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

March 22, 2018

Mr. Richard D. Bologna
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Beaver Valley Power Station
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SUBJECT: BEAVER VALLEY POWER STATION, UNITS 1 AND 2 – STAFF ASSESSMENT OF FLOODING FOCUSED EVALUATION (CAC NOS. MF3286 AND MF3287; EPID L-2017-JLD-0051)

Dear Mr. Bologna:

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807). Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). By letter dated March 2, 2016 (ADAMS Accession No. ML16063A288), FirstEnergy Nuclear Operating Company (the licensee) responded to this request for Beaver Valley Power Station, Units 1 and 2 (BVPS).

By letter dated February 22, 2017 (ADAMS Accession No. ML17040A011), the NRC issued an interim staff response (ISR) letter for BVPS. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the design basis for BVPS and parameters that are a suitable input for subsequent flooding reviews. As stated in the ISR letter, because the local intense precipitation and probable maximum flood concurrent with wind wave action are not fully bounded by the plant's design basis, additional assessments of those flood hazard mechanisms are necessary.

By letter dated October 16, 2017 (ADAMS Accession No. ML17290A033), the licensee submitted the focused evaluation (FE) for BVPS. The focused evaluations are intended to confirm that licensees have adequately demonstrated, for the unbounded mechanism identified in the ISR letter, that: 1) a flood mechanism is bounded based on further reevaluation of flood mechanism parameters; 2) effective flood protection is provided for the unbounded mechanism; or 3) a feasible response is provided if the unbounded mechanism is local intense precipitation. The purpose of this letter is to provide the NRC's assessment of the BVPS FE.

As set forth in the attached staff assessment, the NRC staff has concluded that the BVPS FE was performed consistent with the guidance described in Nuclear Energy Institute (NEI) 16-05, Revision 1, "External Flooding Assessment Guidelines" (ADAMS Accession No. ML16165A178). Guidance document NEI 16-05, Revision 1, has been endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2016-01, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation" (ADAMS Accession No. ML16162A301). The NRC staff has further concluded that the licensee has demonstrated that effective flood protection, if appropriately implemented, exists for the unbounded flooding mechanism during a beyond-design-basis external flooding event at BVPS. This closes out the licensee's response for BVPS for the reevaluated flooding hazard portion of the 50.54(f) letter and the NRC's efforts associated with CAC Nos. MF3286 and MF3287.

If you have any questions, please contact me at 301-415-2864 or via e-mail at Milton.Valentin@nrc.gov.

Sincerely,

Milton O. Valentin, Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Enclosure:
Staff Assessment Related to the
Flooding Focused Evaluation for BVPS

Docket Nos. 50-334 and 50-412

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE FOCUSED EVALUATION FOR

BEAVER VALLEY POWER STATION, UNITS 1 AND 2

AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE

RECOMMENDATION 2.1 - FLOODING

1.0 INTRODUCTION

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) report (ADAMS Accession No. ML111861807).

Enclosure 2 of the 50.54(f) letter requested that licensees reevaluate flood hazards for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). If the reevaluated hazard for any flood-causing mechanism is not bounded by the plant's design basis flood hazard, an additional assessment of plant response would be necessary. Specifically, the 50.54(f) letter stated that an integrated assessment should be submitted, and described the information that the integrated assessment should contain. By letter dated November 30, 2012 (ADAMS Accession No. ML12311A214), the NRC staff issued Japan Lessons-Learned Project Directorate[1] (JLD) interim staff guidance (ISG) JLD-ISG-2012-05, "Guidance for Performing the Integrated Assessment for External Flooding."

On June 30, 2015, the NRC staff issued COMSECY-15-0019 (ADAMS Accession No. ML15153A104), describing the closure plan for the reevaluation of flooding hazards for operating nuclear power plants. The Commission approved the closure plan on July 28, 2015 (ADAMS Accession No. ML15209A682). COMSECY-15-0019 outlines a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's design basis. The revised process describes a graded approach in which certain licensees with hazards exceeding their design basis flood will not be required to complete an integrated assessment, but instead will perform a focused evaluation (FE). As part of the FE, these licensees will assess the impact of the hazard(s) on their site and then evaluate and implement any necessary programmatic, procedural, or plant modifications to address the hazard exceedance.

