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

March 27, 2017

Mr. Robert S. Bement
Executive Vice President Nuclear/
Chief Nuclear Officer
Arizona Public Service Company
P.O. Box 52034, MS 7602
Phoenix, AZ 85072-2034

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NOS. MF7955, MF7956 AND MF7957)

Dear Mr. Bement:

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, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), "Conditions of Licenses" (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).

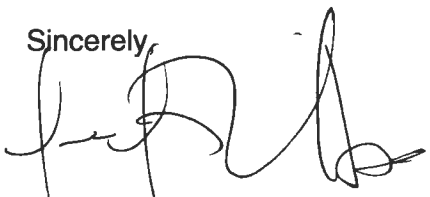
Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (ADAMS Accession No. ML12056A046). Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (ADAMS Accession No. ML12054A735). In order to proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not be based on present-day methodologies and guidance, in the development of their mitigating strategies.

By letter dated December 8, 2016 (ADAMS Accession No. ML16343B070), Arizona Public Service Company (the licensee) submitted the mitigation strategies assessment (MSA) for Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde). 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. The purpose of this letter is to provide the NRC's assessment of the Palo Verde MSA.

The NRC staff has concluded that the Palo Verde MSA was performed consistent with the guidance described in Appendix G of Nuclear Energy Institute 12-06, Revision 2, as endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, and that the licensee has demonstrated that the mitigation strategies are reasonably protected from reevaluated flood hazards conditions for beyond-design-basis external events. This closes out the NRC's efforts associated with CAC Nos. MF7955, MF7956, and MF7957.

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

Sincerely,



Juan F. Uribe, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Enclosure:
Staff Assessment Related to the
Mitigating Strategies for Palo Verde

Docket Nos. 50-528, 50-529 and 50-530

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO MITIGATION STRATEGIES FOR PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3, AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE RECOMMENDATION 2.1

CAC NOS. MF7955, MF7956 AND MF7957.

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, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), "Conditions of Licenses" (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). Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," (ADAMS Accession No. ML12054A735). That order requires holders of operating reactor licenses and construction permits issued under 10 CFR Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit to the NRC for review a final integrated plan (FIP) that describes how compliance with the requirements of Attachment 2 of the order was achieved. To proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not be based on present-day methodologies and guidance, in the development of their mitigating strategies.

The NRC staff and industry recognized the difficulty in developing and implementing mitigating strategies before completing the reevaluation of flood hazards. The NRC staff described this issue and provided recommendations to the Commission on integrating these related activities in COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flood Hazards," dated November 21, 2014 (ADAMS Accession No. ML14309A256). The Commission issued a staff requirements memorandum on March 30, 2015 (ADAMS Accession No. ML15089A236), affirming that the Commission expects licensees for operating nuclear power plants to address the reevaluated flood hazards, which are considered beyond-design-basis external events, within their mitigating strategies.

Nuclear Energy Institute (NEI) 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625), has been endorsed by the NRC as an appropriate methodology for licensees to perform assessments of the mitigating strategies against the reevaluated flood hazards developed in response to the March 12, 2012, 50.54(f) letter. The guidance in NEI 12-06, Revision 2, and Appendix G in particular, supports the proposed Mitigation of Beyond-Design-Basis Events rulemaking. The NRC's endorsement of NEI 12-06, including exceptions, clarifications, and additions, is described in NRC Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) 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). Therefore, Appendix G of NEI 12-06, Revision 2, describes acceptable methods for demonstrating that the reevaluated flooding hazard at the Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde) site is addressed against mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated October 8, 2015 (ADAMS Accession No. ML15280A222), the NRC issued an interim staff response (ISR) letter for Palo Verde. The ISR letter provided the reevaluated flood hazard mechanisms that exceeded the current design basis (CDB) for Palo Verde and parameters that are a suitable input for the mitigating strategies assessment (MSA). For Palo Verde, the mechanism listed as not bounded by the CDB in the ISR letter is the local intense precipitation (LIP). The NRC staff subsequently issued the staff assessment of the flood hazard report for Palo Verde by letter dated November 14, 2016 (ADAMS Accession No. ML16306A444), containing additional details related to the ISR letter. By letter dated December 8, 2016 (ADAMS Accession No. ML16343B070), Arizona Public Service Company (APS, the licensee) submitted the Palo Verde MSA for review by the NRC staff.

