updates and enhancements include: porting the legacy code from the mainframe to minicomputer to PC computers; post processing data routines; updating the random number generation; updating the aerodynamic tip loss function, and addressing compiler differences and numerical round-off issues in various functions from the legacy code. An enhanced method was used for evaluating missiles passing through openings such as pipe penetrations in concrete walls. This method uses a screening of missile impact conditions to evaluate missile impacts that can obviously not pass through an opening. This approach provides an additional output option for estimating the probabilities of missiles passing through small openings in concrete barriers. Based on its review, the NRC staff finds that these methods are reasonable and are therefore acceptable.

Based on the above, the NRC staff determined that the licensee considered and appropriately addressed each of the five points described in the NRC TORMIS SER, dated October 26, 1983. The staff finds that the licensee's analysis meets the guidance of SRP, Section 3.5.1.4, which permits relaxation of the deterministic guidance in SRP, Sections 3.5.1.4 and 3.5.2, as allowed by the NRC TORMIS SER dated October 26, 1983. Moreover, because the licensee's analysis meets the guidance in SRP, Section 3.5.1.4, the NRC staff finds that requirements of GDCs 2 and 4 are met.

The NRC issued RIS 2008-14, "Use of TORMIS Computer Code for Assessment of Tornado Missile Protection," to inform licensees of the following:

1. the NRC staff position on the use of the TORMIS computer code for assessing nuclear power plant tornado missile protection,

2. issues identified in recent license amendment requests to use the TORMIS computer code, and

3. information needed in license amendment applications using the TORMIS computer code.

The RIS further states that, "This RIS does not alter the NRC staff position established in 1983 for the use of the TORMIS methodology." To address the guidance of the RIS, the licensee considered the RIS observations in the development of the Byron TORMIS analysis and addressed each item individually in the application. In its review described above, the NRC staff considered the issues identified in the RIS and by its acceptance of the licensee's TORMIS analysis, determined that the licensee adequately addressed the concerns noted in the RIS. Based on the above, the NRC staff finds that the guidance of RIS 2008-14, is met.

3.3 Ultimate Heat Sink (UHS)

Byron received NCVs 05000454/2015008-06; 05000455/2015008-06 (ADAMS Accession No. ML093100141), for failure to evaluate the adverse effects of changing the SXCT tornado analysis as described in the UFSAR, Section 3.5.4, "Analysis of Missiles Generated by a Tornado," Revision 14. This UFSAR section was revised, without proper evaluation, to assume that two SXCT fans survive a tornado strike. As a result of the corrective actions for this NCV, the UFSAR analysis of record reverted back to the original licensing basis assumption that multiple tornado missile hits could result in the loss of all SXCT fans. An Operability Evaluation was completed and is currently in place to address the concern that, although progressing to cold shutdown is not prevented, it cannot be achieved within 72 hours with no SXCT fans available after a postulated tornado event.

On May 25, 2016, EGC issued Event Notification Report No. 51958, "Discovery of Non-conforming Conditions During Tornado Hazards Analysis." This notification report documents non-conforming conditions in the plant design such that specific TS equipment on both units is considered to be inadequately protected from tornado missiles. These conditions are being addressed in accordance with Enforcement Guidance Memorandum 15-002, "Enforcement Discretion for Tornado-Generated Missile Protection Noncompliance," dated June 10, 2015 (ADAMS Accession No. ML15111A269), and DSS-ISG-2016-01, "Clarification of Licensee Actions in Receipt of Enforcement Discretion Per Enforcement Guidance Memorandum EGM 15-002, "Enforcement Discretion for Tornado- Generated Missile Protection Noncompliance" Interim Staff Guidance," dated February 17, 2016 (ADAMS Accession No. ML15348A202).

As stated in its application, dated October 7, 2016, to resolve this non-conforming condition and close out the Operability Evaluation, the licensee is requesting NRC approval to utilize TORMIS for assessing tornado-generated missile protection of Byron SSCs. Unprotected targets needed for safe shutdown after a tornado, including the unprotected UHS components, are included in the TORMIS analysis. The results from the Byron TORMIS analysis will be used to credit unprotected equipment for post-tornado safe shutdown. Of particular note, the SXCT fans and cells that survive a tornado strike would be credited for UHS cooling as opposed to the original licensing basis that assumed all the unprotected SXCT fans are damaged by tornado-generated missiles.

