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

December 21, 2017

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: R. E. GINNA NUCLEAR POWER PLANT – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT (CAC NO. MF7929; EPID L-2017-JLD-0004)

Dear Mr. Hanson:

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

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

By letter dated November 18, 2016 (ADAMS Accession No. ML16323A173), Exelon Generation Company, LLC (the licensee) submitted the mitigation strategies assessment (MSA) for R. E. Ginna Nuclear Power Plant (Ginna). The MSAs are intended to confirm that licensees have adequately addressed the reevaluated flooding hazards within their mitigating strategies for beyond-design-basis external events. The purpose of this letter is to provide the NRC's assessment of the Ginna MSA.

The NRC staff has concluded that the Ginna MSA was performed consistent with the guidance described in Appendix G of Nuclear Energy Institute 12-06, Revision 2, as endorsed by Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, and that the licensee has demonstrated that the mitigation strategies are reasonably protected from reevaluated flood hazards conditions for beyond-design-basis external events. This closes out the NRC's efforts associated with CAC No. MF7929.

If you have any questions, please contact me at 301-415-1056 or at Lauren.Gibson@nrc.gov.

Sincerely,

Lauren Kate Gibson

Lauren K. Gibson, Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-244

Enclosure:
Staff Assessment Related to the
Mitigating Strategies for Ginna

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO MITIGATION STRATEGIES FOR R. E. GINNA NUCLEAR POWER PLANT AS A RESULT OF THE REEVALUATED FLOODING HAZARD NEAR-TERM TASK FORCE RECOMMENDATION 2.1- FLOODING CAC NO. MF7929

1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012b), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), "Conditions of Licenses" (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the NRC's Near-Term Task Force (NTTF) report (NRC, 2011). Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses (NRC, 2012b). Concurrent with the reevaluation of flood hazards, licensees were required to develop and implement mitigating strategies in accordance with NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (NRC, 2012a). That order requires holders of operating reactor licenses and construction permits issued under 10 CFR Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit to the NRC for review a final integrated plan that describes how compliance with the requirements of Attachment 2 of the order was achieved. In order to proceed with implementation of Order EA-12-049, licensees used the current licensing basis flood hazard or the most recent flood hazard information, which may not be based on present-day methodologies and guidance, in the development of their mitigating strategies. By letter letter dated March 11, 2015 (Exelon, 2015a), Exelon Generation Company, LLC (Exelon, the licensee) submitted its flood hazard reevaluation report (FHRR) for R. E. Ginna Nuclear Power Plant (Ginna) .

The NRC staff and industry recognized the difficulty in developing and implementing mitigating strategies before completing the reevaluation of flood hazards. The NRC staff described this issue and provided recommendations to the Commission on integrating these related activities in COMSECY-14-0037, "Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flood Hazards," dated November 21, 2014 (NRC, 2014). The Commission issued a staff requirements memorandum (SRM) on March 30, 2015 (NRC, 2015a), affirming that the Commission expects licensees for operating nuclear power plants to address the reevaluated flood hazards, which are considered beyond-design-basis external events, within their mitigating strategies.

Nuclear Energy Institute (NEI) 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (NEI, 2015b), has been endorsed by the NRC as an appropriate methodology for licensees to perform assessments of the mitigating strategies against the reevaluated flood hazards developed in response to the March 12, 2012, 50.54(f) letter. The guidance in NEI 12-06, Revision 2, and Appendix G in particular, supports the proposed

Mitigation of Beyond-Design-Basis Events rulemaking. The NRC's endorsement of NEI 12-06, including exceptions, clarifications, and additions, is described in NRC Japan Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (NRC, 2016a). Therefore, Appendix G of NEI 12-06, Revision 2, describes acceptable methods for demonstrating that the reevaluated flooding hazard is addressed within the Ginna mitigating strategies for beyond-design-basis external events.

2.0 BACKGROUND

By letter dated December 4, 2015 (NRC, 2015), the NRC issued an interim staff response (ISR) letter for Ginna. The letter provided the reevaluated flood hazards that exceeded the current design basis (CDB) for Ginna and were suitable inputs for the mitigating strategies assessment (MSA) (i.e., defines the mitigating strategies flood hazard information (MSFHI) described in NEI guidance document NEI 12-06. For Ginna, the mechanisms listed as not bounded by the CDB in the letter are local intense precipitation (LIP) and riverine flood hazard mechanisms.

Based on the March 2015 FHRR, the maximum water surface elevation due to LIP results from a total rainfall depth of 16 inches within 1 hour and 22.4 inches within 6 hours. In the immediate vicinity of the main buildings, the predicted maximum flooding depth of accumulated water range from 2.1 feet (ft.) at the Screen House to approximately 0.5 foot at the Control Building.

By letter dated November 18, 2016 (Exelon, 2016b), the licensee submitted a letter with two enclosures: the mitigating strategies assessment and an amendment to the flood hazard reevaluation report that describes the results of a site-specific probable maximum precipitation (PMP) study. The site-specific PMP (ssPMP) led to reduced riverine flood elevations at the site. The new elevations were less than the March 2015 FHRR elevations, yet, in some cases, were not fully bound by the CDB. The NRC is providing its review of the ssPMP in the technical evaluation below.

The letter also stated that NRC staff would evaluate, as applicable, the flood event duration (FED) parameters (including warning time and period of inundation) and flood-related associated effects (AEs) developed by the licensee during the NRC staff's review of the MSA. This is consistent with the guidance provided in Revision 2 of NEI 12-06. The licensee submitted its MSA by letter dated November 18, 2016, (Exelon, 2016b). The MSA also included the relevant information regarding the FED parameters and AEs needed to complete the review.

3.0 TECHNICAL EVALUATION

3.1 Confirmation of the Flood Hazard Elevations in the MSA

The NRC staff reviewed the updated flood hazard elevations in the MSA letter provided by the licensee (Exelon, 2016b). The staff confirmed that the flood elevations for LIP in the MSA are consistent with the values in the ISR letter dated December 4, 2015 (NRC, 2015). However, the MSA flood elevations for the streams and rivers flood-causing mechanism were changed from the ISR values. The changes are mainly due to adopting ssPMP and improving realism in streams and rivers flood modeling, as described in the amended FHRR attached to the MSA letter (Exelon, 2016b). Therefore, the staff reviewed the amended streams and rivers flood hazard modeling as part of the MSA review. The staff focused its review on the modeling related to site-specific PMP, probable maximum flood (PMF) modeling, and basin lag-time.

3.1.1 Amended Streams and Rivers Flood Hazard Evaluation

A. Site-Specific Probable Maximum Precipitation

The licensee provided information related to the ssPMP analysis to supplement the MSA report (Exelon, 2017). For the ssPMP analysis, the licensee prepared a storm list specific to the Ginna watershed basin, including justifications for inclusion or deletion of various historical storms. They then calculated adjustment factors for each storm on the storm list. The adjustment factors in general include in-place moisture maximization, moisture transposition, and orographic effects. Each storm was transpositioned to the Ginna basin using procedures outlined in the National Oceanic and Atmospheric Administration's (NOAA's) Hydrometeorological reports (HMRs) and World Meteorological Organization manuals as well as previous PMP studies. Using the adjustment factors, the licensee estimated all-season ssPMP values for the Ginna basin at multiple area sizes and durations. The licensee reported in its MSA letter (Exelon, 2016), that the ssPMP values are on average 27 percent lower than the HMR-based values used in the original FHRR. The NRC staff reviewed the licensee's ssPMP estimation as summarized below.

