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

August 5, 2016

Mr. Bryan C. Hanson
President and Chief
Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF EXELON GENERATING COMPANY, LLC'S FLOOD HAZARD REEVALUATION REPORT SUBMITTALS RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR LIMERICK GENERATING STATION, UNITS 1 AND 2 (CAC NOS. MF6107 AND MF6108)

Dear Mr. Hanson:

By letter dated July 21, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15148A286), the U.S. Nuclear Regulatory Commission (NRC) informed you of the staff's plan to conduct a regulatory audit of Exelon Generation Company, LLC's (Exelon, the licensee) Flood Hazard Reevaluation Report (FHRR) submittal related to the Near-Term Task Force Recommendation 2.1-Flooding for Limerick Generating Station, Units 1 and 2. The audit was intended to support the NRC staff review of the licensee's FHRR and the subsequent issuance of a staff assessment.

The audits were conducted on September 24, 2015, and December 9, 2015, and were performed consistent with NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (ADAMS Accession No. ML082900195). The purpose of this letter is to provide you with the final audit report which summarizes and documents the NRC's regulatory audit of the licensee's FHRR submittal.

If you have any questions, please contact me at (301) 415-6197 or by e-mail at Tekia.Govan@nrc.gov.

Sincerely,

Tekia V. Govan, Project Manager
Office of Nuclear Reactor Regulation
Japan Lessons-Learned Division
Hazards Management Branch

Docket Nos. 50-352 and 50-353

Enclosure:
Audit Report

cc w/encl: Distribution via Listserv

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NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF EXELON GENERATION COMPANY LLC'S FLOOD HAZARD REEVALUATION REPORT SUBMITTALS RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR LIMERICK GENERATING STATION, UNITS 1 AND 2

BACKGROUND AND AUDIT BASIS+

By letter dated March 12, 2012, 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 license" (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 Review of Insights from the Fukushima Dai-ichi Accident. Recommendation 2.1 in that document recommended that the NRC staff issue orders to all licensees to reevaluate seismic and flooding hazard for their sites against current NRC requirements and guidance. Subsequent staff requirements memoranda associated with SECY-11-0124 and SECY-11-0137, instructed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f).

By letter dated March 12, 2015, Exelon Generation Company, LLC (Exelon, the licensee) submitted its Flood Hazard Reevaluation Report (FHRR) for Limerick Generating Station, Units 1 and 2 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15084A586). The NRC is reviewing the aforementioned submittal and has completed a regulatory audit of the licensee to better understand the development of the submittal, identify any similarities/differences with past work completed, and ultimately aid in its review of the licensee's FHRR. This audit summary was completed in accordance with the guidance set forth in NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (ADAMS Accession No. ML082900195).

AUDIT LOCATION AND DATES

The audit was completed by document review via a webinar session in conjunction with the use of the licensee's established electronic reading room (ERR) and teleconferences on September 24, 2015, from 1:00 pm to 4:00 pm and December 9, 2015, from 1:00 pm to 2:00 pm.

AUDIT TEAM

Title	Team Member	Organization
Team Leader, NRR/JLD	Tekia Govan	NRC
Technical Monitor	Richie Rivera-Lugo	NRC
Technical Monitor	Laura Quinn-Willingham	NRC
Technical Staff	Warren Sharp	NRC
Technical Deputy Division Director	Andy Campbell	NRC
Technical Branch Chief	Aida Rivera-Varona	NRC
Technical Branch Chief	Christopher Cook	NRC
NRC Contractor	Rajiv Prasad	Pacific Northwest National Lab
NRC Contractor	Yong Yuan	Pacific Northwest National Lab

A list of the licensee's participants can be found in Attachment 2.

DOCUMENTS AUDITED

Attachment 1 of this report contains a list which details the documents that were reviewed by the NRC staff, in part or in whole, as part of this audit. The documents were located in an ERR during the NRC staff's review. The documents, or portions thereof, that were used by the staff as part of the technical analysis and/or as reference in the completion of the staff assessment were submitted by the licensee and docketed, as necessary, to complete the development of the staff assessment. These documents are identified in Table 1.

AUDIT ACTIVITIES

In general, the audit activities consisted mainly of the following actions:

- Understand the selection of important assumptions and parameters that would be the basis for evaluating the individual flood causing mechanisms described in the 50.54(f) letter.

