Exelon Generation.

10 CFR 50.54(f)

RS-17-088

September 8, 2017

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Dresden Nuclear Power Station, Units 2 and 3
Renewed Facility Operating License Nos. DPR-19 and DPR-25
NRC Docket Nos. 50-237 and 50-249

Subject: Exelon Generation Company, LLC Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 3, Flooding Integrated Assessment Submittal

References:

1. NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident; dated March 12, 2012
2. Exelon Generation Company, LLC Letter to USNRC, Response to March 12, 2012 Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flooding Hazard Reevaluation Report, dated May 10, 2013 (RS-13-110)
3. Exelon Generation Company, LLC Letter to USNRC, Response to Request for Additional Information Regarding Fukushima Lessons Learned – Flood Hazard Reevaluation Report, dated May 19, 2014 (RS-14-122)
4. NRC Letter, Supplemental Information Related to Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated March 1, 2013
5. NRC Staff Requirements Memoranda to COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards", dated March 30, 2015
6. NRC Letter, Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design-Basis External Events, dated September 1, 2015

7. Nuclear Energy Institute (NEI) Report, NEI 16-05, Revision 1, External Flooding Assessment Guidelines, dated June 2016

8. U.S. Nuclear Regulatory Commission, JLD-ISG-2016-01, Revision 0, Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flood Hazard Reevaluation; Focused Evaluation and Integrated Assessment, dated July 11, 2016

9. NRC Letter, Dresden Nuclear Power Station, Units 2 and 3 – Staff Assessment of Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (TAC Nos. MF1795 and MF1796), dated March 31, 2015

10. NRC Letter, Dresden Nuclear Power Station, Units 2 and 3 – Supplement to Staff Assessment of Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (TAC Nos. MF1795 and MF1796), dated November 4, 2015

11. Exelon Generation Company, LLC Letter to USNRC, Mitigating Strategies Flood Hazard Assessment (MSFHA) Submittal, dated June 30, 2016 (RS-16-100)

On March 12, 2012, the NRC issued Reference 1 to request information associated with Near-Term Task Force (NTTF) Recommendation 2.1 for Flooding. One of the Required Responses in Reference 1 directed licensees to submit a Flood Hazard Reevaluation Report (FHRR). For Dresden Nuclear Power Station, Units 2 and 3, the FHRR was submitted on May 10, 2013 (Reference 2). Additional information was provided with Reference 3. Per Reference 4, the NRC considers the reevaluated flood hazard to be "beyond the current design/licensing basis of operating plants".

Following the Commission's directive to NRC Staff (Reference 5), the NRC issued a letter to industry (Reference 6) indicating that new guidance is being prepared to replace instructions (Reference 5), and provide for a "graded approach to flooding reevaluations" and "more focused evaluations of local intense precipitation and available physical margin in lieu of proceeding to an integrated assessment".

The Nuclear Energy Institute (NEI) prepared NEI 16-05, "External Flooding Assessment Guidelines" (Reference 7). The NRC endorsed NEI 16-05 (Reference 8) and recommended changes, which have been incorporated into NEI 16-05, Revision 1. NEI 16-05 indicates that each flood-causing mechanism not bounded by the Design Basis (DB) flood (using only stillwater and/or wind-wave runup level) should follow one of the following five assessment paths:

- Path 1: Demonstrate Flood Mechanism is Bounded Through Improved Realism
- Path 2: Demonstrate Effective Flood Protection
- Path 3: Demonstrate a Feasible Response to Local Intense Precipitation (LIP)
- Path 4: Demonstrate Effective Mitigation
- Path 5: Scenario Based Approach

Non-bounded flood-causing mechanisms in Paths 1, 2, or 3 would only require a Focused Evaluation to complete the actions related to external flooding required by the March 12, 2012 10 CFR 50.54(f) letter. Mechanisms in Paths 4 or 5 require an Integrated Assessment.

The enclosure to this letter provides the Flooding Integrated Assessment Summary Report for the Dresden Nuclear Power Station, Units 2 and 3.

The reevaluated flood hazard, summarized by the NRC in References 9 and 10, was utilized as input to this Flooding Integrated Assessment. The Flooding Integrated Assessment reaffirms that Dresden Nuclear Power Station has appropriately addressed plant vulnerabilities to external flooding and will not require additional safety enhancements since mitigating strategies (FLEX) remain feasible (per Reference 11) for the reevaluated flood hazard and effective protection of Key Safety Functions has been demonstrated for higher likelihood flooding scenarios.

The Flooding Integrated Assessment follows Path 5 of NEI 16-05, Revision 1 (Reference 7), and utilized Appendices B and D for guidance on evaluating the site protection features and developing the flood-frequency analysis. This submittal completes the actions related to external flooding required by the March 12, 2012 10 CFR 50.54(f) letter.

This letter contains no new regulatory commitments. If you have any questions regarding this report, please contact David J. Distel at (610) 765-5517.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 8th day of September 2017.

Respectfully submitted,

Patrick R S

Patrick R. Simpson
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Enclosure: Dresden Nuclear Power Station, Units 2 and 3, Flooding Integrated Assessment, dated September 8, 2017

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Enclosure

Dresden Nuclear Power Station, Units 2 and 3

Flooding Integrated Assessment

dated September 8, 2017

(24 Pages)

Exelon.