The licensee compiled and analyzed a total of 26 historical storms as short list storms. These short list storms are nearly identical to those used for the Perry Nuclear Power Plant, Unit 1 and Beaver Valley Power Station, Unit 1 and 2 sites. The ssPMP values for these two sites were already reviewed and accepted by the staff. The staff's review of the Ginna short list storms indicated no unreasonable exclusions of the storms used for the two nearby sites. The staff found no additional storms from the U.S. Army Corps of Engineers (USACE) Black Book (USACE, 1973) that are candidates for inclusion on the storm list. For most short list storms originally analyzed in the USACE Black Book, the licensee simply used the USACE depth-area-duration (DAD) data as input to the Ginna ssPMP study. The only storm which was reanalyzed by the licensee using the Storm Precipitation Analysis System was the Glenville, WV storm. The staff found the licensee's ssPMP analysis to be conservative because the licensee's DAD values are higher (more conservative) than the USACE Black Book DAD values.

For the storm dew point adjustment, the licensee adopted a 7 degrees Fahrenheit (°F) increasing adjustment for two storms (Cooper and Bonaparte) and a 2°F increasing adjustment for three storms (Jefferson, Ironwood, and Hayward). The staff performed a 4°F increasing adjustment instead of a 7°F adjustment conservatively, while the 2°F adjustment remains the same. As a result, the staff found the storms for which a 6-hour conversion was used had differences of dew points of up to 2.5 °F, while the one storm for which a 24-hour conversion was used had a difference of 2 °F. However, the staff found these changes are insignificant in terms of the resulting ssPMP values and flooding rates.

The staff also evaluated all controlling and near-controlling storms to assess whether storm representative dew point timing and storm trajectories used by the licensee to determine a representative dew point were reasonable. As a result, the staff found the dew point timeframes to be reasonable for the controlling storms of interest, and the storm trajectory included in the Ginna analysis was found to be appropriate. The licensee selected a moisture source location that is not well-aligned with the trajectory. However, since the Wellsville, NY storm is a controlling storm only for long-duration, small-area ssPMP estimates for which no major flooding impacts are expected, it is not affected by the trajectory. Dew point timing issues identified for the Big Rapids, Wooster, and College Hill storms remain problematic in the Ginna analysis. However, the staff noted that these storms are sufficiently smaller than controlling storms, so that adjustments would not result in any major changes on ssPMP values.

In addition to the above review, the staff performed an independent estimation of the ssPMP values. For short list storms, the staff independently computed land surface elevation values for the storm center location, storm representative dew point location, transpositioned dew point location, and the Ginna basin centroid location using geospatial data with a 4-kilometer resolution. The staff observed some moderate to large differences in elevations from the values provided by the licensee. The licensee relied upon nation-wide contoured maps of monthly maximum dew point. Using historical land-based dew point data, the staff conducted a gauge-based approach to evaluating ssPMP values and found some differences of:

a) near or lower than licensee's values for storm representative dew point (lower values are more conservative),
b) near or higher than licensee's values for in-place maximum dew point (this parameter typically does not impact PMP), and
c) near or higher than licensee's values for transpositioned maximum dew point (higher values are more conservative).

Using the newly estimated dew point values, the staff computed total adjustment factors (TAFs) for the list storms. The TAF in general includes three independent components: in-place maximization, moisture transposition, and barrier adjustment. The ssPMP value is obtained by multiplying the respective rainfall value from the DAD analysis and the estimated TAF value. Table 3.1.1-1 compares the TAF values estimated by the licensee and staff. While the two TAF estimates show some differences, the staff determined that these differences have minor impacts on Ginna flooding as discussed below.

Overall, the licensee's and staff's PMP values are comparable (see Table 3.1.1-2). The largest increases to ssPMP are for long durations (48-hour and longer) and for large area sizes (500 square miles (mi^2) and larger); however, these ssPMP values are not expected to impact the PMF at Ginna, as the size of the Ginna basin is small. That is, the ssPMP depths of primary importance to the Ginna basin are those for areas of 100 mi^2 and less and for durations of 6-hour and shorter. In particular, given the small Ginna watershed size (14.5 mi^2), the peak of the flood hydrograph is likely closely tied to the 1 hour, 10 mi^2 PMP. For this case, the staff's 1 hour, 10 mi^2 PMP is only 2 percent higher than the licensee's value, which is turned out to be insignificant in terms of the PMF peak rate and flood levels for the Ginna site.

In summary, the staff concludes that the licensee's ssPMP values are reasonable for estimating the PMF for the Ginna basin because the staff's independent analysis with different assumptions and data confirms the licensee-estimated ssPMP values used in the MSA report.

B. Basin Lag-time to Simulate PMF

The licensee created rainfall hyetograph (incremental rainfall-time plot) for the contributory Ginna watershed basin using the estimated ssPMP values (Exelon, 2016b). They then used the hyetograph as input into the Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) hydrologic computer model (USACE, 2000) to simulate PMF flow hydrographs for each subbasin. The Ginna HEC-HMS has two subbasins: Mill Creek and Deer Creek (Figure 3.1.1-1). They then applied FLO-2D (FLO-2D, 2013) to evaluate detailed onsite flood hazards (i.e., flood level, inundation depth, flow velocity, etc.) for the basin PMF event which would overflow the onsite stream channel and inundates the power block area (see Figures 3.1.1-2, 3.1.1-3, 3.1.1-4).

For the amended HEC-HMS modeling in its MSA, the licensee relied on the Natural Resources Conservation Service (NRCS) velocity method to determine basin lag times for two subbasins (Exelon, 2017). The NRCS-based lag time is in general estimated as 60 percent of the total travel time, where the total travel time is a sum of travel times for sheet flow, shallow flow, and channel flow. The sheet flow travel time is estimated as a function of the length, slope, and roughness coefficient. The licensee used a sheet flow length of 300 ft., resulting in sheet flow travel time of 4.92 hours for both subbasins. However, the staff noted that the latest NRCS guidance (NRCS, 2010) recommends using the length of sheet flow of no more than 100 ft. before transitioning from sheet (overland) flow to shallow flow. Assuming a 100 ft. sheet flow length with the same slope and roughness condition, the staff estimated a sheet flow travel time of 1.17 hours, which is much smaller than the licensee's value. Therefore, through the MSA audit process, the staff requested for the licensee to justify the sheet flow travel time used in their HEC-HMS. In response, the licensee provided the following justifications with additional analyses to explain their travel time and PMF estimation (Exelon, 2017).