Nuclear Energy Institute (NEI) 16-05, Revision 1, "External Flooding Assessment Guidelines" (ADAMS Accession No. ML16165A178), has been endorsed by the NRC as an appropriate

[1] The Japan Lessons-Learned Project Directorate was subsequently replaced by the Japan Lessons-Learned Division, which uses the same initials (JLD). No distinction is made between the two organizations in this evaluation.

methodology for licensees to perform the FE in response to the 50.54(f) letter. The NRC's endorsement of NEI 16-05, including exceptions, clarifications, and additions, is described in NRC JLD-ISG-2016-01, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation" (ADAMS Accession No. ML16162A301).

2.0 BACKGROUND

This background section describes the reevaluated flood information provided by the licensee and the associated assessments performed by the NRC staff. The reevaluated flood information includes the flood hazard reevaluation report (FHRR), the mitigation strategies assessment (MSA), and the FE.

Flood Hazard Reevaluation Report

By letter dated March 2, 2016 (ADAMS Accession No. ML16063A288), FirstEnergy Nuclear Operating Company (FENOC, the licensee) submitted the FHRR for Beaver Valley Power Station, Units 1 and 2 (BVPS). In this letter, FENOC informed the NRC staff of two reevaluated flood hazard events (probable maximum flood concurrent with wind wave action at the Ohio River (combined event flood or CEF) and local intense precipitation (LIP)) exceeding the design basis flood. After reviewing the licensee's response, by letter dated February 22, 2017 (ADAMS Accession No. ML17040A011), the NRC issued an interim staff response (ISR) letter for BVPS. The ISR letter discussed the reevaluated flood hazard mechanisms that exceeded the design basis for BVPS and the parameters that are a suitable input for other assessments associated with NTTF Recommendation 2.1 "Flooding." As stated in the ISR letter, because the LIP and CEF are not fully bounded by the plant's design basis, additional assessments are necessary. The NRC staff final assessment of the FHRR will be issued in a separate letter.

Mitigation Strategies Assessment

By letter dated September 20, 2017 (ADAMS Accession No. ML17263A122), FENOC submitted the BVPS MSA for NRC review. The MSAs are intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigation strategies for beyond design basis external events. The licensee stated that the mitigation strategies are adequate and can be implemented without impact of the LIP or CEF. By letter dated March 23, 2018 (ADAMS Accession No. ML18071A169), the NRC issued its assessment of the BVPS MSA. The NRC staff concluded that the MSA was performed consistent with the guidance described in Appendix G of NEI 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625). The NRC's endorsement of NEI 12-06, Revision 2, is described in JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML15357A163). The NRC staff further concluded that the licensee has demonstrated that the mitigation strategies, if appropriately implemented, are reasonably protected from reevaluated flood hazards conditions for beyond-design-basis external events.

Focused Evaluation

By letter dated October 16, 2017 (ADAMS Accession No. ML17290A033), the licensee submitted the FE for BVPS. The focused evaluations are intended to confirm that licensees have adequately demonstrated, for unbounded mechanisms identified in the ISR letter, that: 1) a flood mechanism is bounded based on further reevaluation of flood mechanism parameters;

2) effective flood protection is provided for the unbounded mechanism; or 3) a feasible response is provided if the unbounded mechanism is LIP. These 3 options associated with performing an FE are referred to as Paths 1, 2, or 3, as described in NEI 16-05, Revision 1. The purpose of this staff assessment is to provide the results of the NRC's evaluation of the BVPS FE.

3.0 TECHNICAL EVALUATION

As described in the ISR letter, the LIP and CEF are found to exceed the plant's design basis. The licensee stated that the FE followed Path 2 (effective flood protection is provided for the unbounded mechanism) of NEI 16-05, Revision 1 and followed guidance in Appendix B to evaluate the site's strategy. This technical evaluation characterizes flood parameters and evaluates the following flood impact assessment topics for each unbounded flood-causing mechanisms: description of impact of unbounded hazard; evaluation of available physical margin and reliability of flood protection features; and overall site response.

3.1 Characterization of Flood Parameters

The licensee used the reevaluated flood hazard levels in the ISR letter (ADAMS Accession No. ML17040A011) as input for its FE and concluded that key safety functions (KSFs) are protected from the non-bounded reevaluated flood-causing mechanism (LIP and CEF). The licensee also stated that the site does not require human actions to protect structures, systems, and components associated with the KSFs; therefore, an evaluation of the overall site response was not necessary.