3.0 TECHNICAL EVALUATION

3.1 Mitigating Strategies under Order EA-12-049

By letter dated February 28, 2013 (ADAMS Accession No. ML13136A022), APS submitted its overall integrated plan for Palo Verde in response to Order EA-12-049. By letters dated November 25, 2013 (ADAMS Accession No. ML13308C153), and September 8, 2014 (ADAMS Accession No. ML14239A181), the NRC issued an Interim Staff Evaluation and audit report, respectively, on the licensee's progress implementing the FLEX strategies at the site. By letter dated December 17, 2015 (ADAMS Accession No. ML15351A449), APS submitted a compliance letter which stated that all three units at Palo Verde had achieved full compliance with Order EA-12-049. By letter dated December 24, 2015 (ADAMS Accession No. ML15364A034), APS submitted its FIP in response to Order EA-12-049.

By letter dated July 20, 2016 (ADAMS Accession No. ML16088A261), the NRC staff issued a safety evaluation documenting the results of the NRC staffs review of APS' FLEX strategies for Palo Verde. The safety evaluation concluded that the integrated plans, if implemented as described, will adequately address the requirements of Order EA-12-049.

A brief summary of Palo Verde's FLEX strategies are listed below:

- FLEX portable generator sets will be deployed to provide power to critical electrical loads such as vital instrumentation, two of four trains of battery chargers and battery compartment exhaust ventilation fans, and to a safety-related diesel fuel oil transfer pump.

- The core decay heat removal function is initially achieved using the one essential turbine-driven auxiliary feedwater (TDAFW) pump per unit. The source of water for the TDAFW pump is the unit's condensate storage tank (CST), and the unit's reactor makeup water tank (RMWT) can be manually aligned to the suction of the TDAFW pump if the CST is not available.

- The Reactor Coolant System (RCS) reactivity control is initially achieved by control rod insertion, and some injection of borated water to the RCS is expected. When aligned, the unit's FLEX portable high- pressure RCS injection pump will provide borated makeup to the RCS from the unit's refueling water tank (RWT).

In Phase 2, portable SFP [spent fuel pool] makeup pumps are deployed to supply water from the RWT to each SFP. There is one SFP per unit, each located in its own fuel building. In Phase 3, water for the SFP makeup function will be provided to each unit's RWT from the station reservoirs using a pipeline constructed after the event and pumps sized to match the decay heat.

The National SAFER [Strategic Alliance for FLEX Emergency Response] Response Center (NSRC) will provide high capacity pumps and large turbine-driven diesel generators (DGs) to restore one residual heat removal (RHR) cooling train per unit to cool the reactor cores in the long term.

3.2. Evaluation of Current FLEX strategies against reevaluated hazard(s)

The licensee has assessed the potential impacts of the LIP flood-causing mechanism, as described in the ISR letter, against the mitigating strategies designed to meet Order EA-12-049. The purpose of the MSA was to determine if mitigating strategies are adequate as-is, need to be modified, or new mitigating strategies need to be developed to address this hazard.

The licensee stated in its MSA that Palo Verde is a "dry site" and identified no issues associated with flood-causing mechanisms from probable maximum flood (PMF) on the East or Winters washes, or LIP for Palo Verde Units 1, 2, and 3.

In regards to rainwater accumulation, the licensee stated in the MSA that "Areas adjacent to the power block are sloped away at 0.5 to 1%. This results in a minimum drop of 5 to 7 feet at the peripheral drainage system, as compared to the grade elevation at each unit." And, "[t]he volume of water in the vicinity of the power block area consequent to a 6-hour PMP is based on zero infiltration losses and a complete blockage of the drainage culverts for the storm duration."