The licensee stated in their response that the sheet flow length of 300 ft. is based on the guidelines provided by the NRCS Technical Release 55 (NRCS, 1986). The NRCS guide defines the time of concentration or travel time as the longest travel time from the most hydrologically distant point to the outlet of a subbasin. The licensee stated in the response that more recent NRCS guidance (NRCS, 2010) indicates sheet flow typically occurs over a length of up to 100 ft. as the staff pointed out. However, the licensee used the 300 ft. length of overland flow for the two subbasins for the purpose of reducing the conservatism inherent in the application of the Soil Conservance Service (SCS) method (SCS, 1986). They said that the selection of sheet flow length of 300 ft. is only one component of the hydrologic modeling as a whole and should not be individually evaluated without the context of the overall PMF result. They stated that they agree that calibration and verification of a watershed model is important. Unfortunately, when there is no historical flow or stage data available to the Ginna basin, they said they relied on engineering judgment and available physical data from other similar watersheds to develop a realistic yet conservative estimation of the PMF. To provide additional justifications for their lag times and to demonstrate the overall conservatism of the PMF modeling, the licensee performed the following comparative analyses (Exelon, 2017):

- The licensee estimated 100-year and 500-year floods for the Ginna basin and compared them with other estimates at nearby basins. For this estimation, they used the amended HEC-HMS with the same model parameters (especially, the same lag times), but without nonlinearity adjustments and rainfall values obtained from the NRCS Northeast Regional Climate Center for the 24-hour duration and 100-year and 500-year return periods as input to the model. As a result, the licensee obtained peak flood rates for 100-year and 500-year return periods at Deer Creek of 3,680 cubic feet per second (cfs) and 5,650 cfs, respectively. These flood values are greater than the predicted peak flow rates estimated in the Federal Emergency Management Administration (FEMA) Flood Insurance Study for the Town of Ontario, Wayne County (FEMA, 1977) for which the peak flood rates are 1,680 cfs and 2,200 cfs, respectively.

- They obtained expected peak flood rates estimated using the U.S. Geological Survey (USGS) "StreamStats" web-based program for New York (USGS, 2015). The USGS peak flood rates for 100-year and 500-year return periods at Deer Creek are 690 cfs and

840 cfs, respectively, which are substantially lower than the licensee's HEC-HMS-based estimates above.

- The licensee also obtained stream flood rates for 100-year return period at nearby similar stream gages and adjusted the flow rates for the Ginna drainage area (see Figure 3.1.1-5 and Table 3.1.1-3). The adjusted peak flow rates vary with an average of 1,143 cfs which is only about 30 percent of the HEC-HMS-based estimates (i.e., 3,680 cfs at Deer Creek alone).

As the licensee's HEC-HMS model produces conservative flood rates for the Ginna basin compared to the other available flood values from different sources and at nearby basins, the licensee concluded that the sheet flow lag time is appropriate and the PMF estimates using the HEC-HMS model are still conservative (Exelon, 2017). The staff confirmed the 100-year flood values estimated by USGS and FEMA studies (Exelon, 2017) based on checking of the USGS StreamStats website independently. The staff also found that the licensee followed the current engineering practices for estimating PMF for un-gaged basins. Therefore, the staff concludes that the lag-time and hydrologic modeling used to estimate PMF for the Ginna basin are acceptable for use in the MSA.

D. Sensitivity Analysis

With the amended FHRR attached to the MSA (Exelon, 2016b), the licensee performed sensitivity analyses to evaluate the effects of using an alternative infiltration loss method in HEC-HMS. It is generally understood that the NRCS Curve Number (CN) method (NRCS, 1986) produces low infiltration losses when used with sequential and/or long-duration storms. This approach is conservative in terms of estimating PMF rates. To test this conservatism, the licensee selected the initial and constant loss method as an alternative method in HEC-HMS (Exelon, 2016b). The HEC-HMS Technical Reference Manual recommends calibration of constant loss rates (USACE, 2000). However, there are no stream gage data within the Ginna contributing watershed to calibrate the constant loss rates. Therefore, the licensee estimated the initial and constant loss rates from trial HEC-HMS simulations using the NRCS CN method for a single 24-hour storm, thus eliminating the effect of sequential and long-duration storms on infiltration losses. As a result, they confirmed the estimated constant loss rates are within the ranges of expected loss rates provided in the HEC-HMS manual given the soil types in the watershed. They then generated HEC-HMS flow hydrographs that were used as input into the FLO-2D hydrodynamic model to determine the effects of the alternative loss method on flood levels at the plant site. The licensee also performed a sensitivity analysis of FLO-2D to check the performance of flood routing at the Contaminated Storage Building (CSB) and Canister Prep Building (CPB) (Exelon, 2016b). In the sensitivity analysis, the CSB and CPB exterior walls were assumed to remain using the levee routine in FLO-2D but penetrations (such as doors) were approximately incorporated to allow realistically water to flow through the buildings.

The licensee found from the above sensitivity analyses that the flood elevations at the site decrease on the order of approximately 0.2 ft. to 0.3 ft. at the Auxiliary Building block wall using alternative (realistic) infiltration and building representation inputs (Exelon, 2016b). The staff reviewed the sensitivity analyses with licensee-provided PMF model input and output files and concludes that the licensee's PMF modeling is conservative and acceptable as they followed the current engineering practices.

E. Onsite Flood Elevation Due to PMF

With the amended FHRR, the licensee estimated the site-specific PMF peak rate of 23,180 cfs for the streams and rivers flood-causing mechanism. This PMF flood event is based on the newly-estimated ssPMP. They applied the FLO-2D model to evaluate detailed onsite flood hazards caused by the basin PMF event that would partially overflow the onsite portion of Deer Creek stream channel and inundate the power block area subsequently. The resulting flood elevations estimated by the licensee are summarized in Table 3.1.1-4.

The licensee stated in the amended FHRR that wave runup of up to 0.9 ft. resulting from the onsite Deer Creek flooding with the critical wind speed is expected to influence the flood elevations only at the southern end of the site, with the waves likely to break against the plant buildings (Exelon, 2016b). They determined the greatest overflow fetch for the wind generated waves on the Deer Creek from the FLO-2D-generated inundation map. Using the Gumbel Distribution on the 2-minute wind speed data, the licensee determined the 2-year return period wind speed of 73.9 ft. per second (ft./sec). Based on the re-evaluated PMF analysis, the flood elevations at Turbine Building, Screen House, and Diesel Generator Building are not bounded by the CDB) values (see Table 3.1.1-4). The reevaluated peak PMF elevations at the safety-related structures, systems and components (SSCs) at Ginna generally range from 257.0 ft. to 273.7 ft. Based on its review of the amended HEC-HMS and FLO-2D, the staff found various conservatisms applied to these models, including the use of conservative antecedent soil moisture condition, non-linear adjustment on basin hydrographs, antecedent storm prior to the full PMP, uniform spatial rainfall rate, and arranging upstream inflow hydrographs to get conservative PMF peaks.

In all, the staff concludes that the reevaluated PMF and corresponding onsite flood hazards reported in the amended FHRR and MSA letter (Exelon, 2016b) are adequate for use in the MSA as the licensee followed the current federal guideline and practices. Flood elevations for hazards not bounded by the CDB are summarized in Table 3.1.1-5.

3.2 Mitigating Strategies under Order EA-12-049

The NRC staff evaluated the Ginna strategies as developed and implemented under Order EA-12-049. This evaluation is documented in a safety evaluation issued by letter dated July 14, 2016 (NRC, 2016c).

The safety evaluation concluded that Ginna has developed guidance and proposed designs, which if implemented appropriately will adequately address the requirements of Orders EA-12-049 and EA-12-051.