DRESDEN GENERATING STATION FLOODING INTEGRATED ASSESSMENT SUMMARY

SEPTEMBER 8, 2017
LETTER # RS-17-088
ENCLOSURE

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DRESDEN GENERATING STATION

FLOODING INTEGRATED ASSESSMENT SUMMARY

1 EXECUTIVE SUMMARY

The Dresden Generating Station (DGS) has reevaluated its flooding hazard in accordance with the NRC's March 12, 2012, 10 CFR 50.54(f) request for information (RFI). The RFI was issued as part of implementing lessons learned from the Fukushima Dai-ichi accident; specifically, to address Recommendation 2.1 of the NRC's Near-Term Task Force report. This information was submitted to NRC in a flood hazard reevaluation report (FHRR) on May 10, 2013 and response to Request for Additional Information (RAI) dated May 19, 2014 and summarized in the NRC's "Supplement to the Staff Assessment of Response to Request for Information Pursuant to 10 CFR 50.54(f)" letter dated November 4, 2015. No changes to the flooding analysis have been performed since the issuance of this letter and this flooding analysis served as the input into the Integrated Assessment (IA) summarized in this attachment. There are two mechanisms that were found to be not bounded by the plant's design basis. These mechanisms are listed below and addressed further in this Integrated Assessment (IA):

- Local Intense Precipitation and Associated Drainage
- Failure of Dams and Onsite Water Control/Storage Structures

It should be noted that the "Failure of Dams and Onsite Water Control/Storage Structures" flood-causing mechanism for DGS represents the hydrologic dam failure scenario, which includes a combination of a precipitation-induced Probable Maximum Flood (PMF), upstream dam failure, and wind-generated waves (per Section H.1 of NUREG/CR-7046) along the Illinois River. A flood-frequency analysis, completed in support of this IA, indicates that Illinois River flood scenarios above site grade (elevation 517.0 NGVD29) are characterized as "low likelihood" (less than 10^{-4} annual exceedance probability) events. The IA concluded that "higher probability" flood scenarios are effectively protected by site grade and a feasible mitigation response strategy is available for "lower probability" flood scenarios. Therefore, the IA concludes that DGS has appropriately addressed plant vulnerabilities to external flooding and will not require additional safety enhancements.

This Integrated Assessment followed Path 5 of NEI 16-05, Rev. 1 and utilized Appendices B and D for guidance on evaluating the site protection features and developing the flood-frequency analysis. This submittal completes the actions related to External Flooding required by the March 12, 2012 10 CFR 50.54(f) letter.

2 BACKGROUND

On March 12, 2012, the NRC issued Reference 1 to request information associated with Near-Term Task Force (NTTF) Recommendation 2.1 for flooding. The RFI (Reference 1) directed licensees, in part, to submit a Flood Hazard Reevaluation Report (FHRR) to reevaluate the flood hazards for their sites using present-day methods and guidance used for early site permits and combined operating licenses. For DGS, Units 2 and 3, the FHRR was submitted on May 10, 2013 (Reference 2). Additional information was provided with Reference 3.

Following the Commission's directive to NRC Staff in Reference 5, the NRC issued a letter to industry (Reference 6) indicating that new guidance is being prepared to replace instructions in Reference 4 and provide for a "graded approach to flooding reevaluations" and "more focused evaluations of local intense precipitation and available physical margin in lieu of proceeding to an integrated assessment." NEI prepared the new "External Flooding Assessment Guidelines" in NEI 16-05 (Reference 10), which was endorsed by the NRC in Reference 11. NEI 16-05 indicates that each flood-causing mechanism not bounded by the design basis flood (using only stillwater and/or wind-wave runup level) should follow one of the following five assessment paths:

- Path 1: Demonstrate Flood Mechanism is Bounded Through Improved Realism
- Path 2: Demonstrate Effective Flood Protection
- Path 3: Demonstrate a Feasible Response to LIP
- Path 4: Demonstrate Effective Mitigation
- Path 5: Scenario Based Approach

Non-bounded flood-causing mechanisms in Paths 1, 2, or 3 would require a Focused Evaluation to complete the actions related to external flooding required by the March 12, 2012 10 CFR 50.54(f) letter. Mechanisms in Paths 4 or 5 require an Integrated Assessment. Note that elevations herein reference either the MSL or NGVD29 datums which, per Section 3 of Enclosure 2 in Reference 2, are equivalent at DGS.

3 REFERENCES

1. NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident; dated March 12, 2012.

2. Exelon Generation Letter to USNRC, Response to March 12, 2012 Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flooding Hazard Reevaluation Report, dated May 10, 2013. (RS-13-110)

3. Exelon Generation Letter to USNRC, Response to Request for Additional Information Regarding Fukushima Lessons Learned – Flood Hazard Reevaluation Report, dated May 19, 2014. (RS-14-122)

4. NRC Letter, Supplemental Information Related to Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated March 1, 2013.

5. NRC Staff Requirements Memoranda to COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards", dated March 30, 2015.

6. NRC Letter, Coordination of Requests for Information Regarding Flooding Hazard Reevaluations and Mitigating Strategies for Beyond-Design-Basis External Events, dated September 1, 2015.

7. NRC Letter, Dresden Nuclear Power Station, Units 2 and 3 – Staff Assessment of Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (TAC NOS. MF1795 and MF1796), dated March 31, 2015.

8. NRC Letter, Exelon Generation – Supplement to Staff Assessment of Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanisms Reevaluation (TAC Nos. MF1795 and MF1796), dated November 4, 2015.

9. Nuclear Energy Institute (NEI), Report NEI 12-06, Revision 2, Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, dated December 2015.

10. Nuclear Energy Institute (NEI), Report NEI 16-05, Revision 1, External Flooding Assessment Guidelines, dated June 2016.

11. U.S. Nuclear Regulatory Commission, JLD-ISG-2016-01, Revision 0, Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flooding Hazard Reevaluations; Focused Evaluation and Integrated Assessment, dated July 11, 2016.

12. U.S. Nuclear Regulatory Commission, NUREG/CR-7046, "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America", dated November 2011.

13. Exelon Generation Letter to USNRC, Dresden Generating Station, Units 2 and 3, Mitigating Strategies Assessment for Flooding, dated June 30, 2016. (RS-16-100)

14. EC 391644, Reactor and Diesel Building Flood Barriers.

15. EC 398329, Determination of the Maximum Allowable Opening in a Secondary Containment Penetration that can be Induced During Refueling Op.

16. EC 405127, Rev 2, Water Ingress During the Reevaluated LIP Flood Hazard.

17. Dresden Nuclear Power Station, DRE14-0017, Beyond Design Basis Site-Specific Local Intense Precipitation Analysis (Fukushima) for Exelon's IL Sites, including Dresden, Rev. 0.

