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

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Mr. Richard D. Bologna
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SUBJECT: BEAVER VALLEY POWER STATION, UNITS 1 AND 2– STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST FLOOD-CAUSING MECHANISM REEVALUATION (EPID NOS. L-2016-JLD-001 AND L-2016-JLD-0002.

Dear Mr. Bologna:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information under Title 10 of the *Code of Federal Regulations*, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The request was issued as part of implementing lessons learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood-causing mechanisms using present-day methodologies and guidance. By letter dated March 2, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16063A288), FirstEnergy Nuclear Operating Company (FENOC, the licensee) responded to this request for Beaver Valley Power Station, Units 1 and 2 (Beaver Valley).

By letter dated February 22, 2017 (ADAMS Accession No. ML17040A011), the NRC staff issued an Interim Staff Response (ISR) letter, which provided a summary of the staff's review of Beaver Valley's reevaluated flood-causing mechanisms. The enclosed staff assessment provides the documentation supporting the NRC staff's conclusions summarized in the ISR letter. For Beaver Valley, the reevaluated flood hazard results for the local intense precipitation and streams and rivers flood-causing mechanisms were not bounded by the current design basis, and were considered to be suitable input for additional flooding assessments of plant response.

The NRC staff notes that FENOC has already submitted (and the NRC staff has reviewed) the additional flooding assessments associated with Enclosure 2 to the 50.54(f) letter and the evaluation of mitigating strategies against the reevaluated hazards as described in Nuclear Energy Institute (NEI) 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625). Additional details related to these evaluations are also included in the enclosed staff assessment.

Enclosure 1 transmitted herewith contains Security-Related Information and Critical Electric Infrastructure Information (CEII). When separated from Enclosure 1, this document is decontrolled.

This letter closes out the NRC's efforts associated with EPID L-2016-JLD-001 and L-2016-JLD-0002 , and all actions associated with Enclosure 2 to the 50.54(f) letter.

If you have any questions, please contact me at (301) 415-3809 or by e-mail at Juan.Uribe@nrc.gov.

Sincerely,

Juan F. Uribe, Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket Nos. 50-334 and 50-412

Enclosures:
1. Staff Assessment of Flood Hazard Reevaluation Report for Beaver Valley (Non-public, Security Related)
2. Staff Assessment of Flood Hazard Reevaluation Report for Beaver Valley (Public)

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

BEAVER VALLEY POWER STATION, UNITS 1 AND 2

DOCKET NOS. 50-334 AND 50-412

1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012a), 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 Near-Term Task Force (NTTF) report (NRC, 2011a). Recommendation 2.1 in that document was for the NRC staff to issue orders to all licensees to reevaluate seismic and flooding hazards for their sites against current NRC requirements and guidance. Subsequent staff requirements memoranda associated with SECY-11-0124 (NRC, 2011c) and SECY-11-0137 (NRC, 2011d) directed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f) to address this recommendation.

Enclosure 2 to 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 (ESPs) and combined licenses (COLs). The required response section of Enclosure 2 specified that the NRC staff would provide a prioritization plan indicating the Flooding Hazard Reevaluation Report (FHRR) deadlines for each plant. On May 11, 2012 (NRC, 2012c), the NRC staff issued its prioritization of the FHRRs.

By letter dated March 2, 2016 (FENOC, 2016), FirstEnergy Nuclear Operating Company (FENOC, the licensee) submitted the FHRR for Beaver Valley Nuclear Station, Units 1 and 2 (Beaver Valley). The NRC staff performed an audit as documented in Section 5 and Attachment 1 of this staff assessment.

On February 22, 2017 (NRC, 2017), the NRC issued an interim staff response (ISR) letter to the licensee. The purpose of the ISR letter was to provide the flood hazard information suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 (NRC, 2012b) and the additional assessments associated with NTTF Recommendation 2.1: Flooding. The ISR letter also made reference to this staff assessment, which documents the NRC staff's basis and conclusions. The flood hazard mechanism values presented in the ISR letter's enclosures match the values in this staff assessment without change or alteration.

As mentioned in the ISR letter, the reevaluated flood hazard results for the local intense precipitation (LIP) and streams and rivers flood-causing mechanisms are not bounded by the plant's current design basis (CDB). Consistent with the 50.54(f) letter and amended by the process outlined in COMSECY-15-0019 (NRC, 2015a), Japan Lessons-Learned Directorate

Enclosure 2

(JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, Revision 1 (NRC, 2016a) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c), the NRC staff received and reviewed a focused evaluation for LIP that assessed the impact of the LIP hazard on the site, and evaluated and implemented any necessary programmatic, procedural or plant modifications to address this hazard exceedance. Additionally, for the streams and rivers flood mechanism, the NRC staff received and reviewed a focused evaluation confirming the capability of existing flood protection at the site. Additional details regarding the focused evaluation submittal and the NRC staff's review are provided in Section 2.2.5 of this assessment.

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter (NRC, 2012a) 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 ESPs and COLs. This section describes present-day regulatory requirements that are applicable to the FHRR.

Sections 50.34(a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4), of 10 CFR, describe the required content of the preliminary and final safety analysis reports, including a discussion of the plant site with a particular emphasis on the site evaluation factors identified in 10 CFR Part 100. The licensee should have provided any pertinent information identified or developed since the submittal of the preliminary safety analysis report in the final safety analysis report.

General Design Criterion 2 in Appendix A of Part 50 states that structures, systems, and components (SSCs) important to safety at nuclear power plants shall be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunamis, and seiches without loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to have sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Section 50.2 of 10 CFR defines "design bases" as the information that identifies the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design that each licensee is required to develop and maintain. These values may be (a) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (b) requirements derived from analysis (based on calculation, experiments, or both) of the effects of a postulated accident for which an SSC must meet its functional goals.

Present-day regulations for reactor site criteria (Subpart B to 10 CFR Part 100 for site applications on or after January 10, 1997) state, in part, that the physical characteristics of the site must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site. Factors to be considered when evaluating sites include the nature and proximity of dams and other man-related hazards (10 CFR 100.20(b)) and the physical characteristics of the site, including the hydrology (10 CFR 100.21(d)).

2.2 Enclosure 2 to the 50.54(f) Letter

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter requests all power reactor licensees and construction permit holders to reevaluate all external flood-causing mechanisms at each site. This includes current techniques, software, and methods used in present-day standard engineering practice.

2.2.1 Flood-Causing Mechanisms

Attachment 1, Enclosure 2 of the 50.54(f) letter discusses the flood-causing mechanisms for the licensee to address in the FHRR (NRC, 2012a). Table 2.2-1 of this assessment lists the flood-causing mechanisms the licensee should consider and lists the corresponding Standard Review Plan (SRP) (NRC, 2007) section(s) and applicable ISG documents containing acceptance criteria and review procedures.

2.2.2 Associated Effects

The licensee should incorporate and report associated effects (AEs) per JLD-ISG-2012-05, "Guidance for Performing the Integrated Assessment for External Flooding" (NRC, 2012d) in addition to the maximum water level associated with each flood-causing mechanism. Guidance document JLD-ISG-2012-05 defines "flood height and associated effects" as the maximum stillwater surface elevation plus:

- Wind waves and runup effects
- Hydrodynamic loading, including debris
- Effects caused by sediment deposition and erosion
- Concurrent site conditions, including adverse weather conditions
- Groundwater ingress
- Other pertinent factors.

2.2.3 Combined Effect Flood

The worst flooding at a site that may result from a reasonable combination of individual flooding mechanisms is sometimes referred to as a "combined effects flood." It should also be noted that for the purposes of this staff assessment, the terms "combined effects" and "combined events" are synonyms. Even if some or all of these individual flood-causing mechanisms are less severe than their worst-case occurrence, their combination may still exceed the most severe flooding effects from the worst-case occurrence of any single mechanism described in the 50.54(f) letter (see SRP Section 2.4.2, "Areas of Review" (NRC, 2007)). Attachment 1 of the 50.54(f) letter describes the "combined effect flood" as defined in American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8-1992 (ANSI/ANS, 1992) as follows:

> For flood hazard associated with combined events, American Nuclear Society (ANS) 2.8-1992 provides guidance for combination of flood causing mechanisms for flood hazard at nuclear power reactor sites. In addition to those listed in the ANS guidance, additional plausible combined events should be considered on a site specific basis and should be based on the impacts of other flood causing mechanisms and the location of the site.