3.3 Evaluation of Current FLEX strategies

In the MSA, Section 5 explains that the March 2015 reevaluated flood (i.e. MSFHI) for the LIP and riverine flood-causing mechanisms were used as inputs in developing the FLEX strategy, including aspects related to the storage and deployment of FLEX equipment, validation of FLEX actions, and viability of FLEX connection points.

Local Intense Precipitation

In the MSA, Table 5-1 provides a comparison of the FLEX design-basis and reevaluated (i.e. MSFHI) LIP flood hazard, which includes warning time and period of site preparation.

The licensee made procedural changes in site procedures in ER-SC.2 and O-6.11 to have a more restrictive warning time for the installation of the temporary flood barriers and relocation of portable FLEX equipment and trailers to higher ground as contingency actions in advance of the flooding event. The licensee explained that it revised site procedure O-6.11, Surveillance Requirement/Routine Operations Check Sheet, to monitor for extreme rainfall forecasts and trigger entry into procedure ER-SC.2, High Water (Flood) Plan. The licensee explained that there are two warning time levels of action described in ER-SC.2: Level 1 actions taken when 5 inches of rain is forecasted over a 24-hour period in the next three days and Level 2 actions taken when 10 inches of rain is forecasted over a 24-hour period in the next 3 days. As part of ER-SC.2, operators are directed to install temporary flood barriers to protect installed FLEX equipment, specifically at the Auxiliary Building, and move portable FLEX equipment and trailers to higher ground as contingency actions in advance of the approaching weather event.

The staff finds it reasonable that the LIP event will not impact the implementation of the licensee's FLEX strategy because (1) the design of the licensee's FLEX strategies are based on the MSFHI for the LIP event, (2) the licensee revised existing procedures to monitor rainfall and trigger flood preparation, and (3) operators will relocate FLEX equipment to higher ground and install temporary flood barriers to protect FLEX equipment per existing procedures.

Riverine Flooding (Probable Maximum Flood/Surge/Wind-Wave Event Combinations)

In the MSA, Table 5-2 provides a comparison of the FLEX design-basis and the amended site-specific riverine flood parameters and demonstrates that the FLEX design-basis completely bounds the amended riverine flood hazard. Although the amended riverine flood hazard was used as basis for comparison in the MSA, the staff confirmed that MSFHI for the riverine flood-causing mechanism was used as input in developing the FLEX design-basis (e.g., aspects related to the storage and deployment of FLEX equipment, validation of FLEX actions, and viability of FLEX connection points).

The staff finds it reasonable that the riverine flood event will not impact the implementation of the licensee's FLEX strategy because (1) the design of the licensee's FLEX strategies are based on the MSFHI for the riverine event, (2) the licensee revised existing procedures to monitor rainfall and trigger flood preparation, and (3) operators will relocate FLEX equipment to higher ground and install temporary flood barriers to protect FLEX equipment per existing procedures.

3.4 Evaluation of Associated Effects

The staff reviewed information provided by Exelon (Exelon, 2016b) regarding AE parameters for flood hazards not bounded by the CDB. The AE parameters related to water surface elevation (i.e., stillwater elevation with wind waves and runup effects) were previously reviewed by staff, and were transmitted to the licensee via an ISR letter (NRC, 2015b). The AE parameters not directly associated with water surface elevation are discussed below and are summarized in in Table 3.4-1.

For the LIP flood-causing mechanism, the licensee concluded that the AEs related to hydrodynamic load, debris load, sediment load, and sediment deposition and erosion are either minimal or not applicable due to small inundation depths and low flow velocities within the power block area (Exelon, 2016b). The staff confirmed the depths and velocity of the LIP flood from the licensee-provided model output files. The licensee stated in its FHRR (Exelon, 2016a; 2016b) that concurrent conditions of high wind could be generated with a LIP event, and that it would not affect the plant safety due to the actions taken to install the temporary barriers. They stated groundwater seepage is expected to be minimal because the majority of the plant area is paved or gravel-covered enough to limit the volume of infiltration from LIP.

For the streams and rivers flood-causing mechanism, the licensee concluded that the AEs are either minimal or not applicable for the AE parameters related to hydrodynamic load, debris load, sediment load, sediment deposition and erosion, groundwater ingress, and other pertinent factors (Exelon, 2016b). The licensee stated that concurrent conditions of high wind of 73.9 ft./sec could be generated during a PMF event. However, this event would not affect the plant safety because the plant is designed to safely shutdown following high winds such as those associated with tornados. The staff agrees with the licensee's conclusion on the AE parameters as their approaches are consistent with the guideline provided by Appendix G of NEI 12-06, Revision 2 (NEI, 2015b).

In summary, the staff concludes the licensee's AE parameters are acceptable for use with the MSA.

3.5 Evaluation of Flood Event Duration

The staff reviewed information provided by the licensee (Exelon, 2016b) regarding the FED parameters needed to perform the additional assessments of the plant response for flood hazards not bounded by the CDB. The FED parameter values for the flood-causing mechanisms not bounded by the CDB are summarized in Table 3.5-1.

For the LIP flood-causing mechanism, the licensee stated in its FHRR (Exelon, 2016a; 2016b) that warning time for operator actions credited in the Diverse and Flexible Coping Strategies (FLEX) during the LIP flood is provided based on NEI 15-05 (NEI, 2015a). They also stated that the periods of inundation and recession are not applicable as the estimated flood elevations for LIP at the selected monitoring points are below the respective penetration or door threshold elevation. These FED parameters are based on the numerical LIP modeling. The staff confirmed the licensee's FED parameters using Figures 9-1 through 9-9 of FHRR (Exelon, 2015) and also licensee-provided output files for the LIP FLO-2D modeling.

For the streams and river flood-causing mechanism, the licensee provided the discussion of FED parameters in the MSA (Exelon, 2016b). They defined two FLEX design-basis flood and/or MSFHI warning time levels: the Level 1 action taken when 5 inches of rain is forecasted over a 24-hour period in the next 3 days, and the Level 2 action taken when 10 inches of rain is forecasted over a 24-hour period in the next three days. The licensee stated in its MSA that it will take approximately 5 hours for floodwaters to rise from the elevation 263 to 270 ft. National Geodetic Vertical Datum of 1929 (NGVD29) immediately upstream of the Ginna Access Road at the Driveway Bridge with the total inundation period of about 7 hours. They said that, while the time series plots can be used to estimate the period of recession, the passive barriers used to protect equipment credited in the FLEX strategy can perform their function independent of the recession time. Therefore, they concluded FLEX is unaffected by the flood once the floodwaters drop below grade so period of recession is not a factor.

From Figures 9-10 to 9-18 of FHRR (Exelon, 2015), the staff found most locations in the power block area are inundated for approximately 5 hours to 7 hours with varying recession periods for minor residual flows.

In summary, the staff concludes the licensee's FED parameters are acceptable for use in the MSA, as the reevaluation of the FED parameters for LIP and streams and rivers flood-causing mechanisms uses present-day methodologies and regulatory guidance.