- Review model input/output files to computer analyses such as FLO-2D to have an understanding of how modeling assumptions were programmed and executed.

Table 1 summarizes specific technical topics (and resolution) of important items that were discussed and clarified during the audit. The items discussed in Table 1 may be referenced/mentioned in the staff assessment in more detail.

EXIT MEETING/BRIEFING

On December 21, 2015, the NRC staff closed out the discussion of the technical topics described above. However, to support the development of the Limerick staff assessment, the NRC staff have requested the below information be placed on the Limerick docket. This information will be referenced in the Limerick staff assessment.

- Exelon responses to information need # 2- 5, and 7 - 15
- Input/output files as described below.

Model	Case Folder or File
HEC-HMS	PMF_All_Season_Alternative_1 PMF_Alternative2 PMF_Alternative3 SanatogaCreek PossumHollow Limerick_Aug2004_Verification Limerick_Jun1972_asCalib Limerick_Jun2006_Verification Limerick_June2003_Verification Limerick_Oct1996_Calibration Limerick_Sep1999_Calibration Limerick_Sep2004_Verification Limerick_Sep2011_Calibration Limerick_Aug2011_Verification
HEC-RAS	Sanatoga SchuylkillRiver FINAL-171155.50-HEC-RAS [Hydrologic Engineering Center - River Analysis System] Run Index-13may14.xlsx
HEC-RAS	FINAL-171155.50-Dam Breach Flow_5-19-14.xlsx
FLO-2D	Attachment 7A- Controlling Run Attachment 7B- VBS Sensitivity Attachment 7C- Possum Hollow Sensitivity > Inputs
FLO-2D	FLO-2D Files
FLO-2D	Attachment 7C- Possum Hollow Sensitivity