The Byron UHS is a common system for the two Byron units and consists of two mechanical draft cooling towers (i.e., OA and OB) containing a total of eight SXCT fans. As stated in the application dated October 7, 2016, "The design of the Byron Station UHS is based on having a sufficient number of operable SXCT fans to remove the accident/transient heat load. As described in UFSAR, Section 9.2.5.3.1, "Ultimate Heat Sink Design Basis," (ADAMS Accession No. ML16357A525) the Byron UHS is designed to remove the heat load from one unit experiencing a loss-of-coolant accident (LOCA) coincident with a loss-of offsite power (LOOP)

in one unit and the concurrent orderly shutdown from maximum power to cold shutdown of the other unit. The LOCA analysis considers that two SXCT fans may be out of service as allowed by Byron TS 3.7.9, "Ultimate Heat Sink (UHS)," and a passive electrical failure that results in two additional fans not available to remove the accident heat load. Thus, for a LOOP/LOCA event, as few as four SXCT fans have been shown to be acceptable. The peak heat input to the UHS for a post-tornado two unit shutdown event (which assumes a dual unit LOOP) is much less than the peak heat load imposed on the UHS during a LOCA; therefore, fewer SXCT fans are needed for a post-tornado cooldown of both units; i.e., either two or three SXCT fans are needed depending on the case."

In its application dated October 7, 2016, the licensee states that success is defined as three of eight cells surviving for the "one cell out of service" case; or two of eight cells surviving for the "two cells out of service" case. The licensee defined this criteria by specifying the number of cells that may be initially out of service (one or two) is dependent on the outside air wet bulb temperature and number of operating units, as defined in TS 3.7.9. Each case also assumes a worst-case single-failure of an electrical bus resulting in the loss of power to two additional SXCT fans.

Based on above, the licensee defined TORMIS analysis success as at least three of the remaining five cells surviving when one cell is out of service or two of the remaining four cells surviving when two cells are out of service. The licensee states in its application dated October 7, 2016, "The UHS post-tornado cool down analysis credits the surviving cells and shows that cold shutdown is achieved within 72 hours following a unit shutdown due to a tornado." The licensee also indicated the station will establish administrative controls to ensure the assumed initial conditions in the post-tornado UHS cooldown analysis are met; i.e., the administrative controls will specify the number of SXCT fans required to be operable based on outside environmental conditions.

In its e-mail dated January 19, 2017 (ADAMS Accession No. ML17019A202), the NRC staff in RAI 8 requested the licensee to provide additional details regarding the analysis to demonstrate that only two SXCT fans are required to safely shutdown both units during post-tornado conditions and to verify heat loading capability is adequate for post-tornado event shutdown. In its response dated March 20, 2017, the licensee summarized that their analysis determined that with the available fans and risers, and a wet bulb temperature less than or equal to 65 degree Fahrenheit (° F), cold shutdown conditions can be reached for both units well before 72 hours (i.e., within 36 hours) while maintaining the service water (SX) supply water temperature less than or equal to the design maximum temperature of 100 °F. The licensee response provided the additional details the NRC staff needed to determine that only two SXCT fans are required and resolved the NRC staff question.

During its review, the NRC staff identified that the makeup pumps for the source of makeup water for SX are located in the river screen house, which is not protected against tornado missiles. For the case of a tornado impacting the river screen house, the nonsafety-related onsite deep well pumps are used to provide makeup water, as a defense in depth water source. In an RAI, the staff questioned whether deep well pumps are being credited as alternate makeup for the effects from tornados and asked if supporting equipment is protected. Specifically, in its e-mail dated January 19, 2017 (ADAMS Accession No. ML17019A202), the NRC staff RAI 5 requested the licensee to confirm the piping, electrical, and infrastructure of the nonsafety onsite deep well pumps are adequately tornado protected to ensure makeup water is available for SX makeup pumps. In its response dated March 20, 2017, the licensee clarified that portions of the piping, electrical and infrastructure, of the nonsafety onsite deep well pumps

do not currently have an acceptable level of tornado protection to provide makeup water to fully function as defense in depth for the SX makeup pumps. The licensee also provided a list of items relevant to the deep well pump infrastructure that are not completely protected, but were included in the TORMIS analysis. Based on inclusion of deep well pumps and supporting components in the TORMIS model and probabilistic results, the licensee concluded the aggregate of the piping, electrical and infrastructure, of the nonsafety onsite deep well pumps have been shown to be adequately addressed regarding tornado protection. As an additional safety measure, TS 3.7.9 requires the licensee to verify operability of both deep wells pumps in event that a Tornado Watch is issued by the National Weather Service that includes the Byron site. Based on the inclusion of the deep well pumps and supporting components in the TORMIS model, the licensee's response resolved the NRC staff's questions regarding the availability of the deep well pumps during a tornado.