18. Dresden Nuclear Power Station, Local Intense Precipitation Report, Rev 4, April 2014.

19. Hydrologic Frequency Analysis Work Group (HFAWG), Draft Bulletin 17C, (https://acwi.gov/hydrology/Frequency/b17c/).

20. DRE17-0015 Flood Frequency Analysis per NEI 16-05 Calculation Package for Dresden Generating Station.

21. NRC Letter, Dresden Nuclear Power Station, Units 2 and 3 – Flood Hazard Mitigating Strategies Assessment (CAC NOS. MF7921 and MF7922), dated December 8, 2016.

22. Electric Power Research Institute (EPRI), Riverine Probabilistic Flooding Hazard Analysis Pilot, Proof-of-Concept Study for a Nuclear Power Plant, Report No. 3002003013, Technical Update, August 2014.

23. Procedure DOA 0010-04, Floods

24. Procedure MA-DR-MM-6-00101, Maintenance Activities for Site Flooding

25. Procedure DGP 02-01, Unit Shutdown

26. Procedure DGP 02-03, Reactor Scram
27. Procedure DOA 1000-01, Residual Heat Removal Alternatives
28. Procedure DOP 1300-03, Manual Operation of the Isolation Condenser
29. Procedure DOA 1900-01, Loss of Fuel Pool Cooling
30. EC 391096, Isolation Condenser Pump House Flood Protection

4 TERMS AND DEFINITIONS

- AIM – Assumptions, Inputs, and Methods
- AOP – Abnormal Operating Procedures
- APM – Available Physical Margin
- AEP – Annual Exceedance Probability
- CL – Confidence Limits
- CLB – Current Licensing Basis
- DB – Design Basis
- DGS – Dresden Generating Station
- DOA – Dresden Operating Abnormal
- DOP – Dresden Operating Procedure
- ELAP – Extended Loss of ac Power
- EOP – Emergency Operating Procedures
- FHRR – Flood Hazard Reevaluation Report
- FIAP – Flooding Impact Assessment Process
- FLEX – Diverse and flexible coping strategies covered by NRC order EA-12-049
- IA – Integrated Assessment
- ISPH – Intake Screen and Pump House
- Key SSC – A system Structure or Component relied upon to fulfill a Key Safety Function
- KSF – Key Safety function, i.e. core cooling, spent fuel pool cooling, or containment function.
- LIP – Local Intense Precipitation
- LUHS – Loss of Normal Access to the Ultimate Heat Sink
- MCC – Motor Control Center
- MSA – Mitigating Strategies Assessment as described in NEI 12-06 Rev 2, App G
- MSFHI – Mitigating Strategies Flood Hazard Information
- MSL – Mean Sea Level Datum
- NGVD29 – National Geodetic Vertical Datum of 1929
- NTTF – Near Term Task Force commissioned by the NRC to recommend actions following the Fukushima Dai-ichi accidents
- OCC – Outage Control Center
- PMF – Probable Maximum Flood
- PMP – Probable Maximum Precipitation
- RFI – Request for Information
- USACE – U.S. Army Corps of Engineers

5 FLOOD HAZARD PARAMETERS FOR UNBOUNDED MECHANISMS

The results of the NRC review of the DGS's Flood Hazard Reevaluation Report (Reference 2) and related RAI responses (Reference 3) are contained in the "Staff Assessment Report" (Reference 7) and "Supplement to the Staff Assessment Report" (Reference 8). In Reference 8, the NRC states that the "staff confirmed that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter" and "the reevaluated flood-causing mechanism information is appropriate input to additional assessments or evaluations of plant response, as described in the 50.54(f) letter and COMSECY-15-0019". The enclosure to Reference 8 includes a summary of the current design basis and reevaluated flood hazard parameters, respectively. In Table 3.1.2-1 of Reference 8, the NRC addresses the following flood-causing mechanisms for the design basis flood:

- Local Intense Precipitation;
- Flooding in Streams and Rivers;
- Failure of Dams and Onsite Water Control/Storage Structures;
- Storm Surge;
- Seiche;
- Tsunami;
- Ice Induced Flooding; and
- Channel Migrations/Diversions.

In Tables 4.0-1 through 4.0-3 of Reference 8, the NRC lists flood hazard information for the following flood-causing mechanism that is not bounded by the design basis hazard flood level:

- Local Intense Precipitation and Associated Drainage
- Failure of Dams and Onsite Water Control/Storage Structures

It should be noted that the "Failure of Dams and Onsite Water Control/Storage Structures" flood-causing mechanism for DGS represents the hydrologic dam failure scenario, which includes a combination of a precipitation-induced Probable Maximum Flood (PMF), upstream dam failure, and wind-generated waves (per Section H.1 of NUREG/CR-7046 (Reference 12)) along the Illinois River.

These are the reevaluated flood-causing mechanisms that should be addressed in the external flooding assessment. The non-bounded flood mechanisms for DGS are described in detail in References 2 and 3. The maximum reevaluated LIP stillwater elevation is 518.1 feet with wind-wave runup not being applicable. The maximum reevaluated combined-effects stillwater and wind-wave runup elevations for Illinois River flooding are 524.8 and 529.0 feet, respectively. The following summarizes how the unbounded mechanism was addressed in this external flooding assessment:

Table 1 – External Flooding Assessment Summary

Flood Mechanism		Summary of Assessment
1	Local Intense Precipitation and Associated Drainage	Flood parameters were not revised as a part of this assessment and the flood mechanism will be addressed using its individual parameters, not a bounding set of parameters. Path 2 was determined to be the appropriate path for DGS since, while ingress does occur, no actions need to be taken to protect key SSCs and available physical margin is adequate to protect KSFs. (See FIAP Path Determination Table, Section 6.3.3 of NEI 16-05.)
2	Failure of Dams and Onsite Water Control/Storage Structures (PMF with upstream dam failure along the Illinois River)	Flood parameters were not revised as a part of this assessment and the flood mechanism will be addressed using its individual parameters, not a bounding set of parameters. The mechanism will be addressed through Path 5 to account for a probabilistic characterization of the flood hazard and a blend of protection and mitigation strategies. This evaluation includes defining multiple scenarios for the flood mechanism and demonstrating an adequate response strategy for each scenario using a probabilistic characterization of the flood mechanism.

