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

January 10, 2017

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

SUBJECT: LASALLE COUNTY STATION, UNITS 1 AND 2 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION (CAC NOS. MF3655 AND MF3656)

Dear Mr. Hanson:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The request was issued as part of implementing lessons learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 2 to the 50.54(f) letter requested licensees to reevaluate flood-causing mechanisms using present-day methodologies and guidance. By letter dated March 12, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14079A417), Exelon Generation Company, LLC (Exelon, the licensee) responded to this request for LaSalle County Station, Units 1 and 2 (LaSalle).

By letter dated September 3, 2015 (ADAMS Accession No. ML15211A482), the NRC staff sent the licensee a summary of its review of LaSalle's reevaluated flood-causing mechanisms. The enclosed staff assessment provides the documentation supporting the NRC staff's conclusions summarized in the letter. As stated in the letter, because local intense precipitation and storm surge flood-causing mechanisms at LaSalle are not bounded by the plant's current design basis, additional assessments of the flood hazard mechanisms are necessary.

The NRC staff has no additional information needs with respect to Exelon's 50.54(f) response related to flooding. This staff assessment closes out the NRC's efforts associated with CAC Nos. MF3655 and MF3656.

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

Sincerely,

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

Docket Nos. 50-373 and 50-374

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

LASALLE COUNTY STATION, UNITS 1 AND 2

DOCKET NOS. 50-373 AND 50-374

1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012a), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, 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, 2011b). Recommendation 2.1 in that document recommended that the NRC staff issue orders to all licensees to reevaluate seismic and flooding hazards for their sites against current NRC requirements and guidance. Subsequent staff requirements memoranda associated with SECY-11-0124 (NRC, 2011c) and SECY-11-0137 (NRC, 2011d) directed the NRC staff to issue a request for information to licensees pursuant to 10 CFR 50.54(f) to address this recommendation.

Enclosure 2 to the 50.54(f) letter (NRC, 2012a) requested that licensees reevaluate flood hazards for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits (ESPs) and combined licenses (COLs). The required response section of Enclosure 2 specified that NRC staff would provide a prioritization plan indicating Flooding Hazard Reevaluation Report (FHRR) deadlines for individual plants. On May 11, 2012, the staff issued its prioritization of the FHRRs (NRC, 2012c).

By letter dated March 12, 2014 (Exelon, 2014), Exelon Generation Company, LLC (Exelon, the licensee), provided its FHRR for LaSalle County Station, Units 1 and 2 (LaSalle). The NRC staff subsequently issued requests for additional information (RAIs) to the licensee (NRC, 2014a and NRC, 2015b). The licensee responded to the RAIs by letters dated July 14, 2014 (Kaegi, 2014), and May 5, 2015 (Kaegi, 2015).

By letter dated September 3, 2015, the NRC staff issued an interim staff response (ISR) letter to the licensee (NRC, 2015c). The purpose of the ISR letter is to provide the flood hazard information suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 (NRC, 2012b) and the additional assessments associated with Enclosure 2 of the 50.54 (f) letter. The ISR letter also made reference to this staff assessment, which documents NRC staff's basis and conclusions. The flood hazard mechanism values presented in the ISR letter's enclosures match the values in this staff assessment without change or alteration.

As mentioned in the ISR letter, the reevaluated flood hazard results for the local intense precipitation (LIP), and storm surge on the cooling pond are not bounded by the plant's current design basis (CDB) hazard. Consistent with the 50.54(f) letter and amended by the process outlined in COMSECY-15-0019 and Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2016-01, Revision 0 (NRC, 2015c and NRC, 2016c), the NRC staff anticipates that the licensee will perform a focused evaluation for LIP and associated site drainage that assesses the impact of the LIP hazard on the site and evaluates and implements any necessary programmatic, procedural, or plant modifications to address this hazard exceedance. For the storm surge flood-causing mechanism, the NRC staff anticipates that the licensee will submit either (1) an integrated assessment or (2) a focused evaluation confirming the capability of existing flood protection or implementing new flood protection consistent with the process outlined in COMSECY-15-0019 (NRC, 2015c).

Additionally, the licensee provided supplemental information for flood event duration (FED) parameters and flood-related associated effects (AE) for several sites by letter dated October 4, 2016 (Kaegi, 2016). For the LaSalle site, the licensee provided FED and AE parameters for the LIP flood hazard. The NRC staff's review of this supplemental information is discussed in Section 4 of this staff assessment.

In Enclosure 3 of the FHRR, the licensee provided interim actions and procedures taken to address the higher flood hazards relative to the design basis. These interim actions were reviewed as part of a separate assessment prepared by the NRC staff (NRC, 2015a).

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter (NRC, 2012a) requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for ESPs and COLs. This section of the staff assessment describes present-day regulatory requirements that are applicable to the FHRR.

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

General Design Criterion 2 in Appendix A of 10 CFR Part 50 states that structures, systems, and components (SSCs) important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena, such as earthquakes, tornados, hurricanes, floods, tsunamis, and seiches without the loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to have sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

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

Section 54.3 of 10 CFR defines the current licensing basis (CLB) as "the set of NRC requirements applicable to a specific plant and a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed and in effect." This includes 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 52, 54, 55, 70, 72, 73, 100 and appendices thereto; orders; license conditions; exemptions; and technical specifications, as well as the plant-specific design-basis information as documented in the most recent updated final safety analysis report (UFSAR). The licensee's commitments made in docketed licensing correspondence, which remain in effect, are also considered part of the CLB.

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

2.2 Enclosure 2 to the 50.54(f) Letter

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter (NRC, 2012a) requested, in part, that licensees reevaluate the flood-causing mechanisms for their respective sites using present-day methodologies and regulatory guidance used by the NRC for the ESP and COL reviews.