4.0 CONCLUSION

The NRC staff has reviewed the information provided in the Ginna MSA related to the original FLEX strategies, as evaluated against the reevaluated hazard(s) described in Section 3 of this staff assessment, and found that:

- the sequence of events for the FLEX strategies are not affected by the impacts of the ISR flood levels (including impacts due to the environmental conditions created by the ISR flood levels) in such a way that the FLEX strategies cannot be implemented as currently developed, and

- the deployment of the FLEX strategies is not affected by the impacts of the ISR flood levels.

Therefore, the NRC staff concludes that the licensee has followed the guidance in NEI 12-06, Revision, 2, and demonstrated the capability to deploy the original FLEX strategies, as designed, against LIP and riverine flooding.

5.0 REFERENCES

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

Exelon, 2015a, "Flood Hazard Reevaluation Report Pursuant to 10 CFR 50.54(f) Regarding the Fukushima Near-Term Task Force Recommendation 2.1: Flooding," March 11, 2015. ADAMS Accession No. ML15072A009.

Exelon, 2015b, "R. E. Ginna - Response to NRC Audit Review Request for Additional Information Regarding Fukushima Lessons Learned - Flood Hazard Reevaluation Report," September 30, 2015, ADAMS Accession No. ML15273A138.

Exelon, 2016a, "Exelon Generation Company, LLC Response to March 12, 2012, Request for Information Enclosure 2, Recommendation 2.1, Flooding, Required Response 2, Flood Hazard Reevaluation Supplemental Information Regarding Associated Effects and Flood Event Duration parameter," October 4, 2016, ADAMS Accession No. ML16278A530.

Exelon, 2016b, "R.E. Ginna Nuclear Power Plant – Mitigating Strategies Flood Hazard Assessment (MSFHA) Submittal," November 18, 2016, ADAMS Accession No. ML16295A334.

Exelon, 2017, "R.E. Ginna Nuclear Power Plant – Supplemental Response to Request for Additional Information Regarding Fukushima Lessons Learned – Flood Hazard Reevaluation Report," (This also includes model input and output files and calculations), May 1, 2017, ADAMS Accession No. ML17132A387.

FEMA, 1977. "Flood Insurance Study, Town of Ontario, New York, Wayne County, U.S.," Department of Housing and Urban Development, Federal Insurance Administration, December, 1977.

FLO-2D, 2012, Build No. 14.08.09. "FLO-2D Version 2012 Professional Model Reference Manual," FLO-2D Software, Inc., Nutrioso, Arizona (www.flo-2d.com), 2012.

NEI (Nuclear Energy Institute), 2015a, NEI 15-05, "Warning Time for Local Intense Precipitation Events," Revision 6, April 8, 2015. ADAMS Accession No. ML15104A158.

NEI, 2015b, Report NEI 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide, dated December, 2015 ADAMS Accession No. ML16005A625.

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

Nuclear Regulatory Commission (NRC), 2011, NUREG/CR-7046, "Design Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America," ADAMS Accession No. ML11321A195.

NRC, 2012a NRC Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735).

NRC, 2012b, letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation and Michael R. Johnson, Director, Office of New Reactors, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, “Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident,” March 12, 2012, ADAMS Accession No. ML12056A046.

NRC, 2014. COMSECY-14-0037, “Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flood Hazards,” dated November 21, 2014 (ADAMS Accession No. ML14309A256).

NRC, 2015a, , SRM-COMSECY-14-0037, “Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flood Hazards,” dated March 30, 2015, ADAMS Accession No. ML15089A236.

NRC, 2015b, “R. E. Ginna Nuclear Power Plant – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood Causing Mechanism Reevaluation (TAC No. MF6098)”, December 4, 2015, ADAMS Accession No. ML15334A453.

NRC, 2016a, Lessons-Learned Division (JLD) interim staff guidance (ISG) JLD-ISG-2012-01, Revision 1, “Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events,” dated January 22, 2016. ADAMS Accession No. ML15357A163.

NRC, 2016b, "NRC Report for the Audit of R.E. Ginna Nuclear Power Plant, LLC's Flood Hazard Reevaluation Report Submittals Relating to the Near-Term Task Force Recommendation 2.1 - Flooding for R.E. Ginna Nuclear Power Plant (CAC No. MF6098)," June 9, 2016, ADAMS Accession No. ML16152A116.

NRC, 2016c, “R.E. Ginna Nuclear Power Plant-Safety Evaluation Regarding Implementation of Mitigating Strategies and Reliable Spent Fuel Pool Instrumentation Related to Orders EA-12-049 and EA-12-051 (CAC Nos. MF1152 and MF1147), July 14, 2016, ADAMS Accession No, ML16124A038.

NRC, 2016d, “R. E. Ginna Nuclear Power Plant - Staff Assessment of Response to 10 CFR 50.54(f) Information Request- Flood-Causing Mechanism Reevaluation (CAC NO. MF6098)”, November, 18, 2016, ADAMS Accession No. ML16295A334.

Natural Resources Conservation Service (NRCS), 1986. "Urban Hydrology for Small Watersheds" Natural Resources Conservation Service, Conservation Engineering Division, June 1986.

NRCS, 2010. "Chapter 15 Time of Concentration", Part 630 Hydrology, National Engineering Handbook, U.S. Department of Agriculture Natural Resource Conservation Service, May 2010.

NRCS, 2012. “Extreme Precipitation in New York and New England” (http://precip .eas.cornell.edu\), Version 1 .12, by Natural Resources Conservation Services (NRCS) and Northeast Regional Climate Center, revised October 19, 2011 , accessed September 5, 2012.

US Army Corps of Engineers (USACE). 1973. “Black Book - Storm Rainfall in the United States, 1945–1973.” Washington, DC.

USACE, 2000, “Hydrologic Modeling System HEC-HMS Technical Reference Manual”, U.S. Army Corps of Engineers Hydrologic Engineering Center, March 2000.

U. S. Geological Survey (USGS), 2015. “Streamstats,” New York. http://water.usgs.gov/osw/streamstats/newyork.html. Date Accessed September, 2015.

Table 3.1.1-1. Comparison of Total Adjustment Factors (TAFs) Evaluated by Licensee and Staff, where TAF is a sum of in-place maximization, moisture transposition, and barrier adjustment factors.

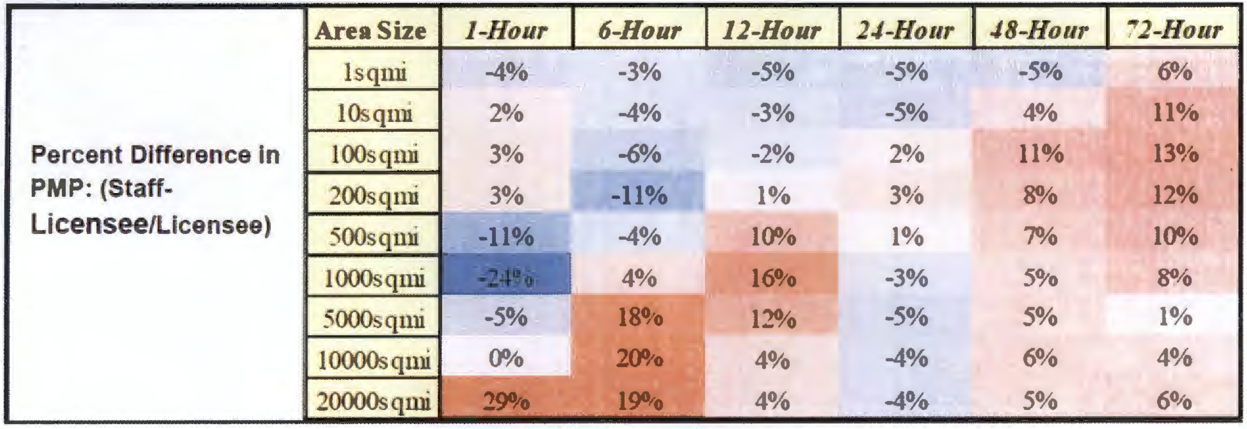
Short List Storm	Total Adjustment Factors		Impacts on Onsite Flooding
	Licensee	Staff	
Simpson, KY	1.11	1.08	Minimal
Glenville, WV	1.16	1.23	Minimal
Aurora College, IL	1.07	1.12	Minimal
Wellsville, NY	1.29	1.46	Minimal