6 OVERALL SITE FLOODING RESPONSE

6.1 DESCRIPTION OF OVERALL SITE FLOODING RESPONSE

Local Intense Precipitation

No actions are taken for the LIP event since DGS relies on permanent passive flooding protection features (site topography and the elevation of key SSCs) and existing doors that limit the in-leakage during the LIP event. There are no active flooding protection features or required site response. The following key SSCs are located in the area receiving LIP ingress, torus basement, and are potentially impacted by the LIP flood. A bounding evaluation (Reference 16) shows that the maximum LIP caused flood depth will be 9.78 inches.

- Torus level sensors, mounted about 2 feet above the floor.
- FLEX pumps, mounted on 12 inches high base-plates.

River (PMF and Dam Failure) Flood

The river flood event combination includes the PMP, snowmelt, upstream dam failure, and wind-generated wave runup along the Des Plaines and Kankakee Rivers (combining to form the Illinois River at DGS). The river flood strategy is based on rainfall forecast and river level observations and projections. Close coordination with the Dresden Lock Master of the USACE is maintained when river levels are rising. Additionally, the Unit 2/3 Intake Screen and Pump House (ISPH) level will be measured at specified frequencies. The following describes the DGS's river flood strategy in procedure DOA 0010-04 (Reference 23):

1. If rainfall forecast exceeds two (2) inches/hour, or the river level exceeds elevation 507 feet, Attachment A of DOA 0010-04 (Reference 23) provides guidance for river monitoring and rainfall forecasting. Additionally, communications with the Dresden Lock Master will be initiated and maintained to obtain information on the operability status and intentions of downstream Dresden Lock and Dam gates. ISPH water level monitoring will be initiated at specified frequencies.

2. If the ISPH water levels are forecast to exceed 507 feet, then the station manager will be notified to staff the outage control center (OCC). Additionally, the OCC manager will be notified to initiate actions in Attachment K of DOA 0010-04 (Reference 23), Flood Preparatory Actions. Major actions include deployment of barge mounted FLEX Flood Pumps in the Unit 3 Turbine Building trackway and filling all the diesel fuel barrels on the barge. The HL130, B.5.b/Flex Pump, Dam Failure Submersible pumps/power packs, Portable Isolation Condenser Diesel Driven Make-up pump and hoses are relocated to an offsite location above elevation 529 feet so they are available during the period

when flood waters recede to the site grade level. The FLEX Diesel Generator and associated power distribution unit are staged on the Turbine Deck at elevation 561 feet. A boat with necessary supplies and fuel will also be staged near the barge. The site has 5 boats available for use.

3. The OCC will initiate actions to install flood barriers per station procedure MA-DR-MM-6-00101 (Reference 24). The plate type flood barriers are designed to cover all reactor building openings and emergency diesel generator rooms for PMF conditions. Access to the reactor building will be made through an airlock on turbine deck at elevation 561 feet. The airlock is at elevation 570 feet on the reactor side.

4. If the ISPH water level is forecast to exceed elevation 509 feet anytime within the next 72 hours, then both U2 and U3 are shut down per DGP 02-01 (Reference 25). The reactor systems are cooled down as quickly as possible per Tech. Spec 3.4.9 to the lowest temperature possible in the time available before U2 and U3 Service Water Systems are secured at elevation 513 feet.

5. U2 and U3 reactor vessels are filled to aid in cool down if time is available before Service Water Systems are secured at elevation 513 feet.

6. The OCC is notified to coordinate installation of the Isolation Condenser Make-Up Pump Building Flood Barriers or construction of a flood protection berm to protect the building to at least a level elevation of 519.5 feet.

7. If the ISPH level reaches elevation 508 feet, the Duty Station Manager will be notified to staff the OCC and to initiate the Flood Preparatory Actions described above.

8. If the ISPH level reaches elevation 509 feet and is forecast to continue to rise then both units will be scrammed per DGP 02-03 (Reference 26) and the reactor systems will be cooled down as quickly as possible.

9. If the ISPH level reaches elevation 513 feet, U2 and U3 Service Water Systems are secured, and DOA 1000-01 (Reference 27), Residual Heat Removal Alternatives is entered. The reactor level is restored between +55" and +60". The reactor cooling is transferred to the Isolation Condensers (DOP 1300-03, Reference 28), and contingency plans are initiated to address loss of fuel pool cooling (DOA 1900-01, Reference 29).

10. If the ISPH level is forecast to exceed elevation 517 feet, then all above-ground storage tanks level will be raised to ≥ 10 feet and the below-ground water storage tanks will be filled.

11. When the ISPH level reaches elevation 517 feet, then power will be removed from transformers and MCCs on elevation 517 feet.

12. When the ISPH Level reaches elevation 518 feet, the barge mounted FLEX Flood Pump is aligned and started. The pump takes flood water suction from the Test boiler pit and delivers to the fire header at elevation 538 feet. The flood pump provides make-up water to the isolation condensers, spent fuel pools and the reactor vessel until flood waters recede and recovery and cleanup activities start. The barge mounted flood pump will be started at flood level of elevation 518 feet. Note that the Isolation Condenser Make-Up Pump Building is protected to a flood level of at least elevation 519′ 6″ (EC 391096, Reference 30). This provides sufficient time to transition from the Make-Up pumps to the barge mounted FLEX Flood Pumps. One Flood Pump will provide make up for the Isolation Condensers, Spent fuel Pools and Reactor Pressure Vessels for both the units. The second Flood Pump on the barge provides redundancy.