If two less severe mechanisms are plausibly combined per ANSI/ANS-2.8-1992 (ANSI/ANS, 1992), then the NRC staff will document and report the result as part of one of the hazard sections. An example of a situation where this may occur is flooding at a riverine site located where the river enters the ocean. For this site, storm surge and river flooding are plausible combined events and should be considered.

2.2.4 Flood Event Duration

The flood event duration (FED) was defined in JLD-ISG-2012-05 (NRC, 2012d) as the length of time during which the flood event affects the site. It begins when conditions are met for entry into a flood procedure, or with notification of an impending flood (e.g., a flood forecast or notification of dam failure), and includes preparation for the flood. It continues during the period of inundation, and ends when water recedes from the site and the plant reaches a safe and stable state that can be maintained indefinitely. Figure 2.2-1 of this assessment illustrates the FED parameter.

2.2.5 Actions Following the FHRR

For the sites where the reevaluated flood hazard is not bounded by the CDB probable maximum flood elevation for any flood-causing mechanism, the 50.54(f) letter (NRC, 2012a) requests licensees and construction permit holders to:

- Submit an Interim Action Plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard; and
- Perform an integrated assessment to: (a) evaluate the effectiveness of the CLB [current licensing basis] (i.e., flood protection and mitigation systems); (b) identify plant-specific vulnerabilities; and (c) assess the effectiveness of existing or planned systems and procedures for protecting against, and mitigating consequences of, flooding for the flood event duration.

If the reevaluated flood hazard is bounded by the CDB flood hazard for each flood-causing mechanism at the site, licensees are not required to perform an integrated assessment. COMSECY-15-0019 (NRC, 2015a) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c) outline a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes an approach in which licensees with a LIP hazard exceeding their CDB flood will not be required to complete an integrated assessment, but instead perform a focused evaluation. As part of the focused evaluation, licensees will assess the impact of the LIP hazard on their site and then evaluate and implement any necessary programmatic, procedural, or plant modifications to address this hazard exceedance. For other flood hazard mechanisms that exceed the CDB, licensees can assess the impact of

these reevaluated hazards on their site by performing either a focused evaluation or a revised integrated assessment (NRC, 2015a and NRC, 2016c).
By letter dated September 20, 2017 (FENOC, 2017a), the licensee submitted its mitigating strategies assessment (MSA) for Beaver Valley. The MSAs are intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. By letter dated March 22, 2018 (NRC, 2018a), the NRC staff issued its assessment of the MSA and concluded that the licensee has demonstrated that the mitigation strategies, if appropriately implemented, are reasonably protected from reevaluated flood hazard conditions.

By letter dated October 16, 2017 (FENOC, 2017b), the licensee submitted the focused evaluation (FE) for Beaver Valley. 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. By letter dated March 22, 2018 (NRC, 2018b), the NRC staff issued its assessment of the FE and concluded that the licensee has demonstrated that effective flood protection exists against the reevaluated flood hazards. The FE staff assessment also concluded that FENOC has satisfactorily completed providing responses to the 50.54(f) activities associated with the reevaluated flood hazard for Beaver Valley.

3.0 TECHNICAL EVALUATION

The NRC staff has reviewed the information provided for Beaver Valley in the FHRR. The licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews. To aid in the review, the NRC staff issued an audit plan by letter dated April 26, 2016 (NRC, 2016b), indicating that audits may be conducted, as necessary, to provide additional insights of the FHRR review, such as methodologies used, parameter selection and assumptions, model development and execution, calculations, analyses performed, and supporting documentation. As part of the audit activities, the licensee made several calculation packages available to the NRC staff via electronic reading room. These calculation packages were only found to expand upon and clarify the information already provided on the docket, and so are not docketed or cited. This audit plan stated that an audit report would be issued summarizing the results of the audit. Section 5 of this assessment provides the audit summary referenced in the audit plan.

The Beaver Valley FHRR (FENOC, 2016) provided elevations using two different vertical datums, the North American Vertical Datum of 1988 (NAVD88) and the National Geodetic Vertical Datum of 1929 (NGVD29), also referred to as mean sea level. Unless otherwise stated, all elevations in this document are given with respect to NGVD29.

3.1 Site Information

The 50.54(f) letter (NRC, 2012a) requested that relevant SSCs important to safety be included in the scope of the hazard reevaluation. The licensee included this pertinent data concerning these SSCs in the FHRR (FENOC, 2016). During the NRC staff's review of the FHRR, the staff requested additional clarifying information.

The licensee provided this additional clarifying information during an audit. The audit information exchange is discussed in the corresponding Section(s) and summarized in Attachment 1 of this staff assessment.

3.1.1 Detailed Site Information

The FHRR (FENOC, 2016) described the site-specific information related to the flood hazard evaluation at the Beaver Valley site. The Beaver Valley site is located on the south side of the Ohio River at river mile 34.7 in Shippingport Borough in Beaver County, Pennsylvania, about 25 miles (mi) northwest of Pittsburgh, Pennsylvania. The total upstream drainage area is about 23,000 square miles (mi^2). The Beaver Valley site is characterized by sloping topography with ground elevations ranging from 664.5 feet (ft.) NGVD29 to 1,160 ft. NGVD29. A small stream, Peggs Run, flows through the eastern portion of the Beaver Valley site and is channeled through a culvert to the Ohio River. Figure 3.1-1 of this staff assessment shows a general layout of the Beaver Valley site.

3.1.2 Design-Basis Flood Hazards

The CDB flood levels are summarized by flood-causing mechanism in Table 3.1-2. The licensee stated that the probable maximum precipitation (PMP) for Beaver Valley, Unit 1, was 13 inches of rainfall in 72 hours, while the PMP for Unit 2 was 31.3 inches over a 10-mi^2 area in 24 hours. The licensee assumed a complete blockage of all yard and roof drains to determine the peak water surface elevation range of 732.4 ft. to 735.4 ft. [[[redacted] .]] While Beaver Valley, Unit 1, does not address LIP, storm surge, seiche, tsunami or channel migration or diversion, the licensee stated that storm surge, seiche, tsunami or channel migration or diversion mechanisms are not applicable to the Beaver Valley, Unit 2, site. Finally, the licensee stated that it is highly unlikely for ice-induced flooding to affect the Beaver Valley site.

~~(CEII)~~

[[[redacted] .]]

~~(CEII)~~

The licensee also stated that the CDB includes a low water event with the Beaver Valley plant shutting down when the river level falls below 654 ft. NGVD29.

3.1.3 Flood-Related Changes to the Licensing Basis

The licensee stated in its FHRR that there have been no changes to the licensing basis with respect to flooding or flood protection. The NRC staff reviewed the information provided in the Beaver Valley FHRR (FENOC, 2016) and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.4 Changes to the Watershed and Local Area

The licensee noted that changes to the watershed include development within the watershed, although this only accounts for a small percentage of the total watershed area. The licensee incorporated these changes into the flood hazard reevaluation.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

[[redacted].]] The licensee also observed that the maximum flood level from LIP at Unit 2 exceeds the lowest access door at 732 ft. NGVD29. However, the accumulation of water would not exceed 1.3 inches deep, and there are no safety-related connections closer than 2 inches from the floor. Therefore, the licensee determined that no mitigation actions were necessary.

~~(CEII)~~

3.1.6 Additional Site Details to Assess the Flood Hazard

Additional information was reviewed by the NRC staff during the audit performed. This additional information was related to the flood hazard reevaluations and are documented in Section 5 and Attachment 1 of this assessment.