In its MSA, the licensee stated that ponding of rain water runoff at the peripheral drainage system will have receded sufficiently within 24 hours to allow hauling of equipment with existing FLEX vehicles to their designated deployment locations. The first of this equipment, deploying after 24 hours, will be the 480 volt alternating current (VAC) generators. A minimal amount of accumulation (ponding from rain water runoff) near the facilities is both expected and will not

impede the operation of the FLEX equipment. No other applicable flood-causing mechanisms will affect the hauling routes of FLEX equipment. Furthermore, the licensee stated that the need to start FLEX pumps and generators is not required until 35.5 hours into the event, as described in the Palo Verde FIP.

As a result of the above information, the licensee determined that the current FLEX strategies can be successfully deployed as designed for all applicable flood-causing mechanisms and no further actions, including modifications to FLEX, are required. This conclusion is aligned to a G.4.1 path under the guidance set forth in NEI 12-06, Appendix G.

The NRC staff has reviewed the information presented in the MSA, as well as supporting documentation. This included a:

- Review of licensing documents,
- Review of the topographical features of the site, and
- Review and documentation of existing mitigating strategies under Order EA-12-049.

In general, FLEX strategies are divided in three phases:

- Phase 1– initial coping relies on installed equipment and on-site resources.
- Phase 2 – coping relies on portable on-site FLEX equipment
- Phase 3 – coping relies on offsite equipment from the NSRC

First, the NRC staff confirmed that the Palo Verde station was designed as a dry site, as stated in the Palo Verde Updated Final Safety Analysis Report Section 2.4.2.2. As a result, the licensee was not required to consider external flooding as a hazard when implementing mitigating strategies under Order EA-12-049. In addition, the NRC staff reviewed the flood hazard elevations in the MSA, and confirmed that the elevations match the values provided in the Palo Verde ISR letter.

The staff then reviewed Table 5, "Sequence of Events Timeline, Modes 1-4," of the FIP. In this Table, the first FLEX equipment that is relied upon as part of the overall Palo Verde FLEX strategy are the Phase 2- 480 VAC generators, which are expected to be deployed after 24 hours of the initiating event (see FIP Section 3.2.3.6). The staff had previously evaluated the implementation of these generators in its July 20, 2016, safety evaluation. The licensee did not make any changes as a result of the MSA evaluation.

As a result of the LIP event, the licensee stated that the transient ponding effect duration from a LIP is reduced to a surface elevation of zero feet at approximately 7 hours (actually or trend towards zero feet). This ponding duration is based on the hydrographs generated for the critical pathways (Units 1, 2, and 3 – pathways 10 or 11 through 21) around the safety-related buildings in the powerblock. Within 24 hours into the event, hauling routes will be accessible allowing equipment to be hauled with existing FLEX vehicles to their designated deployment locations, if FLEX equipment is needed. The staff evaluated the flood event durations provided by the licensee in Section 3.4 of this assessment.

FLEX equipment staging areas, hauling paths and storage locations have been previously reviewed by the staff and documented in its July 20, 2016, safety evaluation. The licensee did not make any changes as a result of the MSA evaluation.

Finally, the staff had previously reviewed the information related to topographical features and drainage in Sections 3.1 and 3.2.2 of the staff assessment to the flood hazard report for Palo Verde issued by letter dated November 14, 2016. The licensee did not make any changes as a result of the MSA evaluation.

Based on the review of the above information, the NRC staff finds that the licensee has adequately assessed the Mitigating Strategies Flood Hazard Information for the LIP event and that the applicable FLEX strategy can be implemented.

3.3 Evaluation of Associated Effects

The staff reviewed the information provided by Palo Verde in the MSA regarding associated effects (AEs) parameters for flood hazards not bounded by the CDB. The AE parameters related to water surface elevation (i.e., stillwater elevation with wind waves and runup effects) were previously reviewed by the NRC staff, and were transmitted to the licensee via the ISR Letter. The AE parameters not directly associated with water surface elevation are discussed below and are summarized in Table 3.3-1.

For the LIP event, the licensee stated that the associated effects of LIP flooding are not considered credible (minimal) due to the relative low flow velocities for a LIP event and limited debris effects within the protected area. The NRC staff confirmed this statement by reviewing the licensee-provided LIP model input and output files. The staff found that the estimated inundation depths and flow velocities are acceptable and that the modeling is reasonable for use in the MSA. The NRC staff agrees with the licensee's conclusion that the AE parameters for LIP are either minimal or will have no impact on the safety-related plant facilities.