2.2.1 Flood-Causing Mechanisms

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

2.2.2 Associated Effects

In reevaluating the flood-causing mechanisms, the "flood height and associated effects" should be considered. Guidance document JLD-ISG-2012-05 (NRC, 2012d) defines "flood height and associated effects" as the maximum stillwater surface elevation plus:

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

2.2.3 Combined Effects Flood

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

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

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

2.2.4 Flood Event Duration

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

2.3 Actions Following the FHRR

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

- Submit an interim action plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard.

- Perform an integrated assessment to (a) evaluate the effectiveness of the CDB (i.e., flood protection and mitigation systems); (b) identify plant-specific vulnerabilities; and (c) assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating consequences of flooding for the flood event duration.

If the reevaluated flood hazard is bounded by the CDB flood hazard for all flood-causing mechanisms at the site, licensees were not required to perform an integrated assessment.

COMSECY-15-0019 (NRC, 2015b) outlines a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes an approach in which licensees with LIP hazards exceeding their CDB flood will not be required to complete an integrated assessment, but instead will perform a focused evaluation. As part of the focused evaluation, licensees will assess the impact of the LIP hazard on their sites and then evaluate and implement any necessary programmatic, procedural, or plant modifications to address the hazard exceedance. For other flood hazard mechanisms that exceed the CDB, licensees can assess the impact of these reevaluated hazards on their site by performing either a focused evaluation or a revised integrated assessment (NRC, 2015b).

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the information provided for the flood hazard reevaluation of LaSalle (Exelon, 2014; Kaegi, 2014; and Kaegi, 2015). The licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

To provide additional information in support of the summaries and conclusions in the LaSalle FHRR, the licensee made calculation packages available to the NRC staff via an electronic reading room. The NRC staff did not rely directly on these calculation packages in its review; they were found only to expand upon and clarify the information provided in the LaSalle FHRR, and so those calculation packages were not docketed or cited.

All elevations in this staff assessment are reported in mean sea level (MSL). The licensee used the North American Vertical Datum of 1988 (NAVD88) at times in the LaSalle FHRR, and provided a conversion to NAVD88 from MSL as:

NAVD88 = MSL + 0.22 ft (.07 m) (Exelon, 2014).

The LaSalle plant grade elevations vary between 710.0 ft (216.4 m) and 710.5 ft (216.6m) MSL.

3.1 Site Information

The 50.54(f) letter includes the SSCs important to safety in the scope of the hazard reevaluation. The licensee included pertinent data concerning these SSCs in the LaSalle FHRR. The NRC staff reviewed and summarized this information as follows in the sections below.

3.1.1 Detailed Site Information

The LaSalle site is located in the southeastern part of LaSalle County, 6 mi (9.7 km) southeast of Marseilles, Illinois (Exelon, 2014). A cooling lake forming a part of the closed cooling system lies to the east of the LaSalle site (Figure 3.1-1). The surface area of the cooling lake at its normal pool elevation of 700 ft (213.4 m) MSL is 2,058 acres (832.8 hectares). The lake is impounded by constructed dikes with the top of the dike elevation varying from 705.0 ft (214.9 m) to 706.6 ft (215.4 m) MSL, which is topped by a road with varying elevations from 705.7 ft (215.1 m) to 707.3 ft (215.6 m) MSL. An unnamed creek (Unnamed Creek) on the south east side of the LaSalle site contributes hydrologic flow to the cooling lake. The terrain around the plant site is gently rolling, with ground surface elevations varying from 700 ft (213.4 m) to 724 ft (220.7 m) MSL (Figure 3.1-2). The LaSalle site is approximately 4.5 mi (7.2 km) from the Illinois River, which is the closest river source, and approximately 68 mi (109.4 km) from Lake Michigan, which is the closest large body of water.

3.1.2 Design-Basis Flood Hazards

The CDB flood levels are summarized by flood-causing mechanism in Table 3.1-1 of this staff assessment. The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.3 Flood-Related Changes to the Licensing Basis

The licensee reported in the LaSalle FHRR that there has been flood-related changes to the licensing basis for LIP flooding. The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.4 Changes to the Watershed and Local Area

The licensee reported in the LaSalle FHRR that no changes were noted in the watershed or local area that would affect the LaSalle site. The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

The licensee noted that the exterior walls, penetration seals, and floor slabs of the safety-related structures perform as incorporated passive flood protection features (Exelon, 2014). The lake screen house is affected by static and dynamic consequences of wave activity. The walls of the lake screen house are designed to withstand hydrodynamic forces caused by wind wave runup superimposed on hydrostatic forces. The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter (NRC, 2012a).

3.1.6 Additional Site Details to Assess the Flood Hazard

The licensee made available for review electronic copies of the input/output files for the computer models and calculation packages used in connection with the flood hazard reevaluations. The NRC staff reviewed that material and determined that sufficient information had been provided in response to Enclosure 2 of the 50.54(f) letter (Kaegi, 2014).

3.1.7 Results of Plant Walkdown Activities

The 50.54(f) letter (NRC, 2012a) requested that licensees plan and perform plant walkdown activities to verify that current flood protection systems are available, functional, and implementable. Other requests described in the 50.54(f) letter asked the licensee to report any relevant information from the results of the plant walkdown activities (NRC, 2012a).

By letter dated November 27, 2012 (Kaegi, 2012), the licensee provided the requisite flood walkdown report for LaSalle. The NRC staff issued a staff assessment on June 30, 2014 (NRC, 2014b), which documented its review of the flooding walkdown report and concluded that the licensee's implementation of flooding walkdown methodology met the intent of the 50.54(f) letter.