Table 1: Limerick Information Needs – Audit/Post-Audit Summary

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
1	**LIP Flood – FLO-2D Model Setup** Background: The staff's review of the FLO-2D model files revealed that a "reservoir water elevation" along the east boundary of the model may not have been applied in the FLO-2D run. The information may not exist because it is possibly an omission caused by a potential misconfiguration of the FLO-2D input file. The issue has the potential to raise water-surface elevations significantly, particularly near and upstream of the boundary cells. Request: In the Possum Hollow Run sensitivity case, the licensee described setting a "reservoir water elevation" to grid #62036 to simulate the PMF backwater conditions. The staff's review of the FLO-2D model files revealed that this condition was not applied in the sensitivity run. The staff request a discussion and clarification of this issue.	In response to this information need the licensee stated that Attachment 13 of local intense precipitation (LIP) Calculation LM-0699 shows the effects of the "reservoir water elevation" set to 193.7 ft National Geodetic Vertical Datum of 1929 (NGVD29) for grid #62036. However, through the course of the audit the licensee determined that an incorrect FLO-2D model output file was included in the set of model files provided to the NRC staff for review. The licensee provided the correct model I/O files, on the docket (ADAMS Accession No. ML16020A497), for the NRC staff to conduct a sensitivity run. The NRC staff was able to reproduce the licensee's results. The staff reviewed the licensee's model configuration and parameter selections and determined they were reasonable. The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.
2	**Streams and Rivers – Watershed Delineation** Background: Figure is needed for inclusion in staff's assessment. This information is in Figure 4 of Calculation FINAL_LM-0700_Limerick_PMF-Hydrology. The issue does not directly affect estimated water-surface elevations but is needed for staff to clearly describe the Schuylkill River watershed in the staff assessment. Request: The FHRR does not include a figure of the Schuylkill River drainage showing subwatersheds and alternative	In response to this information need the licensee provided Figure 4 from Calculation LM-0700 on the docket (ADAMS Accession No. ML15301A705). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
	centroids. The staff request Figure 4 from Calculation FINAL_LM-0700_Limerick_PMF-Hydrology.	
3	**Streams and Rivers – PMP Temporal Distribution** Background: It is not clear that the temporal distributions used by the licensee are typically used front, center, and end-loaded configurations. There are no plots included in the FHRR or the calculations. This information exists in Section 6.2 of Calculation FINAL-Limerick_PMP-LM-0698 and Section 6.9 of Calculation FINAL_LM-0700_Limerick_PMF-Hydrology. The temporal pattern of probable maximum precipitation (PMP) can significantly affect the water-surface elevation near the Limerick Generating Station (LGS) site. Request: The FHRR states that four temporal distributions were used for the all-season PMP. However, no justification is provided for their derivation. The staff requests a detailed description of the four temporal distributions considered by the licensee including example hyetograph plots.	In response to this information need the licensee provided a description and associated plots of the temporal distributions used for the 72-hour PMP storm on the docket (ADAMS Accession No. ML15301A705). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.
4	**Streams and Rivers – PMP Spatial Distribution for the Schuylkill River Drainage** Background: The staff was unable to find isohyets for the Schuylkill River drainage. The isohyetal pattern and its orientation can significantly affect the water-surface elevation near the LGS site. Request: The FHRR does not include a figure showing the isohyetal pattern of the PMP over the Schuylkill River drainage.	In response to this information need the licensee provided the orientation and isohyetal map of the BOSS HMR52-optimized PMP storm over the Schuylkill River drainage on the docket (ADAMS Accession No. ML15301A705). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
	The staff requests an isohyetal map and orientation for the storm estimated by BOSS HMR52.	
5	**Streams and Rivers – PMP Spatial Distribution for Possum Hollow Run and Sanatoga Creek Drainages** Background: It is not clear if the point PMP is used for the Possum Hollow Run and Sanatoga Creek drainages. The staff was unable to find isohyets for these drainages. Using an isohyetal pattern over the two drainages can significantly affect the water-surface elevation near the LGS site. Request: The FHRR states that all-season PMP estimates for the Possum Hollow Run and Sanatoga Creek drainages were developed using BOSS HMR52 software. From the FHRR and the calculations, it is not clear which spatial distributions for the PMP are used for these two drainages. Because the drainage areas for these two drainages are less than 10mi^2, typically the point PMP is used. The staff requests details of the spatial distribution, including isohyetal plots, of the PMP over Possum Hollow Run and Sanatoga Creek drainages.	In response to this information need the licensee provided a description of how the PMP for the Possum Hollow Run and Sanatoga Creek drainages were estimated. The licensee stated that the 10-mi^2 isohyet value "is taken to be the same as point rainfall," per HMR-52 reference manual. Possum Hollow Run: Figure 5.2 shows the watershed completely contained within Isohyet A. The point PMP (1-mi^2 PMP) near the LGS site for 1 and 6-hour durations are 17.9 and 26.9 in. While the cumulative PMP depth shown in Table 5.1 matches for the 6-hour, 1-mi^2 PMP, the cumulative PMP depth for 1-hour duration (14.96 in) over the drainage is smaller than the 1-mi^2, 1-hour PMP (17.9 in) (16% reduction). Sanatoga Creek: As shown in Table 5.2, the cumulative PMP depth for all durations up to 72-hours is less than the corresponding 1-mi^2, 1-hour PMP (20% reduction for 1-hour duration, 2% reduction for 6-hour duration). The licensee provided details of the PMP estimation for Possum Hollow Run and Sanatoga Creek drainages including isohyetal plots docket (ADAMS Accession No. ML16020A497). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
6	**Streams and Rivers – 100-year Rainfall and Spatial Distribution over the Schuylkill River Drainage** Background: It is not clear if the 100-year rainfall is estimated at the LGS site and used as a uniform value over the whole drainage. The staff was unable to find an isohyetal map. The isohyetal pattern and its orientation can significantly affect the water-surface elevation near the LGS site. Request: The FHRR states that the 100-year rainfall depths for the Schuylkill River drainage were estimated from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Frequency Data Server for the LGS location as the all-season mean value. The FHRR and the calculations do not define the all-season mean value. It is also not clear if the 100-year rainfall was spatially uniform over the Schuylkill River drainage. The staff request a detailed description of how the 100-year rainfall over the Schuylkill River drainage was estimated including an isohyetal map to show the spatial distribution of the 100-year rainfall over the drainage.	In response to this information need the licensee stated that the 100-year, all-season rainfall for the site was estimated using the NOAA Atlas 14 Precipitation Frequency Data Server. This rainfall was assumed to be the 100-year, snow season rainfall, distributed uniformly over the Schuylkill River watershed. The Licensee clarified that the 100-year all-season point precipitation value (not area average value) was estimated at the Schuylkill River Basin centroid using the NOAA Atlas 14 Precipitation Frequency Data Server. Using the all-season precipitation for the cool season in the Schuylkill River Basin is conservative. Therefore, the NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.
7	**Streams and Rivers – Snow Water Equivalents for the 100-year Snowpack Depths** Background: The FHRR states that snowmelt for Alternative 3 is limited by the 100-year snowpack. This information is in Sections 6.2 and 7.2 of Calculation FINAL-Limerick_PMP-LM-0698. Initial snow water equivalent and snowmelt rates can significantly affect estimated water-surface elevations near the LGS site.	In response to this information need the licensee provided a detailed description of the process used to estimate snow water equivalents for the Schuylkill River drainage. The licensee stated that each subwatershed of the Schuylkill River drainage and the local drainages for Possum Hollow Run and Sanatoga Creek had their own unique 100-year snow water equivalents that was assumed spatially uniform over each subwatershed's own drainage area. The licensee also provided detailed information about the snowmelt depths for each subwatershed on the docket (ADAMS Accession No. ML15301A705).