The licensee stated that the reevaluated CEF exceeded the design basis flood elevation of 730 feet (ft.) at three locations: (1) 732.8 ft. at the Unit 1 Turbine Building North wall, (2) 734.0 ft. at the ground slope approaching the Unit 2 Reactor Building, and (3) 734.5 ft. at the ground slope approaching the Emergency Outfall Structure and the FLEX Storage Building (FESB). The licensee explained in the FE that flooding of the Unit 1 Turbine Building and the pipe tunnel leading to the Auxiliary Building and Safeguards Area is part of the design basis and does not challenge the KSFs. The licensee also explained that the configuration of several reinforced concrete buildings will protect the site from wave energy propagation. The licensee also stated that wave runup at the Unit 2 Reactor Building, the Emergency Outfall Structure, and the FESB, is maintained on the ground slope approaching the structures. The licensee further stated in the FE, that the critical floor elevations are above the maximum CEF elevations and that this reevaluated flood mechanism does not affect the KSFs.

The licensee stated that flood heights from a LIP event vary at different locations due to the site grade elevation. The BVPS power block elevation varies from 730 ft. to 735 ft. For the same reason, the licensee assessed the accumulation of water in areas that could be temporarily flooded. The analysis performed by FENOC identified doors, leading to areas containing KSFs that could be susceptible to water ingress from the LIP. In its FE, the licensee described that the potential water intrusion through these doors (identified by FENOC) does not compromise KSFs at BVPS, with the exception of two doors. For these two doors, FENOC installed removable flood barrier panels that normally remain in place so that no manual actions are required prior the LIP. By doing so, FENOC stated that it has provided adequate protection against the LIP flood hazard.

3.2 Evaluation of Flood Impact Assessment for Probable Maximum Flood Concurrent with Wind Wave Action at the Ohio River

3.2.1 Description of Impact of Unbounded Hazard

Table 2 of the licensee's FE provides the maximum CEF flood elevation at locations where the 730 ft. site grade elevation is exceeded. The same table includes floor elevations of structures in the proximity of those areas where the CEF water elevation exceeds the grade elevation. For these structures, two of the critical floor elevations do not exceed the CEF elevations. One of these elevations is the Unit 1 Service Building (north wall), where the CEF elevation and the critical floor elevation are reported to be the same. The second elevation is the Unit 1 Turbine Building, which is designed to flood when waters reach 707.5 ft. without adverse impacts to the KSFs.

The licensee also explained that no associated effects are expected from the CEF given the low velocities of the flood waters and the hard surfaces of the power block area. The licensee further stated that, due to the low water velocity, presence of multiple obstacles, and the topographic features of the site, no significant debris is expected in the power block from the CEF.

In addition, FENOC explained that the wind wave runup analysis included a number of conservatisms such as strong wind speeds, general methods rather than analytical modeling, waves were assumed to approach from direct angle, and the use of upper limit methods to calculate the wind wave runup.

3.2.2 Evaluation of Available Physical Margin and Reliability of Flood Protection Features

In general, FENOC relies on the BVPS topographical features to protect the KSFs against the reevaluated CEF hazard. The BVPS power block is located in a terrace surrounded by rolling hill terrain, forcing all rain water to drain into the Ohio River. The licensee reported in its FE that protection against CEF is provided to all areas (except for the Unit 1 Turbine Building area) by site grade and topography, which is inherently permanently-installed and passive protection against floods.

The licensee also explained that, for the Unit 1 Turbine Building flood, protection is provided by the Unit 1 Service Building north wall. This Unit 1 Service Building north wall is a flood barrier designed to provide protection up to elevation 730 ft. as part of the design basis. The Unit 1 Service Building north wall protection relies on seals and a 12-inch curb with provisions to install an electric pump in the event of leakage. The licensee stated that these actions are part of the abnormal operating procedures for BVPS. Following the generic audit plan dated July 18, 2017 (ADAMS Accession No. ML17192A452), the NRC staff reviewed the Abnormal Operating Procedure (AOP) 75.2, "Acts of Nature - Flood," to confirm that FENOC has a comprehensive plan to shut down both reactors and address flooding at BVPS well before flood waters from the Ohio River reach the power block.

As part of the walkdown activities completed under Enclosure 4 of the 50.54(f) letter, FENOC and the NRC staff assessed the effectiveness of flood protection features at the BVPS site. As stated in the NRC staff assessment of the BVPS Flooding Walkdown Report (ADAMS Accession No. ML14156A233), FENOC did not identify any deficiencies in the site's flood protection. As stated in the same assessment, the NRC staff found that the walkdown activities followed the guidance in NEI 12-07, Revision 0, "Guidelines for Performing Verification

Walkdowns of Plant Flood Protection Features," (ADAMS Package Accession No. ML121440522).