3.2 Local Intense Precipitation and Associated Site Drainage

The licensee reported in the LaSalle FHRR that the reevaluated flood hazard, including associated effects, for LIP and associated site drainage is based on a stillwater surface elevation of 710.8 ft (216.65 m) MSL. This flood-causing mechanism is discussed in the licensee's CDB. The CDB probable maximum flood (PMF) elevation for LIP and associated site drainage is based on a stillwater surface elevation of of 710.1 ft MSL for the Zone I (northern portion of the site) and 710.3 ft MSL for the Zone II (southern portion of the site).

3.2.1 Model Inputs and Assumptions

As stated in the LaSalle FHRR (Exelon, 2014), the licensee considered the 1-hr, 1-sq mi probable maximum precipitation (PMP) as the LIP event, as defined in NUREG-7046 (NRC, 2011e). The licensee justified its selection by indicating that the 1- sq mi LIP event would fully encompass the LaSalle site drainage area (Kaegi, 2015). Additionally, the front-loaded temporal distribution of the 1-hr storm event used by the licensee was chosen due to the design meteorological storm as defined in NUREG/CR-7046 (NRC, 2011e). The NRC staff found this to be reasonable for the purposes of the 50.54(f) letter response.

The licensee applied a two-dimensional (2D) numerical model to assess water surface elevations, flow depths, and impact loads. Specifically, the licensee constructed a FLO-2D Pro (FLO-2D, 2013) build 13-08-09 model of the LaSalle site. FLO-2D simulates open channel flow through a numerical approximation of shallow water equations (Exelon, 2014). The 2D model determines flow direction based on a grid of ground topography, more accurately representing lateral flow paths than a one-dimensional model in which a predominant flow direction must be a priori assigned.

The assumptions made by the licensee are based on a conservative approach suggested in NUREG/CR-7046 (NRC, 2011e). The licensee assumed no runoff losses, non-functional active system components, and completely blocked passive drainage system components during the

LIP event (Exelon, 2014). It was also assumed that all the precipitation falling on building roofs is discharged directly to the ground and contributes to the ground surface runoff. The model is run with only the LIP rainfall event and is not coincidental with any other flooding event.

The steps defined by the licensee to set up the LIP event model are as follows:

1. Create a grid system using ground surface topographical data;

2. Assign computational boundary and outflow elements;

3. Specify the site's land cover roughness coefficients (Manning's *n* value);

4. Identify obstructions blocking and/or diverting water flow; and

5. Assign precipitation to the model.

The NRC staff reviewed the licensee's model inputs and assumptions and found them to be reasonable.

3.2.2 Site Topography and Grid Design

Three alternatives (20 ft x 20 ft (6.10 m x 6.10 m), 10 ft x 10 ft (3.05 m x 3.05 m), and 5 ft x 5 ft (1.52 m x 1.52 m)) were selected as potential cell sizes for the grid of the LIP model (Kaegi, 2014). A sensitivity analysis indicated that between the two most refined grid sizes, 10 ft x 10 ft (3.05 m x 3.05 m) and 5 ft x 5 ft (1.52 m x 1.52 m), there was a maximum water surface elevation (WSE) difference of only ± 0.2 ft (0.6 m). With minimal difference in WSE output between the two grids, the licensee initially chose the more run-time efficient 10 ft x 10 ft (3.05 m x 3.05 m) grid size for the model.

The ground surface topography was developed from an aerial survey conducted in 2013 by Aerometric, Inc. using light detection and ranging (LiDAR) technology (Exelon, 2014). Survey points provided calibrations and were used to determine that the terrain model has accuracy of ± 0.083 ft (0.025 m).

The licensee determined the boundary area of the site by evaluating the 5 ft (1.52 m) contours of the LaSalle site (Kaegi, 2014). After the boundary for the LaSalle site was determined based on topographical contours and the model was run using the 10 ft (3.05 m) grid, the licensee determined that the area necessary to capture flooding events was significantly smaller than the previously determined boundaries. Therefore, the simulated area was reduced, and the more refined 5 ft x 5 ft (1.52 m x 1.52 m) model grid was used in the final model calculations.

3.2.3 Site Land Cover

The licensee used aerial imagery and judgment to assign land types to the area covered in the model (Exelon, 2014). The majority of the site is paved surfaces, with smaller sections of water, gravel, shrubs, and grass cover. The Manning's n roughness coefficients were assigned to the specific land cover types based on suggested n-value ranges in the FLO-2D Reference Manual. The licensee determined that the FLO-2D equation which adjusts the roughness coefficients with flow depth was applicable and relevant to the site.

3.2.4 Modeled Obstructions

The licensee identified the obstructions at the site by both LiDAR data and information collected during a site survey (Exelon, 2014). The grid cells containing buildings block flow from going through them. Grid cells occupied by only part of a building are partially blocked. The model accounts for rooftop runoff by routing flow off cells which contain buildings and adding the runoff to the ground flow at the lowest elevation adjacent to the building cells.

Wall barriers located throughout the site are modeled as levees, structures which block water to a specified height and are overtopped once the water elevation is higher than that height (Exelon, 2014). The two types of barriers modeled were the outside vehicle barrier system (OVBS) and the barriers surrounding the power block area. The OVBS elevations were determined by the LiDAR data, while the width was assigned uniformly as 10 ft (3.05 m). The power block area barriers were defined based on aerial imagery and assigned a uniform height of 2.5 ft (0.76 m) based on the site survey data. The staff noticed that although most power block barriers are consistent with those seen in Google Maps imagery (licensee imagery was not provided within the modeling package), the concrete blocks adjacent to and just west of the turbine building are modeled as a singular levee. In aerial imagery, the blocks appear to be separated. However, the licensee states that this will not have a significant impact on the maximum water elevation at nearby critical doors; the topography of the area slopes slightly east, away from the doors.