UFSAR, Table 3.5-4, specifies vertical impact velocities are taken equal to 80 percent of the horizontal impact velocities and UFSAR, Section 3.5.2, states, "The fans and motors are not protected from vertical or near vertical missiles." Due to the SXCT configuration being susceptible to vertical missiles, the NRC staff in its e-mail dated January 19, 2017 (ADAMS Accession No. ML17019A202), requested the licensee via RAI 2 to determine whether vertical missiles were addressed in its TORMIS analysis. The licensee response dated March 20, 2017, clarified that the TORMIS methodology explicitly considers all x, y, and z components of the missile velocity vector, which included vertical missiles. The 3-D simulations integrate the equations of motion for each missile and the resulting trajectories include a continuum of trajectory paths, including horizontal, vertical, and oblique trajectory paths. EPRI NP-2005 Volume 2, Section IV, describes missile motion and orientation models. As such, a continuum of missile velocity vector orientations at impact can occur, including horizontal near horizontal, oblique, near vertical, and vertical. Based on the inclusion of a continuum of missile velocity vector orientations, the licensee's response resolved the NRC staff question regarding vertical missiles.

Based on its review as described above and the licensee TORMIS results that two SXCT cells, including fans, survive during a tornado and the two SXCT cells, including fans, are adequate to safely shutdown both units during post-tornado event shutdown, the NRC staff determined that the UHS TORMIS analysis assumptions adequately support UHS operability for a LOOP/LOCA.

3.4 Results of the Byron Station, Units 1 and 2 TORMIS Analysis

Tables 3.4.4-1 and 3.4.4-2 in Section 3.4.4 of the licensee's application, dated October 7, 2016, provided the estimated damage frequencies of 9.13E-07 and 8.83E-07 for Unit 1 for one SXCT cell, and two SXCT cells out of service cases, respectively, and estimated damage frequencies of 9.66E-07 and 9.36E-07 for Unit 2 for one SXCT cell and two SXCT cells out of service cases, respectively. The licensee further stated that each individual unit damage frequency meets the acceptance criteria of 1.0E-06 per year established in SRP, Section 2.2.3, "Evaluation of Potential Accidents," and the NRC memorandum from Harold R. Denton to Victor Stello, "Position on Use of Probabilistic Risk Assessment In Tornado Missile Protection Licensing Actions," dated November 7, 1983 (ADAMS Accession No. ML080870287). However, for considering multi-unit site basis, the licensee stated that the estimated composite site damage frequencies are slightly over the acceptance criteria. The estimated composite site damage frequencies are 1.61E-06 per year and 1.58E-06 per year for the "1 SXCT Cell out of Service" case and "2 SXCT Cells out of Service" case, respectively.

In Section 3.5.5 of the proposed UFSAR revision described in its October 7, 2016, application, the licensee states that a TORMIS analysis was completed, which includes plant components located in areas not fully protected by missile barriers designed to resist impact from design-basis tornado missiles. These unprotected targets are identified and incorporated into UFSAR Table 3.5-17. The licensee states that the Byron TORMIS tornado missile risk analysis results show that the arithmetic sum of damage frequencies for all target groups affecting the individual units (i.e., Unit 1 plus common components and Unit 2 plus common components) are lower than the maximum acceptable threshold frequency of 1.0E-06 per year established in SRP, Section 2.2.3.

In its October 7, 2016, application, the licensee shows that, Byron, Unit 1 and Unit 2, each meet the acceptance criterion of 1.0E-06 per year; however, there is little margin. This lack of margin will result in limitations on use of TORMIS in the event additional unprotected components are found in future. Based on this small margin, the licensee is considering modifications to install missile protection for the Unit 1 and Unit 2 RWST hatches. If protection is installed for these targets, margin would be improved and the final damage frequency results would be reduced.

Based on review of the submittal, the NRC staff finds that not requiring unique tornado missile protection for identified targets, which have been analyzed by the TORMIS code, would slightly increase the probability of a malfunction of equipment important to safety. Nevertheless, because the frequency of a tornado-generated missile damaging these targets is less than 1.0E-06 per year, the NRC staff finds that it meets the guidance described in the SRP, Section 2.2.3. Therefore, because the results meet the 1.0E-06 criteria with or without additional protection, the NRC staff concludes that NRC approval to use the TORMIS methodology at Byron is not contingent on these potential modifications.

In its e-mail dated January 19, 2017 (ADAMS Accession No. ML17019A202), the NRC staff in RAI 11, requested that the licensee justify how their calculation for a per unit/per year aligns with EPRI NP-2005, and whether this is a deviation from the model methodology. Additionally, staff requested that the licensee provide information for calculation of the composite site damage frequency, whether that aligns with EPRI NP-2005 calculations, and why that result should not be considered for meeting the acceptance criteria of 1.0E-06 per year. Specifically, the staff cited references and calculations that appeared to describe a single, site consideration for event frequency as an overall conclusion, as opposed to a per unit conclusion.