3.1.7 Results of Plant Walkdown Activities

The 50.54(f) letter requested that licensees plan and perform plant walkdown activities to verify that current flood protection systems are available, functional, and implementable. Other parts of the 50.54(f) letter asked the licensee to report any relevant information from the results of the plant walkdown activities. By letter dated November 27, 2012 (FENOC, 2012), as supplemented by letter dated February 25, 2014 (FENOC, 2014), FENOC submitted the Flooding Walkdown Report for the Beaver Valley site. On June 16, 2014 (NRC, 2014), the NRC staff issued its assessment of the Walkdown Report and concluded that the licensee's implementation of the flooding walkdown methodology met the intent of the 50.54(f) letter.

3.2 Local Intense Precipitation and Associated Site Drainage

The licensee reported in its FHRR that the reevaluated flood hazard for LIP and associated site drainage is based on a stillwater-surface elevation of 735.9 ft. NGVD29 at Beaver Valley, Unit 1, and 735.7 ft. NGVD29 at Beaver Valley, Unit 2. This flood-causing mechanism is not discussed for Unit 1 but is discussed as part of the CDB for Unit 2. The CDB flood hazard elevations for LIP is provided in Table 3.1-2.

The licensee utilized a site-specific PMP analysis to evaluate flooding impacts from LIP at the Beaver Valley site. The licensee also performed a LIP analysis using the PMP derived from the applicable hydrometeorological reports (HMR) documents (HMR-51/52) produced by the National Oceanic and Atmospheric Administration (NOAA). The HMR-based PMP resulted in a maximum precipitation depth of 26.4 inches with a corresponding duration of 6 hours. The licensee's site-specific PMP depth was estimated to be 23.1 inches for a duration of 6 hours; a 12.5-percent reduction in the cumulative rainfall depth over 6 hours.

As part of the Streams and Rivers hazard mechanism, the licensee developed an inflow hydrograph for a local tributary named Peggs Run that is hydraulically connected to the site. The development of this hydrograph is described in the Streams and Rivers section of this staff assessment. The inflow hydrograph developed by the licensee for Peggs Run was used as input to the site LIP analysis.

The licensee used a Digital Elevation Model (DEM) to define the topography and surface features such as grading, slope, and drainage divides of the Beaver Valley site. In addition, the licensee obtained land cover information from various sources such as aerial images and site surveys. The licensee incorporated two types of obstructions into the DEM: buildings and other structures that completely block the flow of water regardless of the water surface elevation (WSE), and vehicle and security barriers that block the flow of water unless they are overtopped. The licensee used the FLO-2D hydraulic model to estimate the water surface elevations and velocities at the Beaver Valley site. The licensee assumed the drainage system was non-functional and excluded losses from infiltration.

The NRC staff reviewed the size of the grid used in the FLO-2D model and found it to be reasonable. Additionally, the NRC staff compared the model grid map showing plant structures and barriers with Google Earth aerial imagery and found that the buildings are properly depicted in the FLO-2D model.

The NRC staff reviewed the higher HMR 51/52 rainfall depth for the Beaver Valley site and confirmed that the LIP depths match values reported in the NOAA guidance. Using the licensees FLO-2D model, the NRC staff performed a FLO-2D analysis using the higher HMR-based precipitation depth to estimate the maximum water surface elevations at the Beaver Valley site. The NRC staff determined that the difference in water surface elevations between the HMR-based and the site-specific PMP-based LIP analyses near safety-related structures was negligible (<0.25 ft). Due to the small differences in maximum water surface elevations near these structures, the NRC staff did not review the site-specific PMP analysis provided by the licensee. The NRC staff confirmed the licensee's conclusion that the flood hazard from LIP and associated site drainage is not bounded by the CDB flood hazard. Accordingly, the NRC staff summarized its results in the ISR letter and the licensee used these values as input into the subsequent flooding submittals, as described in Section 2.2.5 of this assessment.

3.3 Streams and Rivers

3.3.1 Ohio River

~~(CEII)~~ [[redacted].]]

On September 21, 2016, the NRC conducted an audit (see Attachment 1 of this assessment) of the licensee's basin-wide site-specific PMP including the methodology and input parameters. Through the audit process, NRC staff identified several issues and concerns with the licensee's original submittal and site-specific PMP estimates. Using revised input parameters, NRC staff independently estimated basin-wide site-specific PMP values that were greater than the licensee's estimates.

~~(CEII)~~ Per Interagency Agreement NRC-HQ-13-I-03-0021, the USACE assisted the NRC in determining the safety significance of hydrologic and geotechnical issues and other features associated with dams that may affect the safe, reliable operation of downstream or nearby nuclear power plants. The USACE analyzed multiple scenarios in assisting the NRC staff to determine the reevaluated flood hazard for the streams and rivers flood-causing mechanism (USACE, 2016). [[redacted].]]

~~(CEII)~~ On January 26, 2017, the NRC staff conducted a site audit. The purpose of the site audit was to address the peak stillwater surface elevation results using the NRC staff's basin-wide site-specific PMP. During the site audit, the licensee demonstrated that there is minimal change or impact to safety-related SSCs at the site between the CDB flood elevation and the peak flood elevation based on NRC staff's site-specific PMP. [[redacted].]]

3.3.2 Peggs Run Stream

~~(CEII)~~ [[redacted]]. This flood-causing mechanism is not discussed for Unit 1 but is discussed in the CDB for Unit 2. The CDB flood hazard elevation for this hazard mechanism is 730 ft. NGVD29 for Unit 2.

For the Peggs Run PMP analysis the licensee considered three alternatives as outlined in NUREG/CR-7046 for floods caused by precipitation events. The controlling scenario is the Alternative 1 all-season PMP based on HMR-51/52. The licensee used a modified "peaked" National Resources Conservation Service (NRCS) unit hydrograph to account for a non-linear watershed response. The licensee increased the peak by 20 percent and reduced the time to peak by 33 percent, while adjusting other portions of the hydrograph to maintain the same runoff volume. This hydrograph was used in HEC-HMS to estimate the peak runoff from the all-season PMP (Alternative 1) for the 3.6-square-mile Peggs Run watershed. The licensee accounted for infiltration losses using the NRCS curve number methodology. The licensee modeled the watershed for Peggs Run in the HEC-HMS model with two sub-basins. The HMR-

51/52 was used to develop the precipitation magnitude and duration. The hydrograph developed for Peggs Run was incorporated into the LIP analysis discussed in Section 3.2.

~~(CEII)~~ [[redacted]]]

The NRC staff reviewed the methodology and input parameter values for the curve number methodology such as the weighted curve numbers, the lag time parameters, and the HMR-51/52 PMP depth-duration parameters. The NRC staff ran the licensee's provided HEC-HMS and Hydrologic Engineering Center-River Analysis System (HEC-RAS) models, and noted that the simulation produced no errors and confirmed the licensee's results.

3.3.3 Maximum Water Level Determination

The licensee described a combined event of the PMF for the Ohio River occurring with wind-generated waves including wave runup. [[redacted]]]

~~(CEII)~~

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard from flooding by streams and rivers is not bounded by the total CDB flood hazard elevation. Accordingly, the NRC staff summarized its results in the ISR letter and the licensee used these values as input into the subsequent flooding submittals, as described in Section 2.2.5 of this assessment.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in its FHRR that the reevaluated flood hazard for failure of dams and onsite water control or storage structures is based on analysis performed by the USACE (USACE, 2015) and did not report a water surface elevation for this flood hazard mechanism in the Beaver Valley FHRR (FENOC, 2016). The staff confirmed that the licensee adopted the USACE's values for this hazard mechanism.

~~(CEII)~~ [[redacted]]]

Per Interagency Agreement NRC-HQ-13-I-03-0021, the USACE assisted the NRC in determining the safety significance of hydrologic and geotechnical issues and other features
~~(CEII)~~ associated with dams that may affect the safe, reliable operation of downstream or nearby nuclear power plants. [[redacted]

[redacted].]]

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard from flooding by failure of dams and onsite water control or storage structures is bounded by the CDB flood hazard. Accordingly, flooding from failure of dams and onsite water control/storage structures does not need to be included in a focused evaluation or revised integrated assessment.