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
	Request: The FHRR states that Alternative 3 precipitation scenario consists of a 72-hour cool-season PMP coincident with snowmelt from a 100-year snowpack. The calculation package describes the estimation of 100-year snowpack depth. A brief but clear description of how the snow water equivalents for the 100-year snowpack depths were estimated is needed for the staff's assessment. The staff request a brief description of how snow water equivalents were determined for the 100-year snowpack depths. The staff also request clarification if the 100-year snowpack was spatially uniform over the Schuylkill River watershed and if it completely melted during the 72-hour cool-season PMP event.	The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.
8	**Streams and Rivers – HEC-HMS Model Calibration** Background: The description of dams and how they affect the calibration and validation of HEC-HMS [Hydrologic Modeling System] model parameters is not clear in the FHRR. Some of this information exists in Section 6.7 of Calculation FINAL_LM-0700_Limerick_PMF-Hydrology. Parameter values used in the estimate of PMF can significantly affect the water-surface elevation near the LGS site. Request: The FHRR states that dams were not incorporated into the HEC-HMS model used to estimate the PMF. The calculation package (LM-0700) states that the Blue Marsh dam was not modeled in HEC-HMS but the discharges measured at the United States Geological Survey gauge downstream of the dam were used for calibration of downstream basins with the exception of the 1972 flood. The staff request a list of	In response to this information need the licensee provided lists of storms used for calibration and validation of the hydrologic model, on the docket (ADAMS Accession No. ML15301A705). The licensee changed the term "verification" to "validation" in the docketed response and also clarified that because of lack of data, the Blue Marsh dam subwatershed was conservatively calibrated such that modeled peak discharge for the 1972 flood exceeded the observed value. The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
	storms/floods for each calibrated subbasin indicating whether those storms/floods were used in calibration or validation.	
9	**Streams and Rivers – HEC-RAS Model Setup** Background: The FHRR does not state why the channel cross-sections estimated for Schuylkill River, Possum Hollow Run, and Sanatoga Creek are conservative. The staff did not find this information in the calculations included in the ERR. The shape of channel cross-section can significantly influence the water-surface elevation for a given discharge. Request: The FHRR states that the licensee assumed the Schuylkill River cross-sections to be triangular in shape. The FHRR also states that the bathymetry information on the Possum Hollow Run and Sanatoga Creek were conservatively ignored. The staff request detailed description of how channel bathymetry for Schuylkill River, Possum Hollow Run, and Sanatoga Creek were determined and why the assumptions stated in the FHRR are conservative.	In response to this information need the licensee stated that river width at each cross section was developed from digital elevation model of Pennsylvania. The channel invert elevations were based on Federal Emergency Management Agency (FEMA) Flood Insurance Study for Berks, Montgomery, and Philadelphia counties. The channel invert elevations were applied to the cross sections as a single point, midway between the stream bank stations, creating the triangular shape. The licensee stated that all modeled peak water-surface elevations for calibration events were greater than the corresponding observed values, by up to 2.7 ft. The licensee also stated that the bathymetry for Possum Hollow Run and Sanatoga Creek were completely ignored and additional cross-sectional areas below normal stream level that would be available for flood conveyance are conservatively ignored. The licensee stated that for Possum Hollow Run and Sanatoga Creek, Manning's roughness coefficient values for channel and overbank areas were selected as 0.06 and 0.12, respectively. Additionally, the roadway crossing Possum Hollow Run is conservatively modeled with the culvert completely blocked. The site grade is at least 49.2 ft and 63.3 ft above the estimated PMF levels for the Possum Hollow Run and Sanatoga Creek drainages, respectively. As a result of the audit, the licensee committed to provide a written description of the top two points of the triangular estimate of cross-section at channel. The bottom point of the triangular estimate was described in their original response. The licensee clarified that the