Table 3.1.1-2. (a) Licensee's Revised Site-specific PMP Values, and (b) Comparison of PMP values estimated by licensee and staff for different duration (column) and basin area (row), where 'sqmi' stands for square miles.

(a) PMP Depth in Inches (from Exelon, 2017).

	Area Size	*1-Hour*	*6-Hour*	*12-Hour*	*24-Hour*	*48-Hour*	*72-Hour*
Ginna Nuclear Power Plant PMP Values in Inches	1sqmi	12.3	22.6	23.5	23.6	23.7	23.8
	10sqmi	10.1	20.0	20.4	20.8	21.7	22.7
	100sqmi	7.0	14.5	15.4	17.7	18.9	20.6
	200sqmi	5.9	13.0	14.0	16.5	**18.0**	19.7
	500sqmi	4.5	11.0	12.1	14.6	**16.7**	18.2
	1000sqmi	3.7	9.6	10.8	13.2	**15.5**	**17.0**
	5000sqmi	1.9	**6.1**	8.1	10.2	**13.0**	**13.8**
	10000sqmi	1.2	**4.6**	6.7	9.0	**11.7**	**11.9**
	20000sqmi	0.7	3.1	5.4	7.3	**9.7**	**10.0**

(b) Comparison of PMP Values between Licensee and Staff.



	Area Size	*1-Hour*	*6-Hour*	*12-Hour*	*24-Hour*	*48-Hour*	*72-Hour*
Percent Difference in PMP: (Staff-Licensee/Licensee)	1sqmi	-4%	-3%	-5%	-5%	-5%	6%
	10sqmi	2%	-4%	-3%	-5%	4%	11%
	100sqmi	3%	-6%	-2%	2%	11%	13%
	200sqmi	3%	-11%	1%	3%	8%	12%
	500sqmi	-11%	-4%	10%	1%	7%	10%
	1000sqmi	-24%	4%	16%	-3%	5%	8%
	5000sqmi	-5%	18%	12%	-5%	5%	1%
	10000sqmi	0%	20%	4%	-4%	6%	4%
	20000sqmi	29%	19%	4%	-4%	5%	6%

Table 3.1.1-3. 100-year Peak Flow Estimations for Deer Creek and Similar nearby Stream Gages, reproduced from the Exelon Letter (Exelon, 2017).

Basin/Station	Drainage Area (mi^2)	Estimated 100-year Peak Flow (cfs)	Drainage Area Adjusted Peak Flow for Ginna Watershed (cfs)
Bear Creek at Ontario, NY	6.74	293	630
Mill Creek Tributary near Webster, NY	2.12	261	1,785
West Creek near Hilton, NY	31.0	1,820	851
East Branch Allen Creek at Pittsford, NY	6.96	626	1,304
Average of above Four Estimates			1,143

Notes: The revised site-specific PMF value from the Mill Creek and Deer Creek watersheds is 23,180 cfs, for the contributing drainage area of 14.5mi^2 (3.7 mi^2 for Deer Creek and 10.8 mi^2 for Mill Creek) (Exelon, 2016).

Table 3.1.1-4. Amended Peak Water Surface Elevations, taken from Exelon (2016b).

Structure	Design Basis PMF Level (ft. NGVD29)	Original FHRR Peak PMF Level (ft. NGVD29)	Amended FHRR			
			Stillwater Level (ft. NGVD29)	Peak PMF Level (ft. NGVD29) (1)	Max Flow Depth (ft.)	Max Flow Velocity (ft. per second)
Reactor Containment	272.0	272.4	271.5	271.5	1.4	0.2
Auxiliary Building (East Wall, South End)	273.8	272.6	271.7	272.6 (1)	1.1	1.4
Auxiliary Building (South Wall)	273.8	N/A	273.7	272.7	3.0	1.0
Turbine Building	256.6	258.2	257.1	257.1	3.1	2.2
Control Building	272.0	272.4	271.5	271.5	1.2	1.1
All-Volatile Treatment Building	272.0	271.3	270.9	270.9	0.3	2.6
Standby Auxiliary Feedwater Pump Building	273.0	272.8	271.9	272.8	1.8	2.5
Standby Auxiliary Feedwater Pump Building Annex	273.8	273.5	272.7	273.6	2.8	2.7
Screen House	256.6	258.2	257.0	257.0		1.4
Diesel Generator Building	256.6	258.4	257.1	257.1		1.5

Notes: The amended FHRR peak PMF levels marked in red are not bounded by the CDB.

1. This value is the sum of riverine PMF level (stillwater), 25-year surge, maximum controlled water level in Lake Ontario, and wind-wave activity in accordance with the NUREG/CR- 7046, Section H.4.2 criterion.

Table 3.1.1-5. Revised Flood Elevations for Flood-Causing Mechanisms Not Bounded by the CDB.

Flood-Causing Mechanism	Stillwater Elevation (ft. MSL)	Waves/Runup (ft.)	Reevaluated Hazard Elevation (ft. MSL)	Reference
Local Intense Precipitation and Associated Drainage	270.09 (Varied)	Minimal	270.09 (Varied)	MSA Table 5.2 (Exelon, 2016)
Streams and Rivers	Varied (see Table 3.2.0-4)	Varied	Varied (see Table 3.2.0-4)	MSA Table 5.2 (Exelon, 2016)

Table 3.4-1. Associated Effects Parameters Not Directly Associated With Total Water Height for Flood-Causing Mechanisms Not Bounded by the CDB.

Associated Effects Parameter	Local Intense Precipitation	Streams and Rivers
Hydrodynamic Loading at Plant Grade	Minimal	Minimal
Debris Loading at Plant Grade	Minimal	Minimal
Sediment Loading at Plant Grade	Minimal	Minimal
Sediment Deposition and Erosion	Minimal	Minimal
Concurrent Conditions, Including Adverse Weather	Minimal	Wind speed of up to 73.9 ft./sec
Groundwater Ingress	Minimal	Minimal
Other Pertinent Factors (e.g., waterborne projectiles)	Minimal	Minimal

Table 3.5-1. Flood Event Durations for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Local Intense Precipitation and Associated Drainage	Refer to NEI 15-05 (NEI, 2015)	> 10 hours (1)	Minimal
Streams and Rivers	24 hours	< 7 hours	Not Applicable

1. These values are based on Figures 9-1 through 9-9 in the original FHRR (Exelon, 2013). However, the MSA letter (Exelon, 2016) states that temporary passive barriers are used to protect equipment, which can perform their function independent of their inundation time.