Also, the NRC staff assessed the effect of wave runup generated by wind at the BVPS. The licensee stated in the FE that multiple obstructions would prevent wave energy transfer into the power block. Examples of these obstructions are the Unit 1 Turbine Building, which is built of steel elements and reinforced concrete, and all the heavy equipment in it. Also around the Unit 1 Turbine Building, are other smaller structures and equipment that could break the waves in the unlikely event of the waters reaching up to the power block. None of these obstructions are considered part of the KSFs.

To better understand the analysis performed by the licensee, the NRC staff audited FENOC Calculation DSC-6799, "Coincident Wave Analysis." In this report, FENOC confirmed grade elevations of the BVPS site and surrounding areas to provide greater assurance of its analysis of the reevaluated flood levels. In essence the calculation evaluated the CEF effects at the BVPS site and surrounding areas used for site access. The NRC staff noticed that the calculation assumes no losses in direction or slope of the waves towards the site, which is considered conservative. Also, Calculation DSC-6799 explains that even if the smaller obstacles before the Unit 1 Turbine Building exterior wall, and the wall itself, were to be damaged by the waves, the building and all internals should remain as obstructions to the waves. Also, the calculation explains that, in a worst-case scenario, water may reach the internal wall dividing the Unit 1 Turbine Building from the Unit 1 Service Building. However, this internal wall is designed as a flood barrier and it has controls in place to mitigate adverse consequences and protect the Unit 1 KSFs. The calculation also states that the water elevation by the internal Service Building wall will remain below the 730 ft. elevation. Other safety-related structures were also considered in Calculation DSC-6799, and were found to be protected from wave runup by the site's topography. Based on the above, the NRC staff concludes that FENOC Calculation DSC-6799 followed the guidance in NEI 16-05 for evaluating and describing flood impacts.

Because increased focus has been placed on flood protection since the accident at Fukushima, licensees and NRC inspectors have identified deficiencies with equipment, procedures, and analyses relied on to either prevent or mitigate the effects of external flooding at a number of licensed facilities. Recent examples include those found in Information Notice 2015-01, "Degraded Ability To Mitigate Flooding Events" (ADAMS Accession No. ML14279A268). In addition, the NRC is cooperatively performing research with the Electric Power Research Institute to develop flood protection systems guidance that focuses on flood protection feature descriptions, design criteria, inspections, and available testing methods under a memorandum of understanding dated September 28, 2016 (ADAMS Accession No. ML16223A495). The NRC staff expects that licensees will continue to maintain flood protection features in accordance with their current licensing basis. The staff also expects that licensees will use the site corrective action program to disposition flood-related maintenance, operations, and design issues, consistent with the provisions of NEI 16-05 and NEI 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features," as endorsed by the NRC, where appropriate. Continued research involving flood protection systems will be performed and shared with licensees in accordance with the guidance provided in Management Directive 8.7, "Reactor Operating Experience Program" (ADAMS Accession No. ML122750292), as appropriate.

Based on the above evaluation, the NRC staff concludes that existing margins and features provide effective flood protection from the CEF event to maintain KSFs as defined in Appendix B of NEI 16-05, Revision 1.

3.2.3 Overall Site Response

The licensee does not rely on any personnel actions or new modifications to the plant in order to respond to the CEF event. As described above, the licensee's evaluation relied on passive existing flood protection features to demonstrate adequate flood protection; therefore, there is no need to review overall site response.

3.3 Evaluation of Flood Impact Assessment for Local Intense Precipitation

3.3.1 Description of Impact of Unbounded Hazard

For the LIP, the licensee stated in the FE that various specific areas of the site could be temporarily flooded with shallow water depths for a short duration of time. Specific water elevations at areas of concern are provided in Table 3 of the licensee's FE. This situation would result in water infiltration through doors leading to areas containing safety-related equipment. The licensee reported having evaluated the leakage into each of these areas and the consequences of water ingress. For most of these doors, water ingress will not result in adverse effects on KSFs. However, the licensee reported that infiltration at two of these doors could result in adverse effects on KSFs. One door (1-F-35-1) is located at the Unit 1 Fuel Building and the other door (2-SB-30-8) at the Unit 2 Service Building. Consequently, the FE states that site modifications were completed to prevent water ingress through these two doors. The evaluation of these modifications is provided in Section 3.3.2 of this assessment.