Hydraulic drainage structures are not modeled because of the assumption of non-functional drainage networks, and therefore channels are not credited with water conveyance (Exelon, 2014). The licensee determined that elevations from the digital terrain model (DTM) should not be modified in drainage channel areas with the justification that although there is no water conveyance, drainage channels will provide water storage volume.

3.2.5 Site-Specific Probable Maximum Precipitation

Initially, the licensee determined the 1-hr, 1-sq mi LIP rainfall amount of 14.8 in (37.6 cm) using Hydrometeorological Reports (HMR) 51 and 52 PMP from the National Oceanic and Atmospheric Administration (NOAA 1978, 1982) rainfall values (as suggested in NUREG/CR-7046) (Exelon, 2014). The licensee also calculated a site-specific PMP (ssPMP) value by compiling local historical meteorological data and identifying local "PMP-type" storms (Exelon, 2014). The licensee created adjustment factors to maximize the large storms for worst-case atmospheric moisture conditions and for transposition of the location of the regional storm to the LaSalle site. The adjustment factors were based on those provided in HMR 52; however, updated maximum dew point climatology, trajectory models, and explicit topographic elevation adjustments were also applied. The largest, adjusted, 1-hr, 1-sq mi rainfall depth of 13.8 in (35.0 cm) was selected as the LIP event and was subsequently divided into sub-hourly (i.e., 15-minute intervals with an end-peaking distribution) increments by the ratios provided in HMR 52. The licensee's reevaluated LIP event results were computed based on the SSPMP depth value.

3.2.6 NRC Staff's Site-Specific Probable Maximum Precipitation Sensitivity Analysis

To evaluate the licensee's use of a LIP event based on an ssPMP value, the NRC staff used information from HMR 52 (NOAA, 1982) to derive an alternative LIP event with a peak rainfall intensity at the endpoint of the event and a 1-h, 1- sq mi (3- sq km) cumulative PMP depth of

14.8 in (37.6 cm). This HMR-based event had a maximum 15-min incremental rainfall depth of about 5 in (12.7 cm) and the same end-peaking temporal distribution used by the licensee. Both maximum depth and peak rainfall intensity for the HMR-based LIP event exceed similar values for the ssPMP-based-event used by the licensee. To evaluate the effects of the licensee's use of an ssPMP-based LIP event, the staff performed an independent calculation to compare the flood modeling results for peak WSE using the licensee's runofff analysis model, FLO-2D, to WSE results obtained by the staff using the licensee's model with an LIP event based on the HMR 52 PMP value.

The results of staff's sensitivity analysis show that the WSEs estimated using the HMR-based event were only slightly higher than the WSEs estimated using the licensee's ssPMP-based event. Differences in the respective WSE estimates did vary from location-to-location within the powerblock area; however, the maximum differences were on the order of +0.1 ft (+0.03 m) near the reactor building. In light of these small differences, the staff determined that it was not necessary to review the manner in which the licensee's ssPMP estimate was derived, and the NRC staff concluded that the licensee's ssPMP values were reasonable to use in the LIP runoff analysis discussed below.

3.2.7 FLO-2D Results

The NRC staff confirmed, based on a review of the licensee-provided FLO-2D output files, that the model has no stability problems nor inappropriate velocity spikes, and that the volume conservation error was very small (less than 0.001 per cent), indicating that FLO-2D had no calculation problems.

The licensee identified the maximum WSEs produced by the model at the doors of the power block buildings. The licensee stated that the reactor building, auxiliary building, and the lake screen house doors are of particular interest because they contain safety-related equipment. The reactor and auxiliary buildings are also connected to other power block buildings, and because the connecting doors could become a pathway to safety equipment, all the power block doors were evaluated.

The CDB is divided into two zones with a maximum water elevation for the entirety of the zone (710.1 ft (216.44 m) MSL for the northern Zone 1 and 710.3 ft (216.50 m) MSL for the southern Zone 2). The licensee compared the maximum water surface elevation at the power block doors to the elevation, at the respective zone, of the CDB (Kaegi, 2014). The majority of the doors have reevalauted WSEs that exceed the CDB.

3.2.8 NRC Staff Conclusion

The NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP and associated site drainage is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit a focused evaluation for LIP and associated site drainage consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015c).

3.3 <u>Streams and Rivers</u>

The licensee reported in the LaSalle FHRR that a reevaluated flood hazard for streams and rivers is based on a stillwater-surface elevation of 705.7 ft (215.1 m) MSL for the LaSalle cooling lake and 706.5 ft (215.3 m) MSL for the Unnamed Creek. The licensee calculated wave runup as part of the storm surge analysis in Section 3.4 of the FHRR (Exelon, 2014). The storm surge flood-causing mechanism and associated waver runup is discussed in Section 3.5 of this staff assessment.

This flood-causing mechanism is discussed in the licensee's CDB. The CDB PMF elevation for streams and rivers is based on a stillwater-surface elevation of 521.8 ft (159.0 m) MSL, and includes wind waves and runup results in an elevation of 522.5 ft (159.3 m) MSL.

The NRC staff reviewed the flooding hazard from streams and rivers, including associated effects, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance.

3.3.1 Probable Maximum Flood Alternative Selection

According to the LaSalle FHRR (Exelon, 2014), the flooding hazard for the PMF in streams and rivers, as well as the cooling pond, were based on the following three alternatives as defined in NUREG/CR-7046 (NRC 2011e):

- Alternative 1 - a combination of mean monthly base flow; median soil moisture; antecedent of subsequent rain, specifically the lesser of: (1) rainfall equal to 40% of PMP, and (2) a 500-yr rainfall; the PMP for all seasons; and 2-yr wind waves along the critical direction.

- Alternative 2 - a combination of mean monthly base flow; probable maximum snowpack; a 100-yr, snow season rainfall; and 2-yr wind waves along the critical direction.