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		channel-edge-point elevations were taken from the edge of Light Detection and Ranging (LIDAR) data at either side of the stream. Text referring to "normal water level" will be changed to reflect that channel estimate data reflect the level of water at the time the LIDAR data were collected. The licensee provided details of its estimation of channel bathymetry for Schuylkill River, Possum Hollow Run, and Sanatoga Creek using LiDAR data (for width of channel at the time) and FEMA stream bed profiles (for channel invert elevations) on the docket (ADAMS Accession No. ML16020A497). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.
10	**Streams and Rivers – HEC-RAS Model Setup** Background: The FHRR does not present figures that show the extents and details of the HEC-RAS modeled reaches for the Schuylkill River, Possum Hollow Run, and Sanatoga Creek. The staff were unable to find this information in the ERR. The issue does not directly affect estimated water-surface elevations but is needed for staff to clearly describe the HEC-RAS model setup for the Schuylkill River, Possum Hollow Run, and Sanatoga Creek in the staff assessment. Request: The FHRR does not present figures that show the extents of the HEC-RAS modeled reaches for the Schuylkill River, Possum Hollow Run, and Sanatoga Creek. The staff request clear, good quality, appropriately labeled figures that show the extent of the HEC-RAS modeled reaches for the Schuylkill River, Possum Hollow Run, and Sanatoga Creek. These figures should clearly show where boundary conditions	In response to this information need the licensee provided Figures 10.22, 10.23, and 10.24 that show the extent and connectivity details of the HEC-RAS model for the Schuylkill River, Possum Hollow Run, and Sanatoga Creek. The licensee also described where boundary conditions were applied and where structures and ineffective areas are located. Both the figures and description were submitted on the docket (ADAMS Accession No. ML15301A705). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.

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	(upstream, downstream, and lateral) are applied, where modeled structures within the reaches are located (dams, bridges), and where ineffective areas are located.	
11	**Streams and Rivers – HEC-RAS Model Calibration** Background: The FHRR does not present values of Manning's roughness coefficients for any of the modeled HEC-RAS reaches. This information is in Sections 7.3 and 7.4 of Calculation FINAL_LM-701_Limerick_PMF-Hydraulics. Manning's roughness values can significantly affect estimated water-surface elevations near the LGS site. Request: The FHRR does not present values of Manning's roughness coefficients for any of the modeled HEC-RAS reaches. The staff request the following for the Schuylkill River reach: (1) initial Manning's roughness coefficients, (2) a brief description of how Manning's roughness coefficients were calibrated, (3) final calibrated values of the Manning's roughness coefficients. The staff also request Manning's roughness coefficients used for the Possum Hollow Run and Sanatoga Creek reaches.	In response to this information need the licensee provided initial values of Manning's roughness coefficients, a description of its process for calibrating them, and the final calibrated values on the docket (ADAMS Accession No. ML15301A705). The licensee also stated that because of lack of data, Manning's roughness coefficients for Possum Hollow Run and Sanatoga Creek reaches were not calibrated but set to conservatively high values (0.06 for main channel and 0.12 for overbank areas). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.
12	**Dam Failures – Locations of Dams Upstream of the LGS Site** Background: The FHRR does not include a figure showing the locations of NID dams upstream of the LGS site. The locations of NID dams are shown in Figure 2 of Calculation FINAL_LM-702_Limerick_DamFailure. The locations of NID dams do not directly affect estimated water-surface elevations but are needed for staff to clearly describe the dam breach analysis for	In response to this information need the licensee provided on the docket a figure showing the locations of the NID dams in the Schuylkill River Basin upstream of the LGS site and the location of the hypothetical dam (ADAMS Accession No. ML15301A705). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.