13. When the ISPH level recedes to below elevation 509 feet, the Service Water System is made operational so that it may be used to control reactor temperature.

Procedure DOA 0010-04, Floods (Reference 23) is the primary procedure that is entered under a flood forecast. This procedure invokes other site procedures such as Emergency Operating Procedures and Abnormal Operating Procedures as needed for different mitigation actions.

6.2 SUMMARY OF PLANT MODIFICATIONS AND CHANGES

None.

7 FLOOD IMPACT ASSESSMENT

7.1 LOCAL INTENSE PRECIPITATION – PATH 2

7.1.1 Description of Flood Impact

The maximum LIP water surface elevations throughout the site range from 517.6 to 518.1 feet (per Table 4 in Enclosure 1 of Reference 2 and Table 4.0-2 in Reference 8), which exceeds the door threshold (or finish floor) elevation (517.5 feet) by as much as 0.6 foot. Since no flood protection measures are installed in preparation for the LIP event, flood waters would likely enter through the gaps between the door and the door sill. To assess the potential impact on safety-related equipment, DGS performed an assessment of the potential flood water ingress into the reactor building through the secondary containment interlock door seals (EC 405127, Reference 16).

The allowable leakage area through the interlock seals is 94.57 square inches (EC 398329, Reference 15). The actual leak area is measured by quarterly surveillance and verified that it is less than 94.57 square inches. Therefore, the potential ingress area through the interlock seals should never exceed 94.57 square inches. An ingress analysis was conducted for the LIP flood in EC 405127 (Reference 16). For the ingress analysis, it was conservatively assumed that the 94.57 square-inch area is open for water ingress during the LIP event. EC 405127 (Reference 16) concluded that "no safety related equipment or newly installed FLEX equipment is adversely impacted by the LIP flooding" for bounding case of a 94.57 square-inch leak opening area. The available physical margin to the lowest key SSC (FLEX Pump), without crediting installed sump pumps, is 2.2 inches. (Crediting the installed sump pumps increases the margin to 5.4 inches.). See the "Conclusion/Findings" section of EC 405127 (Reference 16) for the margin values.

Since reactor building doors are credited to provide some flood protection by reducing the ingress of floodwaters, an evaluation of potential hydrostatic loads on the doors was performed. Per Section 1.2.2.1.3 of DGS's USFSAR, all structures are designed to withstand the maximum potential loadings resulting from a wind velocity of 110 mph. This load capacity equates to approximately 35 psf (below) using the Bernoulli equation to convert wind velocity to dynamic pressure. See below for development of the load calculation:

$$v = \frac{110\, miles}{hour} x \frac{5{,}280\, feet}{1\, mile} x \frac{1\, hour}{3600\, seconds} = 161\, fps$$

$$q = \frac{1}{2}\rho\, v^2 = \frac{1}{2}(0.002683)(161^2) = 35\, psf$$

where:

q = dynamic pressure (lbs per square foot, psf) for the design basis wind load
v = wind velocity in feet per second (fps)
ρ = density of air at 0° F (0.002683 slugs/ft^3)

The exterior doors in safety related areas are all metal construction and open outwards and, therefore, the external water force on the door would be distributed on the entire door frame. The design basis wind load applied to the area of a typical personnel door (3 feet x 7 feet) is equal to 735 lb force (35 psf x 3 feet wide x 7 feet high). The design basis wind load applied to the area of a typical roll-up/bay door (15 feet wide x 21 feet high) is equal to 11,025 lb force (35 psf x 15 feet x 21 feet).

From Table 4, Enclosure 1 of the FHRR submittal (Reference 2), the maximum combined impact and static load at a personnel door is 67.4 lb/foot (Door I34 at 2.0 lb/foot of impact load and 65.4 lb/foot of static load) and the maximum combined impact and static load at the roll-up door is 77.8 lb/foot (Bay I29 at 0.3 lb/foot of impact load and 77.5 lb/foot of static load). The corresponding total loads, multiplying the unit loads by the door width, are 202 lb and 1,167 lb for the personnel and roll-up/bay doors, respectfully. The design basis wind loads provide a safety factor of 3.6 (= 735 lb/202 lb) and 9.4 (= 11,025 lb/1,167 lb) at the personnel and roll-up/bay doors, respectively, for the LIP flooding loads.

7.1.2 Adequate APM Justification and Reliability for Flood Protection

The APM discussed in Section 7.1.1 (2.2-inch margin to FLEX Pump and the 3.6 to 9.4 safety factors at the doorways) is deemed adequate with the following justifications:

- The 18-inch HMR-52 1-hour, 1 square-mile LIP value, used as a basis for the LIP analysis and ingress calculation (EC 405127 (Reference 16)), is considered conservative. A site-specific meteorological study for DGS (DRE14-0017, Reference 17) resulted in a 1-hour, 1 square-mile LIP value of 13.9 inches (Table 7.3.5 of DRE14-0017). An updated LIP flooding analysis (Reference 18) showed a 0.2-foot reduction in the maximum LIP flood depth at key door locations (from 0.6 foot to 0.4 foot). See Table 5 of Reference 18.

- Losses due to infiltration and other surface retention were conservatively ignored in the analysis. The entire ground surface was essentially treated as impervious in the model.

- The contributions of conveyance from active and passive drainage systems were conservatively assumed to be non-functional during the LIP flood.

- In Reference 2, Enclosure 1 (LIP Report), a sensitivity analysis was conducted on the accuracy of the topographic data, used to build the LIP model (FLO-2D), to evaluate its effect on the maximum water surface elevation. Changing the resolution of the topographic data resulted in a change to the peak water surface elevations of only ± 0.1 foot.