- Alternative 3 - a combination of mean monthly base flow; a 100-yr snowpack; snow season PMP; and 2-yr wind waves along the critical direction.

The licensee provided discussions of all of the alternatives (Exelon, 2014). The all-season PMP was derived from the guidance in HMR 51 and HMR 52 (NOAA, 1978; NOAA, 1982). The cool-season PMP estimates were derived from HMR 53 for October to April. The 500-yr and 100-yr rainfall estimates were obtained from NOAA precipitation frequency data server for the LaSalle site (Exelon, 2014). The maximum dew point temperatures, maximum wind speeds, and snow depth data were obtained from meteorological stations near the LaSalle site. The licensee obtained wind speeds typical to the region from NOAA climate maps of the United States. Snow density was obtained from the NOAA interactive snow information website.

Additionally, the licensee obtained mean monthly base flows for the Unnamed Creek from stream flow gauges in close proximity to the LaSalle site (Exelon, 2014). Natural Resource Conservation Service (NRCS) data was used for soil data and the National Land Cover Database 2006 was used to obtain land use land cover data. Manning's roughness coefficients were based on available aerial imagery and guidelines outlined in open-channel hydraulics (Chow, 1959). The licensee used LiDAR data to determine ground surface elevations and data collected from ground surveys for ground features at the LaSalle site (Exelon, 2014). The NRC staff reviewed the available information and concluded that the licensee's alternative selection methodology was reasonable.

3.3.2 Probable Maximum Flood Methodology and Results

Precipitation input for the three alternatives were determined individually. Alternative 1 precipitation event consisted of a 72-hr 500-yr rainfall, followed by three rainless days and then a 72-hr all-season PMP. Alternative 2 consisted of a 72-hr 100-yr cool-season rainfall with snowmelt from a probable maximum snowpack. The Alternative 3 precipitation event consisted of a 72-hr cool-season PMP coincident with snowmelt from a 100-yr snowpack.

The licensee states that the watershed for the LaSalle site was delineated using the ground surface topography (Exelon, 2014). The infiltration loss rate was estimated using the NRCS curve number method with no losses from infiltration applied to the lake subbasin, and infiltration losses were ignored for cool-season PMF alternatives.

The licensee used a synthetic unit hydrograph defined by the National Engineering Handbook (NRCS, 2007) as the basis to transform rainfall to runoff (Exelon, 2014). The licensee used instantaneous rainfall to runoff transformation for the lake subbasin and a 5-min unit hydrograph with 5-min time step intervals to capture peak runoff for the remainder of the LaSalle site. The hydrographs were adjusted to account for non-linear basin response following the guidance in NUREG/CR-7046.

The licensee states in the LaSalle FHRR (Exelon, 2014) that the time of concentration for each sub-basin was determined using guidance found in NRCS TR-55 (NRCS, 1996). The licensee evaluated temporal distributions where the peak rainfall occurred at hour 1, hour 24, hour 36, hour 48, and hour 72. The licensee used U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center-Hydrologic Modeling Software (HEC-HMS) to model reservoir routing in the cooling lake to produce water elevations and to produce hydrographs in the Unnamed Creek for use in hydraulic modeling. Hydraulic modeling of Unnamed Creek was performed using USACE HEC-River Analysis System (RAS) software. The NRC staff reviewed the licensee PMF modeling approach and methodology and determined it was reasonable.

The LaSalle FHRR states that Alternative 1 with a 500-yr rainfall antecedent condition is the controlling combination for the cooling lake and the Unnamed Creek (Exelon, 2014). The licensee determined that the maximum water surface elevation for the cooling lake is 4.3 ft (1.32 m) below the plant grade and 4.8 ft (1.47 m) below the finished floor elevation. The maximum water surface elevation in the Unnamed Creek was determined to be 3.6 ft (1.10 m) below the plant grade elevation and 4.1 (1.23 m) below the finished floor elevation. The NRC staff reviewed the licensee analysis of the PMF for the cooling lake and Unnamed Creek and agrees that Alternative 1 is the controlling combination. Also, the NRC staff finds the licensee results are reasonable.

3.3.3 NRC Staff Conclusion

The NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding from streams and rivers is bounded by the CDB flood hazard. Therefore, the NRC staff determined that flooding from streams and rivers does not need to be analyzed in a focused evaluation or integrated assessment.

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in the LaSalle FHRR that the reevaluated hazard, including associated effects, for failure of dams and onsite water control or storage structures does not inundate the LaSalle site, but did not report a PMF elevation (Exelon, 2014). This flood-causing mechanism is discussed in the licensee's CDB, but no PMF elevation was reported. The licensee states that the LaSalle plant grade elevation is 3 ft (0.91 m) above the top of the cooling lake dikes and a breach in any of the dikes would result in the impounded water discharging directly into local creeks that meet the Illinois River.

The licensee stated in the LaSalle FHRR that the CLB PMF on the Illinois River at the LaSalle site with a discharge rate of 350,000 cfs (9910.9 m^3/s) results in a PMF WSE of 521.8 ft (159.04 m) MSL (Exelon, 2014). The CLB PMF on the Illinois River is 39 ft (11.9 m) above the Illinois River normal pool elevation of 482.8 ft (147.2 m) MSL at the LaSalle site. The licensee then assumed that a reevaluated PMF on the Illinois River results in doubling the water surface elevation of the CLB PMF on the Illinois River from 39 ft (11.9 m) to 78 ft (23.8 m). The resulting WSE would be 560.8 ft (170.9 m) MSL. This hypothetical reevaluated PMF on the Illinois River would be 149 ft (45.4 m) below the plant grade of 710.0 ft (216.41 m) MSL. Therefore, the licensee determined that the possibility of flooding as a result of PMF, including dam failure on the Illinois River, could not impact the LaSalle site.

The NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for failure of dams and onsite water control or storage structures is bounded by the CDB flood hazard. Additionally, the NRC staff reviewed the available information in the LaSalle FHRR and topography of the LaSalle site and concluded that it is reasonable. The NRC staff also concludes that any breach in the cooling lake dikes would induce a flood well below the LaSalle plant grade elevation.

Therefore, the NRC staff determined that flooding from failure of dams or onsite water control or storage structures does not need to be analyzed in a focused evaluation or an integrated assessment.

3.5 Storm Surge

In the LaSalle FHRR, the licensee reported the elevations for both a probable maximum storm surge (PMSS) and a combined events flood that included storm surge (Exelon, 2014). As discussed in Section 3.5.1 below, the PMSS flood-causing mechanism alone would not impact the LaSalle site.

For the combined event, including storm surge, the licensee reported a reevaluated total WSE of 710.6 ft (215.59 m), which also includes waves and runup, at the cooling lake screen house and 712.0 ft (217.02 m) at the inlet structure. Coincident with this event is a 25-yr flood to increase the elevation of the cooling lake to the maximum controlled water level plus winds that drive the probable storm surge, waves, and runup. (Exelon, 2014). The CDB for this hazard is induced by a PMF and is reported in three different locations. The CDB stillwater elevation for PMF on the cooling lake at the dike is 704.3 ft (214.67 m) MSL and with waves and runup the elevation is 707.2 ft (215.55 m) MSL. The CDB stillwater elevation for PMF on the cooling lake at the plant is 704.3 ft (214.67 m) MSL and with waves and runup its 705.6 ft (215.07 m) MSL. The CDB stillwater elevation for PMF on the cooling lake at the lake screen house is 704.3 ft (214.67 m) MSL and with waves and runup the elevation is 706.1 ft (215.22 m) MSL.

3.5.1 Probable Maximum Storm Surge

The licensee noted in the LaSalle FHRR that the reevaluated storm surge analysis is based on guidance outlined in NUREG/CR-7046 (NRC, 2011e), ANS-2.8-1992 (ANSI/ANS, 1992), JLD-ISG-2012-06, and NUREG/CR-6966. The licensee used a digital elevation model (DEM) that was created during the cooling lake construction as input for the lake bathymetry (Exelon, 2014). The licensee used LiDAR data to determine ground surface elevations. A constant over-water wind speed equal to 100 mph (160.9 km/hr) was used to initiate the storm surge event. Intake water level was set as the maximum controlled water level (700 ft (213.4 m) MSL). Mannings roughness values were obtained from Chow (1959) and set to 0.02. Wind data used to calculate the natural oscillation period of wind events was obtained from the Chicago/Midway International Airport.

The licensee used the Delft3D computer model to evaluate the PMSS on the LaSalle cooling lake (Exelon, 2014). The results of the computer model showed that a 90 degree fetch direction caused the largest storm surge event. The PMSS event produced a maximum surge of 2.7 ft (0.02 m). The licensee stated that wave runup computations were performed as part of the combination events (Exelon, 2014), which are described in Section 3.5.2 of this staff assessment. The NRC staff reviewed the methods and results used by the licensee and found the selected method was reasonable and applied appropriately. The NRC staff agrees with the licensee that the PMSS flood-causing mechanism alone could not impact the LaSalle site.

3.5.2 Total Maximum Water Surface Elevation (Combined Events Flood)

The licensee analyzed a wide number of plausibly-combined events with the storm surge hazard, based on the guidance in NUREG/CR-7046 (NRC, 2011e) and ANSI/ANS-2.8 (1992).

<u>Alternative Selection</u>

The licensee analyzed the following combinations for flood-causing events on the cooling pond that included mean monthly base flow (Exelon, 2014):

- Combination of mean the monthly base flow, median soil moisture, an antecedent rain, the PMP, and waves induced by a 2-yr wind speed applied along the critical direction.
- Combination of the mean monthly base flow, probable maximum snowpack, a 100-yr snow season rainfall, and waves induced by a 2-yr wind speed applied along the critical direction.
- Combination of the mean monthly base flow, a 100-yr snow pack, snow season PMP, and waves induced by a 2-yr wind speed applied along the critical direction.

The licensee also analyzed a combination of flooding events that included the probable maximum surge and seiche with wind activity and the maximum controlled level in the cooling lake (Exelon, 2014).

Additionally, the licensee analyzed the following combination of flooding events (Exelon, 2014):

- Combination of the lesser of one-half of the PMF or the 500-year flood, surge, and seiche from worst regional hurricane or windstorm with wind-wave activity, and the lesser of the 100-yr or maximum controlled water level in the cooling lake.
- Combination of the PMF in the cooling lake, a 25-yr surge and seiche with wind-wave activity, and the lesser of the 100-yr or the maximum controlled water level in the cooling lake.
- Combination of the 25-yr flood on the cooling lake, probable maximum surge and seiche with wind-wave activity, and the lesser of the 100-yr or the maximum controlled water level in the cooling lake.

Combined Events Modeling

The licensee stated in the LaSalle FHRR that the combined events were modeled using Delft3D computer software (Exelon, 2014). The licensee modified the Delft3D model to use a water level as a result of a flooding event as a starting water level for the cooling lake and an appropriate wind velocity as a forcing mechanism. The wind was applied in the east-west direction (critical direction) and a west-east direction to assess water levels at different locations on the cooling lake. The critical wind direction produced the highest WSE.