Figure 3.1.1-1. Watershed delineation for HEC-HMS modeling, taken from the licensee letter (Exelon, 2017).

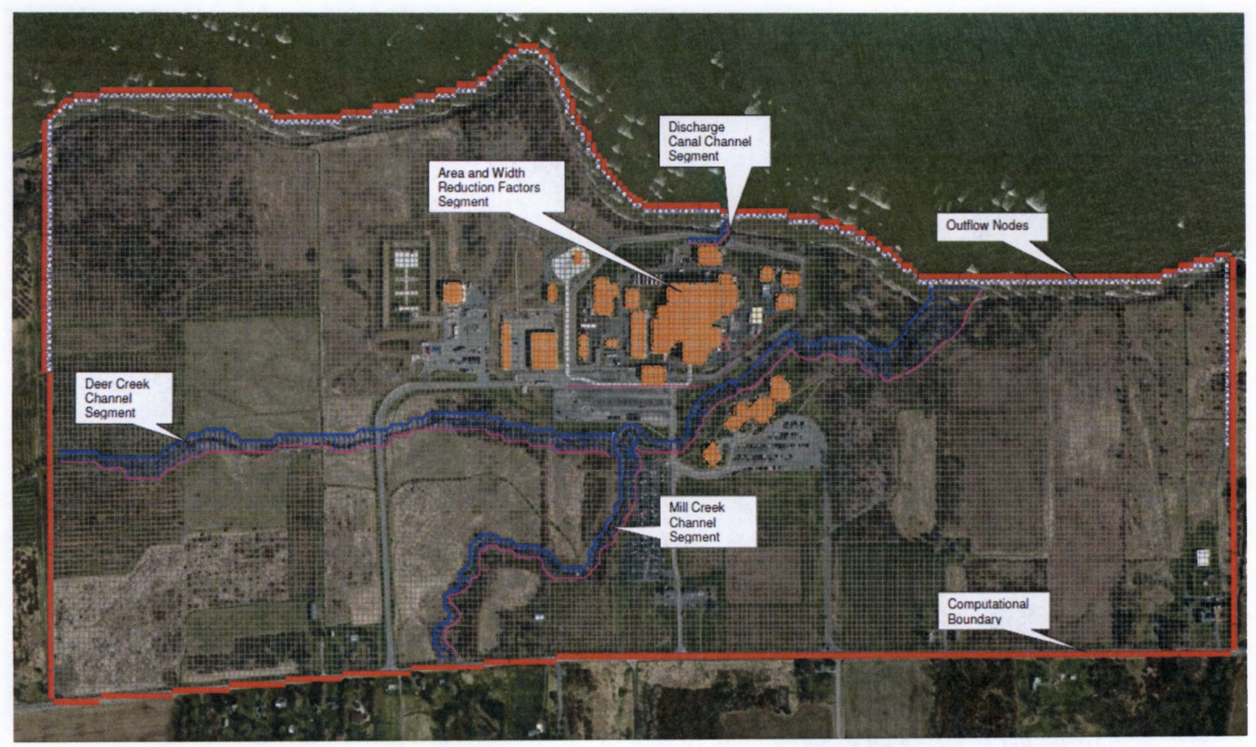


Figure 3.1.1-2. FLO-2D model layout, taken from the licensee letter (Exelon, 2017).

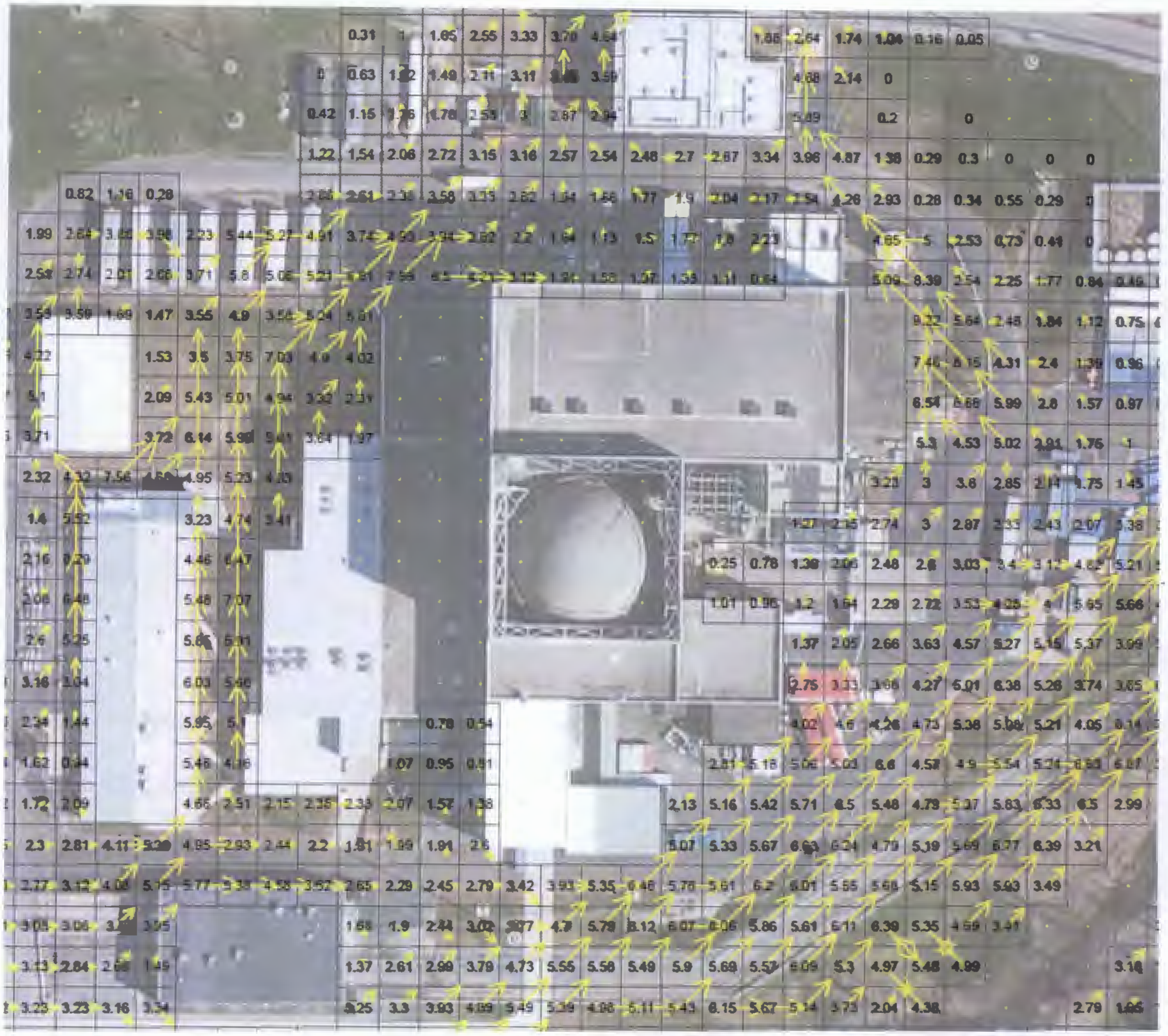


Figure 3.1.1-3. Flow velocity at the power block area for the streams and rivers flood-causing mechanism, taken from the licensee letter (Exelon, 2017).