In its response to RAI 11 in its letter dated March 20, 2017, the licensee stated that the damage frequency from the TORMIS methodology was used on a per year basis, citing EPRI NP-2005 Volume I, Figure II-4, and Equations 34-36. The licensee further stated, in part, the following:

> "... The Byron TORMIS calculation damage frequency uses the damage frequency straight from the TORMIS methodology on a per year basis. NP-2005 Volume I, Figure II-4, "Risk Aggregation for Multiple Time Periods," (found on page II-30) and Equations 34-36 (found on page II-33) address calculating the mean damage probability for multiple time periods such as different phases of plant construction for a multi-unit site. [...]

The NRC staff finds that the licensee's statement does not identify acceptance criteria nor does it discuss application of acceptance criteria on either a ***unit-specific or total site basis.***

However, in the licensee's application dated October 7, 2016, the potential outage missile sources are modeled in distinct TORMIS runs representing outage time periods. Three time

periods were simulated with TORMIS: (1) Unit 1 in an outage state with Unit 2 operational; (2) Unit 2 in an outage state with Unit 1 operational; and (3) Unit 1 and Unit 2 operational. These three time periods were combined to calculate a ***per-unit*** and composite site damage frequency, consistent with the methodology in NP-2005. Based on the above, the NRC staff determined that there is no deviation from the TORMIS methodology for computing per year damage frequency for individual units and/or the plant.

The NRC staff reviewed EPRI NP-2005 including multiple references provided by the licensee in its response to RAI 11. Specifically, Equations 34-36, EPRI NP-2005, Volume 1, provides the following information:

> Page II-33, Multiple Time Periods:
>
> "...The analysis of multiple time periods, corresponding to different phases of plant construction, for example, requires independent simulations. Thus, the combination of probabilities for a multi-unit plant might require the simulation of construction and operational phases. The total probability over time T for *y* time periods is determined from (Equation 34), where (A1) denotes the probability over time period Ti. By assuming independence among damage within each time interval, Eq. 34 can be calculated by (Equation 35).
>
> It is noted that, if the units of PT(A) are per unit rather than per plant, the PT1 (A) should be in the proper units before making the calculation in Eq. 35. With these results, the mean probability per year, P(A), is simply (Equation 36)..."

As explained in EPRI NP-2005 quoted above, Equations 35 and 36 provide a per unit option in performing calculations. Therefore, the NRC staff finds that the Byron TORMIS methodology performed Equations 34 and 36 in accordance with the NRC-approved TORMIS modeling in EPRI NP 2005.

The staff also reviewed the treatment of operational phases, as addressed by the licensee in its application dated October 7, 2016. The licensee provided information that applied to specific calculations performed for non-outage and outage time periods, and considered the potential increase in missiles that could be expected during outage conditions.

Additionally, the licensee considered common SSC's shared between the two units, and adjusted per unit/per year modeling of unit specific SSCs to overlap common SSCs into frequency determinations. Each unit's specific calculations also include common SSCs as part of analysis for that unit.

In addition, the NRC staff's position, as outlined in NRC memorandum from Harold R. Denton to Victor Stello, "Position on Use of Probabilistic Risk Assessment in Tornado Missile Protection Licensing Actions," dated November 7, 1983 (ADAMS Accession No. ML080870287), is that the guidance of SRP, Section 2.2.3, is applicable to tornado missiles. This guidance, which the NRC uses in probabilistic evaluation of the protection of SSCs against tornado-generated missiles, states that an expected rate of occurrence of potential exposures in excess of 10 CFR Part 100 guidelines of approximately 1.0E-06 per year is acceptable if, when combined with reasonable qualitative arguments, the risk can be expected to be lower.

Based on the above information and the licensee's demonstration that the Byron TORMIS methodology performed equations 34 and 36 in accordance with the NRC-approved TORMIS modeling in EPRI NP-2005, the NRC staff determined that the licensee's response to RAI 11 and application of acceptance criteria on a per unit basis is acceptable.

In its e-mail dated January 19, 2017 (ADAMS Accession No. ML17019A202), the NRC staff in RAI 12, requested that the licensee clarify the meaning of a statement in Section 4.4 of its October 7, 2016, letter that referred to "many additional aspects of the TORMIS modeling and inputs that ensure bounding and conservative results."