Wave Runup and Maximum Wave Height

The licensee stated in the LaSalle FHRR that wave runup was determined using guidance outlined in the USACE Coastal Engineering Manual (Exelon, 2014). The maximum wave runup was based on the significant wave height using an irregular waves approach and surf similarity parameter, which is dependent on deep water wave length and period. Wave parameters were determined from Delft3D modeling results. For wave runup on smooth surfaces, the licensee limited the maximum wave runup to 2.5 times the significant wave height. For maximum wave height, the licensee multiplied the significant wave height by 1.67. The licensee determined the maximum WSE by summing the maximum stillwater elevation and the greater of maximum wave runup or maximum wave height.

Combined Events Results and NRC Staff Review

The critical combination of events included the 25-yr flood in stream, probable maximum surge and seiche with wind-wave activity, and the controlled water level in the cooling lake. The 25-yr flood was modeled in HEC-HMS by applying a 25-yr rainfall to produce an all-season PMF over the cooling lake watershed. The probable maximum surge and seiche was determined by applying a 25-yr wind velocity in the Delft3D model along the critical direction. The NRC staff reviewed the licensee's model parameter selections, water surface elevation results, and run-time output. Based on this review, the NRC staff concluded that the licensee's results for the combined flooding events scenario were appropriate and reasonable.

3.5.2 Conclusion

The NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for storm surge as a result of a combination of flood-causing events including the 25-yr flood in stream, probable maximum surge and seiche with wind-wave activity, and the controlled water level in the cooling lake is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit an additional assessment of this flooding mechanism consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015c).

3.6 Seiche

The licensee reported in the LaSalle FHRR that the reevaluated hazard, including associated effects, for seiche-related flooding effects is based on a hypothetical wind storm event which produced a maximum WSE of 704.1 ft (214.61 m) MSL at the lake screen house (Exelon, 2014). The reevaluated seiche flood hazard elevation is approximately 6 ft (1.8 m) lower than the plant grade elevation. This flood-causing mechanism is not discussed in the LaSalle CDB.

The licensee states in the LaSalle FHRR that a hierarchical hazard assessment approach, as described in NUREG/CR-7046 (NRC, 2011e), was used to determine the probable maximum seiche of the cooling lake (Exelon, 2014). The licensee did a comparison of the natural oscillation periods of external forces and natural period of the cooling lake. Additionally, the licensee computed the potential seiche amplitude by applying external forcing at the resonance period.

The licensee determined that based on spectral analysis performed for the cooling lake, the fundamental period is less than the fundamental period of the forcing mechanism (Exelon, 2016). Therefore, based on the spectral analysis, a seiche would not be possible in the cooling lake. However, the licensee created a hypothetical wind storm with the fundamental period corresponding to the fundamental period of the cooling lake. The hypothetical wind storm event produced a seiche height of 4.1 ft (1.25 m) and elevation of 704.1 ft (214.61 m) MSL at the lake screen house. The reevaluated seiche flood hazard is significantly lower than the plant grade elevation of 710.0 ft (216 m) MSL.

The NRC staff reviewed the information provided by the license and agrees that a seiche will not impact the LaSalle site. Therefore, the NRC staff determined that flooding from seiche does not need to be analyzed in a focused evaluation or an additional assessment.

3.7 Tsunami

The licensee reported in the LaSalle FHRR that the reevaluated hazard, including associated effects, for tsunami does not inundate the plant site. This flood-causing mechanism is discussed in the licensee's CDB, but was not considered to be physically plausible due to the inland location of the LaSalle site which does not directly connect with any body of water capable of producing a tsunami.

The licensee stated in the LaSalle FHRR that a review of the NOAA natural tsunami database indicates that no known causes of earthquake events significant enough to produce a tsunami are known to occur near the LaSalle site (Exelon, 2014). Additionally, the licensee stated the LaSalle site is located inland of any major water bodies and the on-site cooling lake does not possess a bottom or and shoreline slopes that are susceptible to tsunami formation.

The NRC staff reviewed the information provided by the license and confirms the licensee's conclusion that a tsunami could not impact the site. The NRC staff also confirmed the licensee's conclusion that the reevaluated hazard for tsunami-induced flooding at the LaSalle site is bounded by the CDB flood hazard. Therefore, the NRC staff determined that flooding from tsunami does not need to be analyzed in a focused evaluation or an additional assessment.

3.8 Ice-Induced Flooding

The licensee reported in the LaSalle FHRR that the reevaluated hazard, including associated effects, for ice-induced flooding does not inundate the plant site, but did not report a probable maximum flood elevation (Exelon, 2014). This flood-causing mechanism is discussed in the licensee's CDB, but no probable maximum flood elevation was reported.

The licensee states in the LaSalle FHRR that there are no historical records of ice jams occurring on streams in the watershed, but are known to occur in the area. The licensee provided an analysis of a hypothetical ice jam on the Unnamed Creek located on the southeast side of the LaSalle site. The results indicate that the potential flood elevation would be less than the PMF WSE. The NRC staff reviewed the available information in the LaSalle FHRR and determined that it is unreasonable for the LaSalle site to flood as a result of an ice jam on the Unnamed Creek.

The licensee noted in the LaSalle FHRR that ice jams on the Illinois River are plausible (Exelon, 2014). However, the distance from the site to the Illinois River is approximately 5 miles (8.0 km) and the LaSalle site is approximately 220 ft (67.1 m) higher than the river. The NRC staff reviewed information available in the USACE's Cold Regions Research and Engineering Laboratory (CRREL) ice jam database for the historic occurrence of ice jams near the LaSalle site (USACE, 2016). The database indicated that the nearest occurrence of historic ice jams are located on the Illinois River downstream of the LaSalle site near the town of Marseilles, Illinois. The NRC staff noted in Section 3.4 of this staff assessment that flood on the Illinois River would be well below the LaSalle plant grade elevation. Therefore, it is reasonable to conclude that flooding as a result of ice jams on the Illinois River would not result in flooding on the LaSalle site.