- In Reference 2, Enclosure 1 (LIP Report), a sensitivity analysis was conducted on the Manning roughness (n) values to evaluate the effect this parameter has on the maximum water surface elevation. The upper and lower ranges of the Manning n-values were analyzed, resulting in a change to the peak water surface elevations of only ± 0.03 foot.
- The assessment of potential ingress conservatively assumed the maximum allowable leakage area at the secondary containment interlock door seals.
- The assessment of potential ingress conservatively assumed that water would accumulate only in one unit's torus basement.
- No credit was given to the two sump pumps (with a capacity of 50 gpm each) located in each reactor basement, which could further reduce the flooding depths. Two additional pumps were later installed to provide redundancy (UFSAR 3.4.1.2.2).

In conclusion, the combined effect of the above factors, sensitivity assessments, and conservatisms in the LIP evaluation provides sufficient justification that the APM for the LIP flood is adequate.

7.1.3 Adequate Overall Site Response for Flood Protection

There are no required human actions for this response to be successful and, therefore, an evaluation of the overall site response is not necessary.

7.2 FAILURE OF DAMS AND ONSITE WATER CONTROL/STORAGE STRUCTURES – PATH 5

7.2.1 Flood-Frequency Development

7.2.1.1 Approach

As discussed in NEI 16-05, Rev 1, FIAP Path 5 permits consideration of likelihood of the flood scenarios when applying standards ("feasible" versus "effective" flood strategy) for assessing flooding impacts, using the 10^{-3} (with margin) to 10^{-4} annual exceedance probability (AEP) range as the "high" and "low" likelihood threshold. Therefore, the approach in developing a probabilistic characterization of the flood hazard is principally concerned with defining a flood-frequencies to an AEP greater than 10^{-4}. Flood scenarios with lesser AEPs are simply designated having a "low likelihood".

The probabilistic (flood-frequency) approach will follow the USGS's draft "Guidelines for Determining Flood Flow Frequency, Bulletin 17C" (Reference 19). Bulletin 17C provides guidance and procedures for generating flood flow-frequency where systematic streamflow gage records are available. The log-Pearson Type III (Pearson Type III distribution with log transformation of the streamflow data or LP-III) is the basic method used for probabilistically characterizing the annual maximum peak streamflow series. The approach includes procedures for estimating regional skewness and provides an option for extending the record with nearby, hydrologically similar, streamflow gage stations. The method of moments, using the "Expected Moments Algorithm" (EMA), is used for parameter estimation and can utilize multiple sets of data (systematic streamflow records and historical, paleo flood, and botanical flood information). A flood-frequency analysis was conducted in Reference 20, which includes a description of:

- Systematic peak annual streamflow and historic flood input;
- Streamflow gage transpositioning to DGS;
- Flow ranges and perception thresholds for historic and estimated flood flows;
- Bulletin 17C analysis and results;
- Stage-discharge-frequency estimation at DGS;
- Aleatory variability and epistemic uncertainty treatment; and
- Results and conclusions.

The following sections summarize the flood-frequency analysis and results.

7.2.1.2 Basis for the Data, Models, and Methods

The Bulletin 17C approach was implemented using the USACE Hydrologic Engineering Center Statistical Software Package (HEC-SSP), Version 2.1 (2016). HEC-SSP, Version 2.1, incorporates enhanced methods and procedures described in Bulletin 17C for flood-frequency analyses using peak annual streamflow, historic, paleo, and botanical flood data. Flood stages have been recorded at several locations along the Illinois River as early as in the 1860s. Additionally, there are high water mark records of floods going back to the flood of 1844, which appears to be the flood of record for nearly all sites on the Illinois River.

The inputs for the HEC-SSP analysis for DGS include systematic peak annual streamflow gage information from the USGS at Marseilles IL (dating back to 1892), peak annual streamflow gage information from the USACE at Dresden Lock and Dam (dating back to 1988), and historical flood information, including high water marks and flow/stage values at Peoria IL, from the flood of 1844. The following summarizes these key locations and associated drainage areas:

Table 2 – Key Locations of Flood Information

Location	Drainage Area (sq. mi.)
USACE Dresden Island Lock and Dam gage	7,278
USGS Marseilles gage (05543500) - historical location	7,483
USGS Marseilles gage (05543500)	8,259
Peoria River Mile 162.3 (at Lower Wagon Bridge)	13,479

The USACE streamflow gage is located at River Mile 271.5 from Grafton, IL and has been recording annual peak flows continuously from 1987. However, the first full water year with annual peak streamflow is year 1988. USGS Gage 5543500 in Marseilles has been recording annual peak flows since 1892; however, there are some missing years at the early stages of the data recording, namely in 1893, 1899, 1901, 1902, and 1903. In addition, prior to October 1939, the gage was located in Morris, IL approximately 16.6 miles upstream from its current location.

Based on the review of historical information, Peoria has the most consistent historical record of gage readings and estimates of flows for major flood events. The gage records, stage-discharge rating curves, and analysis of flow estimates of major floods were provided in two main publications: 1) Report of the Rivers and Lakes Commission on The Illinois River and Its Bottom Lands by John W. Alvord and Charles B. Burdick (1915); and 2) Congressional Report by the Mississippi River Commission and Board of the Corps of Engineers, U.S. Army (1905). Readings at Peoria were taken by the U.S. Engineer Department from January 1, 1867 to December 31, 1868; the Illinois canal commissioners from December 31, 1868 to September 30, 1871; the Peoria Bridge Association from January 13, 1873 to November 30, 1877, and the U.S. Weather Bureau from May 1, 1882 to December 31, 1904. In addition to Peoria historical gage readings, several high-water marks measurements for floods prior to the establishment of the gage are available. At the time of the writing of the 1915 report, the flood of 1844 was considered the greatest flood before the establishment of the gages. Due its magnitude, well authenticated high-water marks distributed throughout the river valley were available for estimation of the flood stage. The Congressional Report provides two additional high-water mark measurements for the floods of 1849 and 1858.

7.2.1.3 Key Assumptions

Below is a list of key assumptions made in the flood-frequency analysis. See Section 4 of the flood-frequency calculation for DGS (Reference 20) for a detailed discussion, including bases, for the assumptions.