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	the Schuylkill River watershed in the staff assessment. The selected location of the hypothetical dam directly affects the estimated water-surface elevation near the LGS site. Request: The FHRR states that the locations of all dams upstream of the LGS site were obtained from the National Inventory of Dams (NID). The FHRR does not include a figure showing the locations of these dams. The staff request the licensee to provide a clear, good quality figure showing: (1) the locations of NID dams in relation to the LGS site and (2) the location of the hypothetical dam.	
13	**Combined Events – Wind-wave Calculations** Background: The FHRR does not provide a figure illustrating wave runup transects. The two wave runup transects are shown in Figure 3 of Calculation LM-0707 LGS Combined Events Analysis. Request: The FHRR states that two wave runup transects were used in wind-wave effects calculations. The FHRR does not provide a figure illustrating these transects. The staff request a clear, appropriately labeled, good quality figure showing the two transects.	Based on discussions during the audit, the NRC staff concluded that a figure showing the wave runup transects is not necessary for the Staff Assessment. The NRC staff determined, reviewing the licensee's calculation, that the wind-wave calculations are appropriate.
14	**Combined Events – Wind-wave Calculations** Background: The FHRR does not provide a justification for using a wind speed slower than that suggested in ANSI/ANS-2.8-1992, Figure 1 for the LGS site. Wind speeds can affect the wave setup and runup and therefore, the combined effects water-surface elevation at the LGS site.	In response to this information need the licensee stated that the 2-year wind speeds were estimated using site-specific data and that this approach is consistent with the recommendation in American National Standards Institute/ American Nuclear Society (ANSI/ANS)-2.8-1992, Section 9.1.4. The staff determined, reviewing the licensee's calculation, that the wind-wave calculations are appropriate. The documentation to support the

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	Request: The FHRR and the combined events calculation report that the 2-year return period, 2-minute wind speed is estimated to be 39.7 mi/h. Figure 1 of ANSI/ANS-2.8-1992 shows that annual extreme-mile, 30-ft above ground, 2-year mean recurrence interval wind speed to be slightly less than 50 mi/h. The staff request a justification for using the slower wind speed for wind-wave estimates.	response to this information need was provided on the docket (ADAMS Accession No. ML16020A497). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.
15	**All Flood Causing Mechanisms – Comparison of Reevaluated Flood Hazard with Current Design Basis** Background: Recommendation 2.1 of the 50.54(f) letter provides instructions for the FHRR. Under Section 1, Hazard Reevaluation Report, Items c and d, licensees are requested to perform: a. Comparison of current and reevaluated flood causing mechanisms at the site. Provide an assessment of the current design basis flood elevation to the reevaluated flood elevation for each flood causing mechanism. Include how the findings from Enclosure 4 of this letter (i.e., Recommendation 2.3 flooding walkdowns) support this determination. If the current design-basis (CDB) flood bounds the reevaluated hazard for all flood-causing mechanisms, include how this finding was determined. b. Interim evaluation and actions taken or planned to address any higher flooding hazards relative to the design-basis, prior to completion of the integrated assessment described below, if necessary.	In response to this information need the licensee provided on the docket an explanation that the CLB and CDB can be considered to have the same meaning for LGS (ADAMS Accession No. ML15301A705). The NRC staff concluded that the information provided by the licensee was sufficient to address the information need request.

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	The Limerick FHRR provides a comparison of the reevaluated flood hazards with the current licensing basis (CLB) instead of comparing with the CDB for each flood hazard mechanism. In the FHRR, Section 3.0 and Table 4.0.1 summarize this comparison. Request: Clarify and where necessary correct the comparison of the reevaluated flood hazard to the CDB for each flood hazard mechanism throughout the report.	
16	**FHRR Clarification** In section 3.2.4 of the FHRR, the licensee states: "The Sanatoga Creek CLB maximum PMF water surface elevation at LGS is not identified in the Updated Final Safety Analysis Report. The reevaluated maximum water surface elevation due to the Sanatoga Creek PMF at LGS is equal to 153.7 feet NGVD29. The reevaluated maximum water surface elevation is 20.3 feet below the Schuylkill River CLB maximum water surface elevation." The licensee does not state any justification for this scenario not triggering an integrated assessment or focus evaluation other than a reference to it in Section 4.0 Flood Parameters and Comparison that states: "For LGS, the following flood-causing mechanisms are either determined to be implausible or completely bounded by other mechanisms or the current design basis: 1. Surge, Seiche, and Tsunami; 2. Ice Induced Flooding; and	There is no CDB for Sanatoga Creek. The licensee stated that it is appropriate to also compare the Sanatoga Creek PMF elevation to the Schuylkill River CDB because Sanatoga Creek flows into the Schuylkill River immediately upstream the site. The licensee found that the reevaluated PMF elevations for both Sanatoga Creek and the Schuylkill River were bounded by the Schuylkill River CDB. The licensee further noted that the Schuylkill River CDB is at least 10 ft below the LGS site grade. The NRC staff determined that, because of the close proximity of the site, the Schuylkill River, and Sanatoga Creek, the licensee response is satisfactory and resolves this information need.