3.5 Storm Surge

The licensee reported in its FHRR that the reevaluated flood hazard for storm surge does not inundate the Beaver Valley site, but did not report a probable maximum flood elevation. This flood-causing mechanism is discussed in the licensee's CDB, but a PMF elevation was not reported. The licensee provided no CDB maximum flood elevation for storm surge in the FHRR. The licensee stated that because the Beaver Valley site is not located on a coast or adjacent to cooling ponds or reservoirs, flooding from storm surge is not applicable.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from storm surge is not applicable to the Beaver Valley site. Therefore, the NRC staff determined that flooding from storm surge does not need to be analyzed in either a focused evaluation or revised integrated assessment.

3.6 Seiche

The licensee reported in its FHRR that the reevaluated hazard for seiche does not inundate the plant site, but did not report a PMF elevation. This flood-causing mechanism is discussed in the licensee's CDB, but a PMF elevation was not reported. The licensee stated that the Beaver Valley site is not located on a coast or adjacent to cooling ponds or reservoirs, therefore flooding from seiche is not applicable.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from seiche is not applicable to the Beaver Valley site. Therefore, the NRC staff determined that flooding from seiche does not need to be analyzed in a focused evaluation or a revised integrated assessment.

3.7 Tsunami

The licensee reported in its FHRR that the reevaluated hazard for tsunami does not inundate the plant site, but did not report a PMF elevation. This flood-causing mechanism is discussed in the licensee's CDB, but a PMF elevation was not reported. The licensee stated that the Beaver Valley site is not situated on a coast or adjacent to cooling ponds or reservoirs, therefore tsunamigenic waves are not applicable.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from tsunami is not applicable to the Beaver Valley site. Therefore, the NRC staff determined that flooding from tsunami does not need to be analyzed in a focused evaluation or a revised integrated assessment.

3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated flood hazard for ice-induced flooding is negligible. This flood-causing mechanism is discussed in the licensee's CDB, but a flood elevation was not reported.

The licensee described two mechanisms by which ice jams and ice dams could lead to flooding of a site: 1) collapse of an upstream ice jam creating flood waves, and 2) formation of downstream ice jam causing a flood at the site via backwater effects. The licensee reviewed historical ice effects in the Ohio River in the vicinity of the Beaver Valley site and determined that ice jam events are possible. The licensee searched the USACE Ice Jam Database (USACE, n.d.) and selected the event that produced the maximum flood stage at a specific location. The licensee then used an unsteady-state flow HEC-RAS hydraulic model calibrated using U.S.Geological Survey gage data and a roughness coefficient based on land use and land cover data. The licensee estimated the maximum reported upstream ice jam to be 28.4 ft. resulting in a maximum WSE of 700.6 ft. NGVD29. The maximum downstream ice jam would result in a maximum WSE of 719.3 ft. at the Beaver Valley site.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for ice-induced flooding is bounded by the CDB flood hazard at the Beaver Valley site. Therefore, the NRC staff determined that ice-induced flooding effects do not need to be analyzed in a focused evaluation or a revised integrated assessment for the Beaver Valley site.

3.9 Channel Migrations or Diversions

The licensee reported in its FHRR that the reevaluated hazard for channel migrations or diversions does not inundate the plant site, but did not report a maximum flood elevation. This flood-causing mechanism is discussed in the licensee's CDB, but no maximum flood elevation was reported.

The licensee stated that it used historical records and hydrogeomorphological data to reevaluate the potential for flooding due to channel migrations or diversions of the Ohio River. The licensee did not evaluate channel migration of Peggs Run due to the small drainage areas and distance to the Beaver Valley site. The licensee consulted topographic maps from 1901, 1954 and 2013 and concluded that there are slight differences between the 1901 and 1954 map, but there is no evidence of channel migration between 1954 and 2013. The licensee determined that the inherent inaccuracy of the methods used to create the 1901 topographical map may account for the differences and therefore concluded that channel migration is not probable at the Beaver Valley site.

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from channel migrations or diversions is bounded by the CDB flood hazard. Therefore, flooding from channel migrations or diversions does not need to be analyzed in a focused evaluation or a revised integrated assessment for the Beaver Valley site.

4.0 REEVALUATED FLOOD HEIGHT, EVENT DURATION, AND ASSOCIATED EFFECTS FOR HAZARDS NOT BOUNDED BY THE CURRENT DESIGN BASIS

4.1 Reevaluated Flood Height for Hazards Not Bounded by the Current Design Basis

Section 3 of this staff assessment documents the NRC staff's review of the licensee's flood hazard water height results. Table 4.1-1 contains the maximum flood height results, including waves and runup, for flood mechanisms not bounded by the CDB. The NRC staff agrees with the licensee's conclusion that LIP, and flooding from streams and rivers are the flood-causing mechanisms not bounded by the CDB.

4.2 Flood Event Duration for Hazards Not Bounded by the Current Design Basis

The NRC staff reviewed information provided in FENOC's 50.54(f) response (FENOC, 2016) regarding the FED parameters needed to perform the additional assessments of plant response for flood-causing mechanisms not bounded by the CDB. The FED parameters provided in the FHRR for the two flood-causing mechanisms not bounded by the CDB are summarized in Table 4.2-1.

By letter dated September 20, 2017 (FENOC, 2017a), the licensee submitted its MSA, which included the FED parameters for the two controlling scenarios. The NRC staff's review and conclusions regarding the FED parameters provided in the MSA are documented in a separate staff assessment that was issued on March 22, 2018 (NRC, 2018a).

4.3 Associated Effects for Hazards Not Bounded by the Current Design Basis

The NRC staff reviewed information provided in FENOC's 50.54(f) response (FENOC, 2016) regarding the AE parameters needed to perform the additional assessments of plant response for flood hazards not bounded by the CDB. The licensee also presented the AE parameters associated with the two, unbounded, flood-causing mechanisms directly related to LIP and PMF with wind waves and runup in the MSA. The AE parameters are presented in Table 4.3-1.

In its MSA, the licensee included these AE parameters for the two controlling scenarios. The NRC staff's review and conclusions regarding the AE parameters provided in the MSA are documented in a separate staff assessment issued on March 22, 2018 (NRC, 2018a). In that MSA staff assessment, the NRC staff agreed with the licensee that the waterborne loads, including hydrostatic, hydrodynamic, debris, and sediment loads, would induce minimal impacts to plant operations due to the low LIP water depths and velocities. They also concluded that other associated effects, including sediment deposition and erosion, concurrent site conditions, and effects on groundwater intrusion are insignificant at the plant site.

4.4 Conclusion

Based upon the preceding analysis, the NRC staff confirmed that the reevaluated flood hazard information defined in Section 4.1 was appropriate input to the additional assessments of plant response as described in the 50.54(f) letter, COMSECY-15-0019 (NRC, 2015), and the associated guidance.

The licensee developed FED parameters and applicable flood AEs to conduct future additional assessments as discussed in NEI 12-06, Revision 2, Appendix G (NEI, 2015), JLD-ISG-2012-05 (NRC, 2012d), and JLD-ISG-2016-01, Revision 0 (NRC, 2016c). The NRC staff review and conclusions for the FED and AE parameters provided in the MSA (FENOC, 2017a) are documented separately from this staff assessment (NRC, 2018a).

5.0 AUDIT

The NRC staff issued an audit plan by letter dated April 26, 2016 ((Agencywide Documents Access and Management System (ADAMS) Accession No. ML16105A211), indicating that audits may be conducted relative to the Beaver Valley FHRR, as necessary, in order to provide additional insights of the review and analysis performed. These insights included, but were not limited to, methodologies used; parameter selection criteria and assumptions; model development, configuration and execution; calculations; reference material; analyses performed, and supporting documentation.