1. The skew of the computed curve was calculated from the station data set.

(Regional or weighted skew was not used.)

2. Discharges obtained from the various gages throughout the watershed are based on unregulated flow.

3. Gage transposition was performed using a widely accepted formula based on drainage-area ratio estimates and a 'b' exponent, estimated using a peak streamflow correlation analysis in lieu of the Maintenance of Variance Extension (MOVE) technique presented in Bulletin 17C.

4. For determining the 'b' exponent for transposition of peak flows from Peoria and Marseilles, concurrent flood peaks are those that occurred in the same water year and not necessarily on the same flood event.

5. The contribution of diverted water from Lake Michigan was considered uniform throughout the period of record and relatively insignificant compared to the annual peak flows.

6. The effect of climate change was considered negligible.

7. The effects of land use change were considered negligible.

8. The period of record was extended to 1813 using a perception threshold of 89,000 cfs corresponding to the discharge during the 1844 flood transposed to Dresden Island Lock & Dam.

7.2.1.4 Treatment of Uncertainties

NEI 16-05, Rev 1, Appendix D, states that the "licensee should identify and address important sources of aleatory variability and epistemic uncertainty (e.g., alternate data sources, options for filtering data, or alternate functional forms for probability distributions) for each flood mechanism. The licensee may utilize simplifying and bounding assumptions to address uncertainty, but should also clarify how they affect key insights and conclusions. Sensitivity studies examining the effect of key components and assumptions on flood hazard estimates may be used to address epistemic uncertainty". Uncertainties is addressed in Section 8 of the flood-frequency calculation (Reference 20), and summarized below:

- **Aleatory Variability** – Refers to the natural and sampling variability in the hydrologic and/or hydraulic processes and includes the following considerations:
    - Sample moment variability;
    - Regional skewness;
    - Natural variation in the river system;
    - Urbanization; and

  - Climate change.

- **Epistemic Uncertainty** – Refers to the uncertainty in the knowledge or modeling of the hydrologic and/or hydraulic processes and includes the following considerations:
  - LP-III probability distribution function, goodness-of-fit and assessment of alternatives;
  - Potential error in stage-discharge relationship; and
  - Event combinations (specifically upstream dam failure).

The uncertainty analysis resulted in confirming the LP-III representation of the streamflow-frequency relationship and adjusting the stage-discharge curve (increased by 2 feet) to account for potential error in the stage-discharge relationship and upstream dam failure.

It should be noted that EPRI completed a "proof-of-concept" probabilistic flood hazard pilot study that, although not mentioned by name in the body of the report, was based on DGS's river flooding (Reference 22). EPRI's "proof-of-concept" used stochastic approaches in developing flood-frequency relationships. Per the EPRI report, stochastic flood modeling is applied by treating various flood-producing inputs as random variables (following a specified probability distribution function) instead of fixed values. The random variables are input into a deterministic rainfall-runoff-hydrodynamic model, following Monte Carlo sampling procedures, to simulate the watershed's response to the inputs and generate the flood-frequency relationship. Two stochastic models were applied: the Stochastic Event Flood Model (SEFM) and the Stochastic Runoff Routing Monte Carlo (RORB_MC) model. Table 8-1 of the EPRI report (Reference 22) indicates that a flood at site grade (elevation 517 feet) corresponds to a median AEP of 1/57,000-year (1.8×10^{-5}) using the SEFM model. Table 8-2 of the EPRI report (Reference 22) indicates that a flood at site grade corresponds to a median AEP of 1/17,000-year (5.9×10^{-5}) using the RORB_MC model. Both models show an AEP less than 1/10,000 (10^{-4}) at site grade, consistent with the HEC-SSP/17C results in Section 7.2.1.5.

7.2.1.5 Results

The final flood-stage-frequency results are provided in Sections 7.5 and 7.7 of the flood-frequency calculation (Reference 20). The following table summarizes the results at select points along the frequency curve.

Table 3 – Flood-Frequency Results Summary

AEP (%)	Recurrence Interval	Peak Discharge (cfs)		Peak Flood Stage (feet MSL/NGVD29)[1]	
		Median	95% Confidence Limit	Median	95% Confidence Limit
0.01	10,000	114,000	156,000	512.6	516.3
0.1	1,000	97,200	120,000	510.8	513.2
1	100	78,700	89,000	508.3	509.7

[1] Includes a 2-foot increase above the computed value to account for uncertainties as discussed in the previous section.

As indicated in Table 3, the threshold that differentiates "high" and "low" AEP (or likelihood) can be conservatively set to a water surface elevation (stage) of 516.3 feet at DGS, 0.7 foot below site grade (517.0 feet) and 1.2 feet below the plant's finish floor elevation (517.5 feet). The basis for setting the threshold at elevation 516.3 feet and characterizing this elevation as conservative is as follows:

- Corresponds to a flood with an AEP of 10^{-4} (1 in 10,000 years) at a 95% confidence limit
- Includes an additional 2 feet to the stage for uncertainties (including the assumption that upstream dams fail)
- Significant margin above a flood with an AEP of 10^{-3} (1 in 1,000 years), at both the median value and 95% confidence limit
- The HEC-SSP/17C analysis shows low variability. For example, the table at the top of page 9 of the HEC-SSP output (Attachment A of Reference 20) shows a variance (log units squared), at 10^{-4} AEP, of 0.00396; equating to a Standard Error (SE) of -13% to +16% or an average of ±14.5%. Applying ±14.5% to the median HEC-SSP value of 114,000 cfs (from Table 13 of Reference 20) yields a range of 97,500 to 130,500 cfs for ±1 SE (68% confidence interval). As indicated in Table 14 of Reference 20, this bounds the peak flow values for four distributions based on L-moments.

7.2.2 Description of Flood Scenarios

7.2.2.1 Define flood scenarios

The site grade of 517.0 feet was chosen as a convenient dividing point between consequential and non-consequential floods.