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
	3. Channel Migration or Diversion 4. Combinations in Section H.1 of NUREG/CR-7046 (Floods Caused by Precipitation Events) for the Schuylkill River (including hydrologic dam failure) 5. Combinations in Section H.1 of NUREG/CR-7046 (Floods Caused by Precipitation Events) for Sanatoga Creek 6. Seismically-Induced Dam Failure (Combination H.2) The NRC staff request the licensee to provide justification for the above scenario not triggering and integrated assessment or focused evaluation.	
17	**<u>FHRR Clarification</u>** In Section 3.1.4 the licensee states: "The maximum reevaluated water surface elevation due to the LIP at LGS equal to 218.4 feet NGVD29 does not exceed the CLB maximum LIP water surface elevation equal to 218.6 feet NGVD29." But in section 4.0 Flood Parameters and Comparison with the CDB the licensee states: "For LGS, the following flood-causing mechanisms are either determined to be implausible or completely bounded by other mechanisms or the current design basis: 1. Surge, Seiche, and Tsunami; 2. Ice Induced Flooding; and 3. Channel Migration or Diversion 4. Combinations in Section H.1 of NUREG/CR-7046 (Floods Caused by Precipitation Events) for the Schuylkill River (including hydrologic dam failure) 5. Combinations in Section H.1 of NUREG/CR-7046 (Floods Caused by Precipitation Events) for Sanatoga Creek	The licensee stated that the statement in Section 4.0 of its FHRR regarding LSG being potentially exposed to local intense precipitation flood hazards was referring to the previously unanalyzed area on the south side of the diesel generator enclosures, where door numbers 211, 213, 215, 217, 219, 221, 223, and 225 are the doors of concern. The licensee had performed a limited-scope integrated assessment (IA), but had not updated the FHRR to reflect the results, hence the apparent discrepancy. The staff reviewed the limited scope IA and found it reasonable. In the interim hazard letter to LGS for the reevaluated flood hazards, dated December 24, 2015 (ADAMS Accession No. ML15357A517), the NRC staff indicated that the reevaluated LIP flooding hazard for the area adjacent to the diesel generator enclosures should be addressed in the licensee's mitigating strategies for beyond-design-basis external events.

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
	6. Seismically-Induced Dam Failure (Combination H.2) LGS is considered potentially exposed to the flood hazards (individual flood-causing mechanisms and/or combined-effects flood scenarios per Appendix H of NUREG/CR-7046) listed below. In some instances, an individual flood-causing mechanism (e.g. 'Flooding in Streams and Rivers') is addressed in one or more of the combined-effect flood scenarios. 1. Local Intense Precipitation 2. Combinations in Section H.1 of NUREG/CR-7046 (Floods Caused by Precipitation Events) for Possum Hollow Run Please clarify the discrepancy.	