Attachment 1 of this staff assessment contains additional technical and logistical details of the audits performed, such as the clarifying information requested from FENOC and the corresponding resolution of each item. In addition, each information need requested has been discussed in the corresponding Section of this assessment. Following the guidance of NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 ADAMS Accession No. ML082900195), this staff assessment conveys the results of the audit performed and therefore a separate report is not needed. In conclusion, the audit performed allowed the NRC staff to better understand the Beaver Valley FHRR, supported the completion of the staff's review and the subsequent issuance of an interim hazard letter. During its review, the NRC staff did not identify any issues or open items and considers the audit completed and closed.

6.0 CONCLUSION

The NRC staff reviewed the information provided for the reevaluated flood-causing mechanisms of the Beaver Valley site. Based on the review of the above, available information provided in FENOC' s 50.54(f) response (FENOC, 2016), the NRC staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

Based upon the preceding analysis, the NRC staff confirmed that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter, dated March 12, 2012. In reaching this determination, NRC staff confirmed the licensee's conclusions that (1) the reevaluated flood hazard results for LIP and streams and rivers are not bounded by the CDB flood hazard, (2) additional assessments of plant response would need to be performed for LIP and for flooding from streams and rivers and (3) the reevaluated flood-causing mechanism information is appropriate input to the additional assessments of plant response, as described in 50.54(f) letter and COMSECY-15-0019, and associated guidance.

By letter dated September 20, 2017 (FENOC, 2017a), the licensee submitted the MSA whereby they provided additional assessments of the plant response for the LIP and streams and rivers flood-causing mechanisms. The NRC staff review and conclusions for the additional FED and

AE parameters provided in the MSA have been documented separately from this staff assessment (NRC, 2018a). The NRC staff has no additional information needs at this time with respect to the FENOC's 50.54(f) response.

6.0 REFERENCES

Note: ADAMS Accession Nos. refers to documents available through NRC's Agencywide Documents Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html.

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NRC, 2011a, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

NRC, 2011b, "Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," Enclosure to Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML111861807.

NRC, 2011c, "Recommended Actions to be Taken Without Delay from the Near-Term Task Force Report," Commission Paper SECY-11-0124, September 9, 2011, ADAMS Accession No. ML11245A158.

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USACE, 2016,"Evaluation of Upper Ohio River Basin Dams and Potential Flood Hydrographs at the Beaver Valley Nuclear Power Plant", US Army Corps of Engineers, October 2016.

Table 2.2-1. Flood-Causing Mechanisms and Corresponding Guidance

Flood-Causing Mechanism	SRP[1] Section(s) and JLD-ISG
Local Intense Precipitation and Associated Drainage	SRP 2.4.2 SRP 2.4.3
Streams and Rivers	SRP 2.4.2 SRP 2.4.3
Failure of Dams and Onsite Water Control/Storage Structures	SRP 2.4.4 JLD-ISG-2013-01
Storm Surge	SRP 2.4.5 JLD-ISG-2012-06
Seiche	SRP 2.4.5 JLD-ISG-2012-06
Tsunami	SRP 2.4.6 JLD-ISG-2012-06
Ice-Induced	SRP 2.4.7
Channel Migrations or Diversions	SRP 2.4.9

Notes:

1. SRP is the Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NRC, 2007)
2. JLD-ISG-2012-06 is the "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment" (NRC, 2013a)
3. JLD-ISG-2013-01 is the "Guidance for Assessment of Flooding Hazards Due to Dam Failure" (NRC, 2013b)

Table 3.1-2. Current Design Basis Flood Hazards

Mechanism	Stillwater Elevation (NGVD29)	Waves/Runup	Design Basis Hazard Elevation (NGVD29)	Reference
Local Intense Precipitation				
Beaver Valley Power Station Unit 2: Fuel and Decontamination Building (1 Door)	735.3 ft.	Minimal	735.3 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4-6
Beaver Valley Unit 2 Fuel and Decontamination Building (3 Doors)	735.3 ft.	Minimal	735.3 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Emergency Diesel Generator Building (3 Doors)	732.4 ft.	Minimal	732.4 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Main Steam Valve Building Area	732.5 ft.	Minimal	732.5 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Safeguards Building	732.5 ft.	Minimal	732.5 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Auxiliary Building (3 Doors)	735.4 ft.	Minimal	735.4 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Control Building (3 Doors; South)	735.4 ft.	Minimal	735.4 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Control Building (1 Door; North)	735.4 ft.	Minimal	735.4 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Service Building (1 Door; SB30-8)	732.5 ft.	Minimal	732.5 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Reactor Containment (Equipment Hatch)	735.1 ft.	Minimal	735.1 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Emergency Diesel Generator Building (1 Door)	732.5 ft.	Minimal	732.5 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Beaver Valley Unit 2: Service Building (1 Door)	732.5 ft.	Minimal	732.5 ft.	FHRR Section 2.1.1 & UFSAR Table 2.4.6
Streams and Rivers				
~~(CEII)~~ Probable Maximum Flood	[[redacted]	[redacted]	[redacted].]]	FHRR Section 2.1.2 & Table 3
Peggs Run - Beaver Valley Unit 1	Not included in DB	Not included in DB	Not included in DB	FHRR Section 2.1.2 & Table 3

Peggs Run - Beaver Valley Unit 2	No Impact on the Site Identified	No Impact on the Site Identified	No Impact on the Site Identified	FHRR Section 2.1.2 & Table 3
Combined Event – Probable Maximum Flood with Wind Wave for Units 1 & 2 at the Intake Structure	[[redacted]	[redacted]	[redacted].]]	FHRR Section 2.1.8 & Table 3
Failure of Dams and Onsite Water Control/Storage Structures				
~~(CEII)~~ Conemaugh Dam with Standard Project Flood - Units 1 & 2	[[redacted]	[redacted]	[redacted].]]	FHRR Section 2.1.3 & Table 3
Storm Surge				
Beaver Valley Unit 1	Not Included in DB	Not Included in DB	Not Included in DB	FHRR Section 2.1.4 & Table 3
Beaver Valley Unit 2	No Impact on Site Identified	No Impact on Site Identified	No Impact on Site Identified	FHRR Section 2.1.4 & Table 3
Seiche				
Beaver Valley Unit 1	Not Included in DB	Not Included in DB	Not Included in DB	FHRR Section 2.1.4 & Table 3
Beaver Valley Unit 2	No Impact on Site Identified	No Impact on Site Identified	No Impact on Site Identified	FHRR Section 2.1.4 & Table 3
Tsunami				
Beaver Valley Unit 1	Not Included in DB	Not Included in DB	Not Included in DB	FHRR Section 2.1.5 & Table 3
Beaver Valley Unit 2	No Impact on Site Identified	No Impact on Site Identified	No Impact on Site Identified	FHRR Section 2.1.5 & Table 3
Ice-Induced Flooding				
Beaver Valley Unit 1	No Impact on Site Identified	No Impact on Site Identified	No Impact on Site Identified	FHRR Section 2.1.6 & Table 3

Beaver Valley Unit 2	No Impact on Site Identified	No Impact on Site Identified	No Impact on Site Identified	FHRR Section 2.1.6 & Table 3
Channel Migrations/Diversions				
Beaver Valley Unit 1	Not Included in DB	Not Included in DB	Not Included in DB	FHRR Section 2.1.7 & Table 3
Beaver Valley Unit 2	No Impact on Site Identified	No Impact on Site Identified	No Impact on Site Identified	FHRR Section 2.1.7 & Table 3

Note:

1. Reported values are rounded to the nearest one-tenth of a foot.

Table 4.1-1. Reevaluated Flood Hazard Elevations for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Stillwater Elevation	Waves/Runup	Reevaluated Flood Hazard	Reference
Local Intense Precipitation				
Beaver Valley Unit 1: Main Steam Cable Vault (MS-35-1)	735.5 ft. NGVD29	Minimal	735.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Diesel Generator Building (G-35-2)	735.3 ft. NGVD29	Minimal	735.3 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Diesel Generator Building (G-35-3)	735.3 ft. NGVD29	Minimal	735.3 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Diesel Generator Building (Removable Shield E)	735.2 ft. NGVD29	Minimal	735.2 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Diesel Generator Building (Removable Shield W)	735.3 ft. NGVD29	Minimal	735.3 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Coolant Recovery Tanks (TA-35-1)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Coolant Recovery Tanks (Removable Panel)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Safeguards (SG-47-1)	735.4 ft. NGVD29	Minimal	735.4 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Fuel Building (F-35-1; F-35-3)	735.9 ft. NGVD29	Minimal	735.9 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Fuel Building (F-35-2)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Fuel Building (F-35-4)	735.7 ft. NGVD29	Minimal	735.7 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Decontamination Building (D-35-1)	735.2 ft. NGVD29	Minimal	735.2 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Decontamination Building (D-35-2)	735.3 ft. NGVD29	Minimal	735.3 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3