In addition, the licensee explained that the LIP will cause difficulties when performing external activities, including site access and availability of offsite personnel. The licensee further stated that, based on the short duration of this event, and because of the shallow and low water velocities, the LIP will have no impact in any required activities.

3.3.2 Evaluation of Available Physical Margin and Reliability of Flood Protection Features

The licensee stated in its FE that modifications were implemented to prevent water intrusion into the Unit 1 Fuel Building and the Unit 2 Service Building. These modifications were described in the FE, as installation of removable flood barrier panels to a level above the maximum LIP water elevation estimated at these two doors. The licensee explained that the flood barriers are to be normally installed and therefore no manual actions are required prior to a LIP event.

Using the audit process, performed in accordance with a generic audit plan dated July 18, 2017 (ADAMS Accession No. ML17192A452), the NRC staff audited FENOC's evaluation of LIP effects on building internals (FENOC Calculation 10080-DSC-0368, "BDB LIP Internal Effects Analysis"). The NRC staff confirmed that the calculation used the same flood parameters provided in the ISR. The LIP analysis for the BVPS is documented in FENOC Calculation 10080-DSC-6794, "Beaver Valley Power Station: Effects of Local Intense Precipitation Analysis." This reference is included in both the FHRR submittal (ADAMS Accession No. ML16063A288) and Calculation 10080-DSC-0368. The NRC staff confirmed that the LIP Internal Effects Analysis (FENOC Calculation 10080-DSC-0368) quantifies the amount of water ingress into the 12 doors identified in FENOC Calculation 10080-DSC-6794. Calculation 10080-DSC-0368 also

describes the impact of internal flooding at all affected doors and provides the logic for proposing permanent modifications at the two doors where water ingress could affect the KSFs.

To understand the level of protection added with the modifications proposed in the licensee's FE, the NRC staff accessed, under the audit process cited above, documents associated with the flood barriers installed at the two critical doors identified by FENOC. The FE describes these flood barriers as 10 inches high, which is at least 4 inches higher than the water level estimated at both critical doors. To support the NRC staff review of the flood barriers, FENOC facilitated access by ePortal to Engineering Change Package (ECP) 15-0357-000, "Barrier Installation at Exterior Plant Doors." This ECP provides the configuration and design details of the flood barriers, including analyses of hydrostatic and hydrodynamic forces against the flood barrier. The licensee also considered the seismic loads in the design of channels where flood barriers will be installed. The NRC staff evaluation of the ECP confirmed that the design of the flood barriers followed the guidance in Appendix B of NEI 16-05 for evaluation of flood protection features.

Based on the above evaluation, the NRC staff concludes that existing margins and protective features provide effective flood protection from the LIP event to maintain KSFs as defined in Appendix B of NEI 16-05, Revision 1.

3.3.3 Overall Site Response

The licensee does not rely on any personnel actions or new modifications to the plant in order to respond to the LIP event. As described above, the licensee's evaluation relied on passive existing flood protection features to demonstrate adequate flood protection; therefore, there is no need to review overall site response.

4.0 AUDIT REPORT

The July 18, 2017, generic audit plan (ADAMS Accession No. ML17192A452) describes the NRC staff's intention to issue an audit report that summarizes and documents the NRC's regulatory audit of the licensee's FE. The NRC staff's BVPS audit was limited to the review of the calculations and procedures described above. Because this staff assessment appropriately summarizes the results of the audit, the NRC staff concludes a separate audit report is not necessary, and that this document serves as the audit report described in the staff's July 18, 2017, letter.

5.0 CONCLUSION

The NRC staff concludes that FENOC performed the BVPS FE in accordance with the guidance described in NEI 16-05, Revision 1, as endorsed by JLD-ISG-2016-01, and that the licensee has demonstrated that effective flood protection exists against the reevaluated flood hazards. Furthermore, the NRC staff concludes that BVPS screens out of performing an integrated assessment based on the guidance found in JLD-ISG-2016-01. As such, in accordance with Phase 2 of the process outlined in the 50.54(f) letter, additional regulatory actions associated with the reevaluated flood hazard, beyond those associated with the MSA, are not warranted. The licensee has satisfactorily completed providing responses to the 50.54(f) activities associated with the reevaluated flood hazard.

SUBJECT: BEAVER VALLEY POWER STATION, UNITS 1 AND 2 – STAFF ASSESSMENT OF FLOODING FOCUSED EVALUATION (CAC NOS. MF3286 AND MF3287; EPID L-2017-JLD-0051) DATED March 22, 2018

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