Table 4 – Flood Scenario Definitions

Flood Scenario	Critical Water Surface Elevation (feet MSL/NGVD29)	Description
1	≤ 517.0	Site grade
2	> 517.0 to 529.0	Peak flood elevation

7.2.2.2 Characterization of flood parameters for each scenario

Table 5 – Flood Parameters for each Scenario

Flood Mechanism Parameters			Scenario 1	Scenario 2
Flood Level and Associated Effects	1	Max Stillwater Elevation (feet MSL)	517.0	524.8
	2	Max Wave Run-up Elevation (feet MSL)	517.0[1]	529.0
	3	Max Hydrodynamic (psf)/Debris (lb) Loading	N/A[1]	117.2 / 3,387
	4	Effects of Sediment Deposition/Erosion	N/A[1]	No impact (see Reference 3)
	5	Other Associated Effects	N/A[1]	None
	6	Concurrent Site Conditions	N/A[1]	Hail, strong winds
	7	Effects on Ground Water	No impact (see Reference 3)	No impact (see Reference 3)
Flood Event Duration	8	Warning Time (hours)	N/A[1]	23 hrs 25 min
	9	Period of Site Preparation (hours)	N/A[1]	20 hrs 40 min
	10	Period of Inundation (hours)	N/A[1]	159
	11	Period of Recession (hours)	N/A[1]	165
Other	12	Plant Mode of Operation	All	All
	13	Other Factors	None	None

[1] Associated effects and flood event duration parameters not applicable to flood scenarios below site grade.

7.2.2.3 Description of flood strategy and high/low exceedance probability estimate, with justification

Table 6 – Description of Likelihood and Flood Strategy

Flood Scenario	Critical Water Surface Elevation (feet MSL)	Likelihood	Description of Flood Strategy
1	≤ 517.0	High	Site Grade – Effective Protection
2	> 517.0 to 529.0	Low	Feasible Response/Mitigation

7.2.3 Flood Scenario 1 – Below Grade (with No Impact to Key SSCs)

7.2.3.1 Calculate APM to the site grade based on level

Table 7 – Available Physical Margin

Annual Exceedance Probability	Water Surface Elevation[1] (feet MSL/NGVD29)	Available Physical Margin to Site Grade El 517.0 feet MSL/NGVD29
10^{-4} @ 95% Confidence Limit	516.3	0.7 feet
10^{-4} Median	512.6	4.4 feet
10^{-3} @ 95% Confidence Limit	513.2	3.8 feet
10^{-3} Median	510.8	6.2 feet

[1] APM calculated using a stillwater value for the "modified" stage (including 2 feet added for uncertainty) from Section 7.2.1.5. See below for discussion regarding wind-wave runup.

7.2.3.2 Determine APM for any other relevant associated effects such as erosion and ground water ingress

APM for flooding associated effects (listed in Table 5) in Scenario 1 are not applicable for the following reasons:

- Wind-Wave Runup – For Flood Scenario 1, wind-wave runup was considered negligible since this flood scenario is below grade and would have limited fetch in the critical direction.

- Hydrodynamic/debris loads – This flood effect is not relevant since site grade and natural topography is the protection feature and would not be impacted.
- Erosion – The river adjacent to the site is considered stable and not showing signs of erosion or migratory trends. See Reference 3.
- Sediment Deposition – The river channel geometry is relatively stable and not subject to abrupt changes in flow direction, depth, or velocity. Therefore, sediment is not expected to deposit in the channel or at the site in a manner that would adversely affect flood depths. See Reference 3.
- Concurrent Site Conditions – The site topography protection feature would not be affected by concurrent site conditions, such as high winds, since no manual actions or flood protection features are used to provide protection.
- Groundwater Ingress – The plant was designed assuming below-grade structures would be subject to saturated hydrostatic conditions to the ground surface. Flood Scenario 1, being at or below site grade, is bounded by the design basis.

7.2.3.3 Adequate APM Justification

Under Flood Scenario 1 (below site grade), the APM to site grade at the flood threshold between "high" and "low" likelihood, as defined in Section 7.2.1.5, was determined to be adequate because:

- A 10^{-4} AEP at a 95% confidence limit was used to set the threshold, with significant margin to the median 10^{-4} and 10^{-3} values; and
- The conservatisms built into the flood stage-frequency curve to address uncertainty.

7.2.4 Flood Scenario 2 – Feasible Response/Mitigation Approach

7.2.4.1 Summarize Mitigating Strategy Assessment

The MSA for DGS was submitted with Reference 13. The mitigating (FLEX) strategy was designed using input parameters from the reevaluated non-bounding "Failure of Dams and Onsite Water Control/Storage Structures" flood-causing mechanism, including aspects related to the storage and deployment of FLEX equipment, validation of FLEX actions, and viability of FLEX connection points. Therefore, the MSA concluded that the FLEX strategy can be successfully implemented as designed, without modification, and further assessment of the strategy was not required. The MSA for DGS was approved by the NRC in Reference 21.

7.2.4.2 Discuss any changes to flood parameters compared to parameters used in the MSA

The parameters listed in Table 5 for Scenario 2 in this impact assessment for the reevaluated "Failure of Dams and Onsite Water Control/Storage Structures" flood-causing mechanism are the same as the parameters listed in Table 1 (Section G.3) of the MSA (Reference 13). Therefore, there are no changes to the flood parameters used in the MSA and the feasible response demonstrated in the MSA remains valid for Flood Scenario 2.

8 CONCLUSION

DGS has appropriately addressed plant vulnerabilities to external flooding and will not require additional safety enhancements since mitigating strategies (FLEX) remain feasible for the reevaluated flood hazard and effective protection from natural topography (to site grade) of key safety functions has been demonstrated for higher likelihood flooding scenarios. The flood-stage-frequency analysis shows that flood scenarios above site grade, when mitigating strategies are implemented, have a "low likelihood" of occurrence (based on criteria defined in NEI 16-05). Therefore, this submittal completes the actions related to External Flooding required by the March 12, 2012 10 CFR 50.54(f) letter for DGS.