Beaver Valley Unit 1: Service Building (S-35-44)	735.5 ft. NGVD29	Minimal	735.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Service Building (S-35-48)	735.5 ft. NGVD29	Minimal	735.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Service Building (S-35-49)	735.5 ft. NGVD29	Minimal	735.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Service Building (35-67)	735.5 ft. NGVD29	Minimal	735.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Warehouse (W-35-1)	735.5 ft. NGVD29	Minimal	735.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Waste Gas Storage Area (DT-27-1)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Containment (Equipment Hatch)	735.2 ft. NGVD29	Minimal	735.2 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Control Building (O-35-1)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Control Building (S-35-71)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Control Building (S-35-72)	735.8 ft. NGVD29	Minimal	735.8 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 1: Control Building (S-35-74)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 1 & 3
Beaver Valley Unit 2: Safeguards (SG-37-4)	734.7 ft. NGVD29	Minimal	734.7 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2: Diesel Generator Building (DG-32-5)	732.3 ft. NGVD29	Minimal	732.3 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2: Auxiliary Building (A-35-1)	735.7 ft. NGVD29	Minimal	735.7 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2: Auxiliary Building (A-35-3)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2: Auxiliary Building (A-35-5)	735.6 ft. NGVD29	Minimal	735.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2: Fuel Building (F-35-1)	735.5 ft. NGVD29	Minimal	735.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2: Fuel Building (F-35-2)	735.4 ft. NGVD29	Minimal	735.4 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3

~~(CEII)~~

Beaver Valley Unit 2: Containment (Equipment Hatch)	734.6 ft. NGVD29	Minimal	734.6 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2 Main Steam Cable Vault (MS-35-3)	732.5 ft. NGVD29	Minimal	732.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2 Safeguards (SG-37-5)	732.5 ft. NGVD29	Minimal	732.5 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Beaver Valley Unit 2 Fuel Building (F-35-3)	735.3 ft. NGVD29	Minimal	735.3 ft. NGVD29	FHRR Section 3.8.4 & Tables 2 & 3
Streams and Rivers				
Combined Event – Probable Maximum Flood with Wind Wave for Unit 1 Turbine Building North Wall	[[redacted] [4] [redacted]]]	[[redacted].]]	[[redacted]ft. [redacted]]]	USACE 2015 Evaluation of Upper Ohio River Basin FHRR Section 3.7 & Table 3
Combined Event – Probable Maximum Flood with Wind Wave for Unit 2 at Ground Slope Approaching Reactor Building	[[redacted] [4] [redacted]]]	[[redacted].]]	[[redacted]]]	USACE 2015 Evaluation of Upper Ohio River Basin FHRR Section 3.7 & Table 3
Combined Event – Probable Maximum Flood with Wind Wave at Ground Slope Approaching the Emergency Outfall Structure	[[redacted]. [4] [redacted]]]	[[redacted].]]	[[redacted]. [redacted]]]	USACE 2015 Evaluation of Upper Ohio River Basin FHRR Section 3.7 & Table 3

Notes:

1. Refer to (FENOC, 2017) and (NRC, 2018a).
2. Reevaluated hazard mechanisms bounded by the CDB (see Table 3.1-1) are not included in this table.
3. Reported values are rounded to the nearest one-tenth of a foot.
4. [[redacted].]]

Table 4.2-1. Flood Event Duration for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	**Time Available for Preparation for Flood Event**	**Duration of Inundation of Site**	**Time for Water to Recede from Site**
Local Intense Precipitation			
Unit 1	Note 1	Note 1	Note 1
Unit 2	Note 1	Note 1	Note 1
Streams and Rivers			
Combined Event – PMF with Wind Wave for Unit 1 Turbine Building North	Note 1	Note 1	Note 1
Combined Event – PMF with Wind Wave for Unit 2 at Ground Slope Approaching Reactor Building	Note 1	Note 1	Note 1
Combined Event – PMF with Wind Wave for Unit 2 at Ground Slope Approaching the Emergency Outfall Structure	Note 1	Note 1	Note 1

Note:

1. Refer to (FENOC, 2017) and (NRC, 2018a).

Table 4.3-1. Associated Effects for Flood-Causing Mechanisms Not Bounded by the CDB (Sources: FHRR (FENOC, 2016) and MSA (FENOC 2017))

Associated Effects Factor	Flooding Mechanism			
	Local Intense Precipitation Units 1 and 2	Combined Event – PMF with Wind Wave for Unit 1 Turbine Building North	Combined Event – PMF with Wind Wave for Unit 2 at Ground Slope Approaching Reactor Building	Combined Event – PMF with Wind Wave for Unit 2 at Ground Slope Approaching the Emergency Outfall Structure
Hydrodynamic loading at Plant Grade	Note 1	Note 1	Note 1	Note 1
Debris loading at plant grade	Note 1	Note 1	Note 1	Note 1
Sediment loading at plant grade	Note 1	Note 1	Note 1	Note 1
Sediment deposition and erosion	Note 1	Note 1	Note 1	Note 1
Concurrent Conditions, including adverse weather	Note 1	Note 1	Note 1	Note 1
Groundwater ingress	Note 1	Note 1	Note 1	Note 1
Other pertinent factors (e.g., waterborne projectiles)	Note 1	Note 1	Note 1	Note 1

Note:

1. Refer to (FENOC, 2017) and (NRC, 2018a).

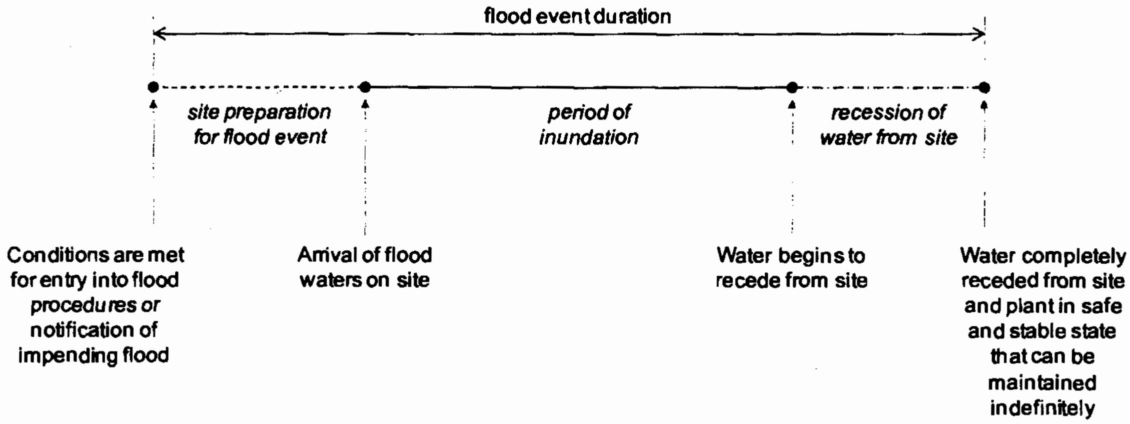

Figure 2.2-1 Flood Event Duration (NRC, 2012c)

Figure 3.1-1 Site Location Map (adapted from FHRR Figure 2.0-1)

ATTACHMENT 1

Audit Summary Report

I. **Background:**
By letter dated April 26, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16105A211), the NRC staff issued an audit plan indicating that audits may be conducted related to the Beaver Valley FHRR, as necessary, in order to provide additional insights of the review and analysis performed. Audits were conducted following the guidance of NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML082900195).