The staff reviewed the potential for debris load at the Palo Verde site and concluded that there are no significant sources of material (trees, vegetation, etc.) that would contribute to debris loads at the site. In light of the small inundation depths and low flood water velocities anticipated, the NRC staff found that the debris, sediment, and hydrostatic loads would be minimal. Consequently, the licensee's assumptions and AE parameters are reasonable for use as part of the MSA review.

In summary, the staff determined the licensee's methods were appropriate and the provided AE parameters are reasonable for use in the MSA.

3.4 Evaluation of Flood Event Duration

The staff reviewed information provided by the licensee in the MSA regarding the flood event duration (FED) parameters associated with flood hazards not bounded by the CDB at Palo Verde. The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 3.4-1.

The licensee did not report a warning time for LIP-related flooding, as documented in the ISR letter; however, the National Weather Service qualitative precipitation forecast for the

conterminous United States is typically 24 hours and this duration is acceptable to the staff for the purposes of the MSA exercise. The staff notes the licensee also has the option to use the guidance in NEI 15-05 "Warning Time for Local Intense Precipitation Events," Revision 6, to estimate warning time for LIP.

The maximum water surface elevations are generated during the LIP event at three locations within the Palo Verde powerblock; those locations and their corresponding elevations are described in Table 2 of the ISR letter (NRC, 2015). In its MSA letter, the licensee did not describe the duration of inundation due to LIP event at those locations. In the flood hazard report, the licensee previously relied on a 6-hr precipitation event for the purposes of LIP analysis. In light of the grading of the site and existing surface water drainage system within the powerblock previously described in the flood hazard report, the staff found that a 6-hr estimate for inundation is reasonable to use for the purposes of the MSA. In its MSA letter, the licensee reported that the time necessary for the flood waters to recede completely from critical site locations within the powerblock is about 7 hrs and that within 24 hrs surface ponding would have receded sufficiently at the periphery of the powerblock to allow for the staging of FLEX equipment.

Based on this review, the staff determined that the licensee's FED parameters for LIP are reasonable and acceptable for use in the MSA.

3.5 Evaluation of Flood Protection Features

No additional flood protection features were necessary as a result of the MSA.

4.0 CONCLUSION

The NRC staff has reviewed the information provided in the Palo Verde MSA related to the FLEX strategies, as evaluated against the reevaluated hazard(s) described in Section 2 of this staff assessment, and found that:

- The FLEX strategies are not affected by the impacts of the ISR flood levels (including impacts due to the environmental conditions created by the ISR flood levels),

- The deployment of the FLEX strategies is not affected by the impacts of the ISR flood levels, and

- Associated effects and FED are reasonable and acceptable for use in the Palo Verde MSA, and have been appropriately considered in the Palo Verde MSA.

Therefore, the NRC staff concludes that the licensee has followed the guidance in NEI 12-06, Revision 2, and demonstrated the capability to deploy the original FLEX strategies, as designed, against a postulated beyond-design-basis event for LIP flood-causing mechanism, including associated effects and flood event duration.

Table 3.3-1. Associated Effects Parameters not Directly Associated with Total Water Height for Flood-Causing Mechanisms not Bounded by the CDB.

	FLOODING MECHANISM
Associated Effects Parameter	**LOCAL INTENSE PRECIPITATION**
Hydrodynamic loading at plant grade	3.2 lb/ft
Debris loading at plant grade	Minimal
Sediment loading at plant grade	Minimal
Sediment deposition and erosion	Minimal
Concurrent conditions, including adverse weather	Minimal
Groundwater ingress	Minimal
Other pertinent factors (e.g., waterborne projectiles)	Minimal

Table 3.4.-1. Flood Event Durations 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 and Associated Drainage	24 hrs	≈ 7 hrs (1)	< 24 h (1)
(1) MSA Letter (APS, 2016)			

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2 AND 3– FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED MARCH 27, 2017

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