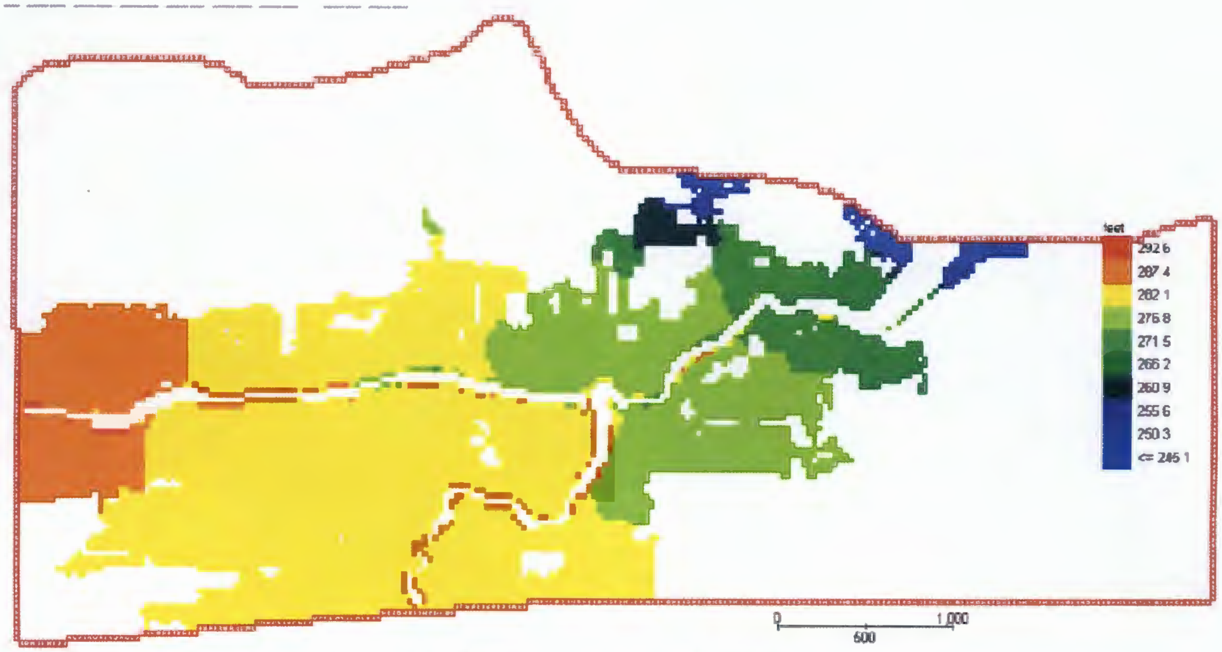


Figure 3.1.1-4. PMF-induced flood elevations for the streams and rivers flood-causing mechanism, generated using licensee-provided PMF FLO-2D output files (Exelon, 2017).

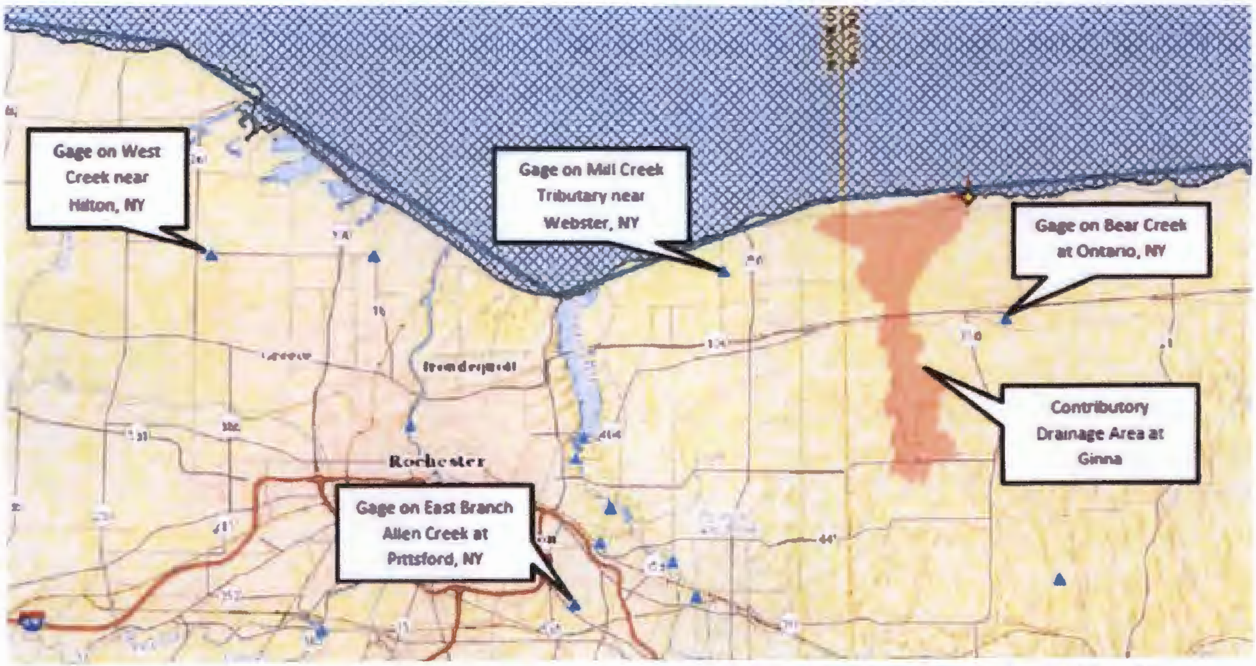


Figure 3.1.1-5. Nearby stream gage locations to confirm the Ginna site-specific PMF value, taken from the licensee letter (Exelon, 2017).

R. E. GINNA NUCLEAR POWER PLANT – FLOOD HAZARD MITIGATION STRATEGIES ASSESSMENT DATED December 21, 2017

DISTRIBUTION
Public
PBMB R/F
RidsNRRDlp Resource
RidsNrrDorllpl1 Resource
RidsNrrDorl Resource
RidsNrrPMREGinna Resource
RidsNrrlaSLent Resource
RidsOgcMailCenter Resource
RidsOpaMail Resource
RidsACRS_ MailCtr Resource
RidsNroDsea Resource
RidsRgn1MailCenter Resource
SBailey, NRR
TBrown, NRR
MShams, NRR
LKGibson, NRR
JBoska, NRR

ADAMS Accession No. ML17345A990 ***concurrence via e-mail**

OFFICE	NRR/DLP/PBMB/PM	NRR/DLP/PBMB/LA	NRO/DSEA/BC*
NAME	LKGibson	SLent	CCook (SDevlin-Gill for)
DATE	12/14/17	12/12/17	11/16/17
OFFICE	NRR/JLD/JERB/BC	NRR/DLP/PBMB/BC	NRR/DLP/PBMB/PM
NAME	SBailey*	MShams	LKGibson
DATE	12/20/2016	12/17/17	12/21/17

OFFICIAL RECORD COPY