II. **Scope:**
The scope of the audit was detailed in the audit plan and included, but was not limited to,

a) The methodologies used in the analyses,
b) Parameter selection criteria and assumptions,
c) Model development, configuration and execution;
d) Calculations, reference material; analyses performed, and supporting documentation.

Attachment 1 contains additional technical and logistical details of the audits performed and provides the full scope of the review.

III. **Logistical Details:**

Audit Date	Audit Location	Audit Participants
September 21, 2016	Teleconference Call	*NRC*: Chris Cook, Kenneth See, Brad Harvey, Aida Rivera, Mohammed Shams, Gregory Bowman, Juan Uribe
January 26, 2017	Beaver Valley Site	*FENOC*: Phil Lashley, Kathleen Nevins, Tom Lentz, Collin Keller, Mark Manoleras

IV. **Technical Evaluation:**
The Audit Table contains the technical details regarding the clarifying information requested from FENOC, and the corresponding resolution of each item. In addition, each information need requested is discussed in the corresponding Section of this assessment. As part of the audit activities, the licensee made several calculation packages available to the NRC staff via electronic reading room. These calculation packages were only found to expand upon and clarify the information already provided on the docket, and so are not docketed or cited.

V. **Conclusion:**
The audit performed satisfactorily allowed the NRC staff to better understand the Beaver Valley FHRR, supported the completion of the NRC staff's review and the subsequent issuance of an interim hazard letter. During its review, the NRC staff did not identify any issues or open items and considers the audit completed and closed.

Audit Table
Summary of Information Reviewed
Beaver Valley Power Station, Units 1 and 2

Info Need	Information Need Description	Action (Post-Audit)
1	Observed Depth-Area Duration Data Discrepancy Background: The NRC staff requested clarifying information regarding the complete list of storms used in the storm analysis. In response, the licensee provided the complete storm analysis information for the all-season and cool-season storms, including electronic files, storm analysis spreadsheets (which include observed depth-area-duration [DAD] data and adjustment factors), SPAS output data, and other pertinent information. After reviewing the information provided, NRC staff noticed discrepancies between the storm output DAD values and the DAD values used by the licensee as a part of the site-specific PMP evaluation for Beaver Valley. Specifically, staff noticed discrepancies in DAD values for the following storm: • Wellsville, NY – June 1972 storm occurring in New York. For example, the SPAS-based observed 72-hour, 20,000-mi^2 depth is 10.2 inches (from *SPAS_1276_DAD_Template.xlsx*), compared to a value of 6.4 used by the licensee for storm analysis (from *Wellsville-NY-06-1972-SPAS_1276_Zone1.xlsx*). Request: For the Wellsville, NY storm, explain why the observed SPAS-based DAD output values do not match with the final values used by the licensee. Clarify which set of values should be used as the observed DAD values. If corrections are warranted, provide updated envelopment curves.	The licensee indicated that the SPAS-based DAD values provided to NRC staff as a part of the initial information request were actually the results of a sensitivity case. This case was conducted as a part of the site-specific PMP (ssPMP) for the Conowingo dam safety study, and reflected the combination of both the Wellsville, NY and Zerbe, PA storm centers that occurred during the June 1972 storm. The licensee stated that Beaver Valley ssPMP study only considers the Wellsville, NY storm center to be transpositionable to the Beaver Valley watershed and that the corresponding values were used to develop the FHRR-based DAD values without transpositioning the Zerbe, PA storm center. The licensee also provided the observed DAD tables for both storm centers and the SPAS isohyetal plot of the full storm. The NRC staff notes that the Zerbe, PA storm center exceeds the Wellsville, NY storm center for the 72-h, 20,000-mi^2 depth. Since both storm centers resulted from the same tropical storm system, NRC staff issued a follow-up information need to seek justification for separating the June 1972 storm into two storm centers (see Information Need #1a).

Info Need	Information Need Description	Action (Post-Audit)
1a	Follow-Up: Depth-Area Duration Values for the June 1972 Storm Background: NRC staff issued Information Need #1 related to differences in the SPAS-based and FHRR-based DAD values provided by the licensee for the Wellsville, NY June 1972 storm. In response, the licensee clarified that the SPAS-based DAD values provided in response to the initial NRC request for supplemental information were from an internal sensitivity analysis that Allied Weather Associates (AWA) completed as a part of the Conowingo site-specific PMP analysis. The licensee stated that the sensitivity combined both storm centers from the June 1972 storm, one east of the Appalachians near Zerbe, PA and one near Wellsville, NY. The licensee clarified that only the Wellsville, NY storm center was used as a part of the Beaver Valley study. The response provided by the licensee for the initial information need raised additional questions about the approach used for the June 1972 storm. Specifically, NRC staff requested additional clarifying information for separating the June 1972 storm into two storm centers based on the Eastern Continental divide. Request: Provide justification for separating the June 1972 storm into two storm centers. As a part of the response, describe the extent to which the National Weather Service (NWS) HMRs split rainfall into separate storm centers. In addition, provide the adjusted DAD values for the June 1972 storm when applying the full storm (i.e., combined storm center data) to the Beaver Valley location.	The licensee stated that the use of separate storm centers for DAD analysis has been employed by the HMRs and is determined by timing of rainfall, differences in synoptic meteorological environment, and differences in topographical controls, which all help determine whether separate storm centers are warranted. The licensee provided material from the USACE/NWS Black Book which exemplifies cases in which separate storm centers were analyzed for the same storm system. The NRC staff notes, however, that the June 1972 storm centers were of closer proximity than these other cases and occurred within 24 hours of each other. The Wellsville, NY storm center experienced peak rainfall intensity prior to the Zerbe, PA storm center, and the licensee stated that the Wellsville, NY rainfall utilized low-level moisture from the Gulf of Mexico. However, NRC staff finds it unlikely that the Wellsville, NY storm center pulled from a different moisture source than the Zerbe, PA storm center as the timing of the storm track and rainfall and the significant distance of Wellsville from the Gulf do not support a Gulf moisture source for Wellsville (the hurricane was located near the North Carolina coast around the time of major rainfall in Wellsville). The storm track provided by the licensee and available from online sources indicates that the hurricane formed in the Gulf of Mexico, the storm clearly weakened as it crossed the Florida panhandle, Georgia, and the Carolinas before strengthening as it pulled moisture from the Atlantic. The licensee also provided non-public working notes from the NWS that were produced during evaluation of the Zerbe, PA storm. [[redacted]

Info Need	Information Need Description	Action (Post-Audit)
		[redacted].]] The NRC staff notes that many major historical storms produced multiple storm centers and that separation of such storm centers should be used with caution. In the case of the June 1972 storm, the licensee's response does not provide clear evidence that the Zerbe, PA storm is not transpositionable to the Beaver Valley watershed. To test the sensitivity of how the full June 1972 storm (i.e., both storm centers included) would impact the Beaver Valley ssPMP, the NRC staff performed an independent ssPMP evaluation to adjust the storm to the Beaver Valley watershed. The NRC staff computed independent values for the storm representative dew point, in-place maximum dew point climatology, transpositioned maximum dew point climatology, and in-place average elevation. The results indicate that the June 1972 storm's adjusted DAD for 72-h, 20,000-mi^2 may be estimated as 10.4 inches, compared to the licensee's all-season ssPMP of 10.0 inches (a 4% increase). However, this ssPMP estimate was bounded by the NRC staff's analysis of the Big Rapids, MI storm (see Information Need #2).