INFO NEED	INFORMATION NEED DESCRIPTION	ACTION (POST-AUDIT)
18	**FHRR Clarification** For Possum Hollow Run which the licensee states the re-evaluated elevation is above the CBD in Section 3.2.4 "The Possum Hollow Run CLB maximum PMF water surface elevation at LGS is 159 feet NGVD29. The reevaluated maximum water surface elevation due to the Possum Hollow Run PMF at LGS is equal to 167.8 feet NGVD29. The reevaluated maximum water surface elevation is 8.8 feet above the Possum Hollow Run CLB maximum water surface elevation. However, the reevaluated maximum water surface elevation is 6.2 feet below the Schuylkill River CLB maximum water surface elevation and does not affect the lowest grade level entrance to any safety-related structure of 217 feet NGVD29." In Section 3.9 this scenario is not evaluated for associated effects. This scenario is in Section 4.0 in Table 4.0.3, which does summarize the associated effects along with duration parameters, but in that table for each footnote it states: "Reevaluated elevation is bounded by the CLB for the Schuylkill River." Please explain why Limerick compared the reevaluated hazard for Possum Hollow Run to another scenario's CDB and not the CDB for Possum Hollow Run?	The licensee explained that they did compare the reevaluated water surface elevation in Possum Hollow Run with the CDB for Possum Hollow Run. The licensee stated that although the reevaluated PMF elevation exceeds the CDB elevation, it is appropriate to also compare the Possum Hollow Run PMF elevation to the Schuylkill River CDB because Possum Hollow Run flows into the Schuylkill River immediately downstream the site. The licensee found that the reevaluated PMF elevations for both Possum Hollow Run and the Schuylkill River were bounded by the Schuylkill River CDB. The licensee further noted that the Schuylkill River CDB is at least 10 ft below the LGS site grade. The NRC staff determined that, because of the close proximity of the site, the Schuylkill River, and Possum Hollow Run, the Schuylkill River is the controlling source of flooding for the mechanism and the licensee response is therefore satisfactory.

ATTACHMENT 1
Limerick Audit Document List

Highlighted below provides as example of information/format needed.

1. Exelon Generation Company, LLC's "Limerick Generating Station Flood Hazard Reevaluation Report," Revision 0, [Enclosure 1 in letter RS-15-064 from J. Barstow to NRC dated March 12, 2015, Subject: "Exelon Generation Company, LLC Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Report,"], ADAMS Accession No. ML15084A586.
2. Exelon Generation Company, LLC's "Response to NRC Audit Review Request for Additional Information Regarding Fukushima Lessons Learned - Flood Hazard Reevaluation Report," dated October 28, 2015, ADAMS Accession No. ML15301A705.
3. Exelon Generation Company, LLC's "Supplemental Response to NRC Audit Review Request for Additional Information Regarding Fukushima Lessons Learned - Flood Hazard Reevaluation Report," dated January 13, 2016, ADAMS Accession No. ML16020A497.
4. Exelon Generation Company, LLC, Calculation FINAL-Limerick_PMP-LM-0698: Probable Maximum Precipitation (PMP)—Fukushima Flood Hazard Analysis, Rev. 0.
5. Exelon Generation Company, LLC, Calculation LM-0699: Local Intense Precipitation (LIP)—Fukushima Flood Hazard Analysis, Rev. 0.
6. Exelon Generation Company, LLC, Calculation FINAL-Limerick_PMP-LM-0700_Limerick_PMF-Hydrology: Probable Maximum Flood---Hydrology—Fukushima Flood Hazard Analysis, Rev. 0.
7. Exelon Generation Company, LLC, Calculation FINAL-Limerick_PMP-LM-0701_Limerick_PMF-Hydraulics: Probable Maximum Flood---Hydraulics—Fukushima Flood Hazard Analysis, Rev. 0.
8. Exelon Generation Company, LLC, Calculation FINAL-Limerick_PMP-LM-0702_Limerick_DamFailure: Dam Failure—Fukushima Flood Hazard Analysis, Rev. 0.
9. Exelon Generation Company, LLC, Calculation LM-0707_LGS Combined Events Analysis: Combined Events—Fukushima Flood Hazard Analysis, Rev. 0.

ATTACHMENT 2
List of Limerick Audit Participants

	Name	Organization
1.	Dave Distel	Exelon
2.	Joe Bellini	Aterra Solutions
3.	Valmicky Samlal	Exelon
4.	James Barbis	AMECFW
5.	Chuck Behrend	Exelon
6.	Vinod Aggarwal	Exelon
7.	Jim Armstrong	Exelon
8.	Jesse Lucas	Exelon
9.	Bill McSorley	Exelon
10.	Kyle Kaminski	Enercon
11.	Tom O'Reilly	Enercon

If you have any questions, please contact me at (301) 415-6197 or by e-mail at Tekia.Govan@nrc.gov.

Sincerely,

/RA/

Tekia V. Govan, Project Manager
Office of Nuclear Reactor Regulation
Japan Lessons-Learned Division
Hazards Management Branch

Docket Nos. 50-352 and 50-353

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Audit Report

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