In its March 20, 2017, response to RAI 12, the licensee stated that "the intent of this statement was to generally summarize that various aspects of the modeling and input parameters already mentioned in the LAR ensure bounding and conservative results." The licensee further provided a list of items in Sections 3.4.1, 3.4.3, and 3.4.6, which were noted in the LAR as conservatisms in the analysis. The NRC staff finds that the licensee's response sufficiently clarified the statements in the application and the RAI, is therefore, resolved.

In its e-mail dated January 19, 2017 (ADAMS Accession No. ML17019A202), the NRC staff in RAI 13 requested the licensee to clarify if the calculation of any mean (cumulative) tornado missile damage frequency uses any intersection ($\cap$) operator that requires damaging multiple targets simultaneously for establishing a damaged state. This RAI requested that the licensee summarize the guidelines used to identify such groups and explain how they are modeled in TORMIS if multiple targets need to be simultaneously struck.

In its response, the licensee stated that the intersection operator, that required damaging multiple targets simultaneously for establishing a damage state, was used to calculate the TORMIS tornado missile damage frequency for the UHS target group. Therefore, multiple targets need to be damaged during the simulated tornado to result in failure of the UHS.

A listing of failure events affecting the survival of the UHS are defined in the licensee's application dated October 7, 2016, Attachment 1-1, Table 4. As an example, combination number 10 is Fan H and Fan D damaged by tornado missiles. For the one cell out of service case, this results in one cell out of service (Cell B is assumed to be randomly out of service for maintenance), two cells lost to the single failure (Cells E and F are assumed to be out of service because electrical room 132Z experienced random electrical failure), two cells lost to tornado missiles (Fan H and Fan D) with three cells surviving, which is not considered a failure. An additional UHS target would need to be damaged to result in a UHS target group failure.

The Boolean Logic was created for the UHS based on the minimum tower requirement as described in the licensee's letter dated October 7, 2016, Section 3.4.3. The licensee stated that the Boolean Logic was modeled in the analysis with the TORMIS post-processor TORSCR using the Boolean intersection ($\cap$) operator. The licensee's application dated October 7, 2016, Section 3.4.2 described that TORSCR is a FORTRAN computer code used to post-process TORMIS output files. Its primary function is to compute Boolean combinations of target hit and damage probabilities over multiple targets. The intersection operator was only used for the UHS in the Byron TORMIS analysis because multiple components need to be damaged to cause a failure of the UHS.

In its March 20, 2017, response to RAI 8 from the NRC staff's e-mail dated January 19, 2017 (ADAMS Accession No. ML17019A202), the licensee stated that the basis for success of the UHS is at least defined as three of the remaining five cells surviving for the one cell out service

case; or two of four remaining cells surviving in the two cells out of service case depending on outside air wet bulb temperature and number of operating units. Each case assumes a worst-case single-failure of an electrical bus that results in the loss of power to two paired SXCT fans.

Based on the use of the intersection operator to evaluate failures that need multiple components damaged from tornado missiles, the NRC staff finds that the licensee's use of the intersection operator to be acceptable for the components of the UHS.

Based on the above evaluation, the NRC staff concludes that the EPRI TORMIS methodology, is implemented appropriately in accordance with the guidance provided in the NRC TORMIS SER dated October 26, 1983, and RIS 2008-14. Furthermore, the staff concludes that the reported results are acceptable and consistent with the NRC guidance of SRP, Section 3.5.1.4, which permits relaxation of the deterministic guidance in SRP, Sections 3.5.1.4 and 3.5.2, as allowed by the NRC TORMIS SER dated October 26, 1983. Additionally, because the licensee's methodology meets the guidance in SRP, Section 3.5.1.4, the staff finds that requirements of GDCs 2 and 4 have also been met. Therefore, the staff finds that the licensee's proposed update of the Byron UFSAR to incorporate the TORMIS as the methodology used for assessing tornado-generated missile protection of unprotected plant SSCs and to describe the results of the Byron site-specific tornado hazard analysis as described in the licensee's application dated October 7, 2016, as supplemented by letter dated March 20, 2017, and this staff SE to be acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Illinois State official was notified on June 29, 2017, of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendments change requirements with respect to installation or use of a facility's components located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding (81 FR 87969; December 6, 2016). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

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Date of issuance: August 10, 2017

SUBJECT: BYRON STATION, UNIT NOS, 1 AND 2 - ISSUANCE OF AMENDMENTS REGARDING USE OF TORMIS FOR ASSESSING TORNADO MISSILE PROTECTION (CAC NOS. MF8446 AND MF8447) DATED AUGUST 10, 2017

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ADAMS Accession No.: ML17188A155 ***By Memo**

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