Info Need	Information Need Description	Action (Post-Audit)
2	Big Rapids Dew Point Values Background: As a part of it ssPMP review process, the NRC staff has collected observational dew point data for use in conducting independent ssPMP evaluations similar to AWA's process. The NRC staff independently computed values for storm representative dew point, in-place maximum dew point, and transpositioned maximum dew point. The NRC staff reviewed the Beaver Valley short list storms for cool-season and all-season ssPMP and identified various differences in these dew point values, particularly for the Big Rapids, MI all-season storm. As described in the AWA Audit Report (ADAMS Accession No. ML15113A029, Section 2b), "the final determination of what stations to use in assigning the storm representative dew point temperature is subject to professional judgment." After evaluation, the NRC staff concluded that: 1. The storm representative dew point for the Big Rapids, MI all-season storm may be more conservatively estimated as 68.5 F, compared to the licensee's value of 70.5 F. The NRC staff's evaluation includes differences related to two features: 1) the storm representative dew point timeframe and 2) the storm representative dew point location. Regarding the storm representative dew point timeframe, staff made the following observations: a) The timeframe for which the station-based storm representative dew point temperature was selected occurs after the rainfall event starts. For KMMO, the 24-hour storm representative dew point was selected from 9/10/1900UTC to 9/11/1800UTC (from *BigRapids_obs_data.xlsx*), when nearly one third of	The licensee described the process involved in identifying the moisture source location and timing associated with the 1986 Big Rapids, MI storm. The basic procedure for identifying storm moisture source involves several key considerations, including ensuring that the storm moisture source location is upstream of the precipitation and outside of the rain shield and that the moisture track excludes intervening barriers which would reduce moisture. The licensee also stated that when identifying the moisture source location, observed dew point values should be elevated and display similarities in both time and space. In some cases (partially applicable to Big Rapids), the analysis is limited by data availability, and professional judgment may be needed. The licensee explained that the Big Rapids, MI storm is an extremely large historical rainfall event and often controls PMP values (and in some cases produces PMP values in excess of HMR 51). The licensee suggests that since the storm is so significant, additional scrutiny, analysis, and consideration is needed when compared to other storms. Since the storm was so large, the licensee argues that the calculated in-place maximization factor of 1.38 is significantly larger than would be expected for such an event, and was "unreasonable" for Big Rapids, MI. The licensee provided description of the timing of the Big Rapids rainfall event and the storm dynamics that were observed for the storm. The observed dew point value was selected using the KMMO station (Marseilles, Illinois) and was determined to be 70.5 °F. The KMMO station is located approximately 230 miles southwest of Big Rapids. Given the average wind speed during the selected 24-hour storm representative dew point time period was 13.5 mph at KMMO, the licensee suggested that it would take

Info Need	Information Need Description	Action (Post-Audit)
	the precipitation has occurred before the timeframe (from *SPAS 1206 Mass Curve.xlsx*). This timeframe is also inconsistent with licensee's HYSPLIT analysis that back calculated Big Rapids' moisture trajectory since 9/9/1200UTC (i.e., Big Rapids' starting time). Regarding the storm representative dew point location, staff made the following observations: b) When using a timeframe for averaging that is consistent with the storm rainfall period and is informed by the HYSPLIT trajectories, a more appropriate storm representative dew point location may be in Iowa, where the storm representative dew point could be approximated as 68.5 F. <u>Request:</u> Provide justification for selecting a storm representative dew point value of 70.5 degrees Farenheit (°F) for the Big Rapids, MI all-season storm. As a part of the response, discuss the rationale for selecting the timeframe and location of the station-based storm representative dew point temperatures used for the Big Rapids storm which appear to be inconsistent with the period of rainfall. If corrections are warranted, provide updated envelopment curves.	approximately 17.0 hours for moisture to travel from KMMO to Big Rapids. Using HYSPLIT trajectories and daily synoptic weather maps, the licensee identified potential regions of moisture inflow. During an audit held September 21, 2016, the licensee noted that the selected moisture source location and timeframe was appropriate for the Big Rapids storm. The NRC staff questioned whether the selected timeframe adequately represented the first half of the precipitation event. The licensee stated that the dew point value of 70.5 °F was reasonable and was representative of the last half of the precipitation event. Since rainfall occurred over a multi-day period, while the licensee used a 24-h period to compute storm representative dew point, the current approach does not allow for representation of the full rainfall event. The NRC staff's independent analysis reveals a storm representative dew point value of approximately 68.5 °F found from assessing a different timeframe and location than used by the licensee. The difference results in an in-place maximization factor of 1.50, which increased the Big Rapids DAD values and resulted in an increase to the ssPMP values. Sensitivity runs were performed by the USACE and the results and resolution is documented in Section 3.3 of this assessment.

<table>
<tr><th>Info Need</th><th>Information Need Description</th><th>Action (Post-Audit)</th></tr>
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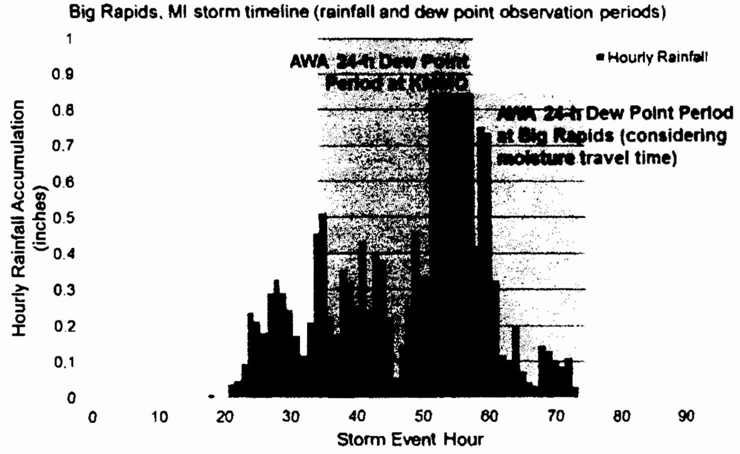

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<tr><td>3</td><td>

<u>Initial Storm Long List Screening</u>

<u>Background:</u> After reviewing the initial storm list developed by the licensee for the all-season ssPMP evaluation, it is not clear to the NRC staff why one storm was removed. As a result, further clarification is requested. The screening criteria used to exclude this storm should be clearly stated.

1. <u>Golconda, IL</u> – October 1910 storm occurring in Illinois, with an observed 72-hour, 20,000-mi^2 rainfall of 10.7 inches (according to the USACE Black Book). This storm is listed as being removed due to being "Not PMP Storm Type".

<u>Request:</u> Provide further reasoning for the removal of the above storm. If corrections are warranted, provide updated envelopment curves.

</td><td>

The licensee clarified that the reason for excluding the Golconda, IL storm from the short storm list was because the storm was not transpositionable to the Beaver Valley basin.

To support its claim, the licensee presented hand-drawn maps of transposition limits established by the NWS for other historical storms occurring in the Midwest and Great Plains. None of these documents were made public and meteorological justification for setting the transposition limits of these storms was not provided. Most of the storms used for comparison were much further west or occurred at a different time of year than the Golconda storm, and the transposition limits for Golconda were not explicitly defined by the NWS. The licensee relied upon professional judgement to determine the storm is not transpositionable to the Beaver Valley watershed and stated that the Golconda storm was not used for PMP development in HMR 51.

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Info Need	Information Need Description	Action (Post-Audit)
		The licensee also presented an initial evaluation of the Golconda, IL storm in an attempt to transposition it to Beaver Valley and assess the impacts on the Beaver Valley ssPMP. The results indicated that the storm would not impact the ssPMP values and that the total adjustment factor was approximately 0.83. Using the storm representative dew point location and storm center location provided by the licensee, the NRC staff conducted an independent assessment for Golconda and determined that the Golconda, IL storm would not impact ssPMP and estimated a total adjustment factor of 0.86.

SUBJECT: BEAVER VALLEY POWER STATION, UNITS 1 AND 2– STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST FLOOD-CAUSING MECHANISM REEVALUATION (EPID NOS. L-2016-JLD-001 AND /L-2016-JLD-0002 DATED July 24, 2018

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NAME	JUribe	SLent	KSee*
DATE	6/7/18	6/7/18	4/17/2018
OFFICE	NRO/DSEA/RHM2/BC	NRR/DLP/PBMB/BC	NRR/DLP/PBMB/PM
NAME	CCook*	BTitus(a)	JUribe
DATE	4/17/2018	7/23/18	7/24/18

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