The NRC staff confirmed the licensee's conclusion that the PMF from ice-induced flooding would not inundate the LaSalle site. The NRC staff also confirmed the licensee's conclusion that the reevaluated hazard for ice-induced flooding of the site is bounded by the CDB flood hazard. Therefore, the NRC staff determined that ice-induced flooding does not need to be analyzed in a focused evaluation or an additional assessment.

3.9 Channel Migrations or Diversions

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

For the Illinois River, the licensee compared historical and current topographic maps spanning a 55 year period and found no evidence of channel migration (Exelon, 2014). The NRC staff examined U.S. Geological Survey (USGS) topographic maps dating from 1916 to 2016 confirm that no channel migration of the Illinois River channel occurred during that period (USGS, 2016).

The NRC staff reviewed the information provided by the license and confirms the licensee's conclusion that the flood hazard from channel migration or diversions is bounded by the CDB flood hazard. Therefore, the NRC staff determined that flooding from channel migration or diversion does not need to be analyzed in a focused evaluation or an additional assessment.

4.0 REEVALUATED FLOOD ELEVATION, EVENT DURATION AND ASSOCIATED EFFECTS FOR HAZARDS NOT BOUNDED BY THE CDB

4.1 Reevaluated Flood Elevation for Hazards Not Bounded by the CDB

Section 3 of this staff assessment documents the NRC staff review of the licensee's flood hazard water elevations results. Table 4.1-1 contains the maximum flood height results, including waves and run-up, for flood mechanisms not bounded by the CDB presented in Table 3.1-1. The NRC staff agrees with the licensee's conclusion that LIP and storm surge flood-causing mechanisms are not bounded by the CDB. Consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015c), the NRC staff anticipates the licensee will submit a focused evaluation for LIP and associated site drainage. Additionally, the NRC staff anticipates that the licensee will submit an additional assessment for the storm surge flood-causing mechanism, consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015c).

4.2 Flood Event Duration for Hazards Not Bounded by the CDB

The NRC staff reviewed information provided in Exelon's 50.54(f) response (Exelon, 2014 and Kaegi, 2016) regarding the FED parameters needed to perform the additional assessment of plant response for flood hazards not bounded by the CDB. The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 4.2-1. The NRC staff considers the values reported to be reasonable.

The licensee provided FED parameter values for the LIP flood-causing mechanism (Kaegi, 2016). The licensee computed flood duration times at power block doors using FLO-2D Model results. The duration of site inundation ranged up to 66 minutes (1.1 hrs). The licensee states in the LaSalle FHRR that there is no appreciable warning time except those provided by weather forecasts. The licensee states that they will follow NEI 15-05 (NEI, 2015) guidance regarding LIP warning time. The period of inundation includes the time for water to recede from the LaSalle site. Based on the NRC staff's review of the LaSalle FHRR, the inundation recession time is less than 1-hr and thus minimal (Exelon, 2016).

The licensee stated that the storm surge flood-causing mechanism is not bounded by the CDB; however, this flood-causing mechanism also does not inundate the LaSalle site (Exelon, 2014). The licensee states in the LaSalle FHRR Table 4.0.4 that the lake intake screen house and core standby cooling system (CSCS) inlet structure are protected by means of permanent and passive flood protection. Therefore, the storm surge FED parameters are not applicable.

The NRC staff reviewed the site layout with topographic map provided by the FSAR Figure 2.5-59, from which the NRC staff determined that the plant is free from the cooling pond storm surge flooding because the reevaluated flood level in the cooling pond may not exceed the ground elevation between the plant and the cooling pond. The NRC staff agrees with the licensee conclusion that FED parameters are not applicable to the reevaluated storm surge flood-causing mechanism.

The NRC staff reviewed the FED parameters provided in the licensee's response (Exelon, 2014; Kaegi, 2014; Kaegi, 2015; and Kaegi, 2016) and determined that they are reasonable for use in future assessments of plant response.

4.3 Associated Effects for Hazards Not Bounded by the CDB

The NRC staff reviewed information provided in Exelon's 50.54(f) response (Exelon, 2014; Kaegi, 2014; Kaegi, 2015; and Kaegi, 2016) regarding associated effects parameters needed to perform future additional assessments of plant response for flood hazards not bounded by the CDB. Associated effects parameters not directly associated with a maximum WSE are listed in Table 4.3-1.

For the LIP reevaluated flood hazard, the licensee used 2D modeling results to determine that the maximum hydrodynamic force per linear foot of structure is 3.94 lbs/ft (0.545 kg/m) (Exelon, 2014). Additionally, the licensee determined that the hydrostatic force is 27.72 lbs/ft (3.832 kg/m). The licensee also stated that the reevaluated LIP flood-causing mechanism produced flow velocities ranging between 0.03 and 3.0 ft/s (0.09 to 0.91 m/s) at the LaSalle site. The licensee stated that these low velocities would not produce erosion or scouring at the LaSalle site and sediment transport would not occur. Thus, the licensee did not provide sediment loads for the LIP flood causing mechanism. Additionally, the licensee stated that the debris load was negligible due to the low flow velocities and absence of heavy debris on the LaSalle site. The NRC staff reviewed the input and output of the model and determined that the associated effects parameters for LIP were reasonable.

The licensee provided the maximum hydrodynamic loading for the storm surge flood-causing mechanism at the lake screen house (1134 lb/ft (456.8 kg/m)) and the CSCS inlet structure (4759 lb/ft (658.0 kg/m)) (Exelon, 2014). The licensee stated that debris loads were not considered due to an absence of heavy debris at the LaSalle site. The licensee stated that sediment deposition and erosion were negligible due to the small watershed of the cooling lake and absence of upstream dams. The NRC staff reviewed the input and output of the model and determined that the associated effects parameters for storm surge were reasonable.

The NRC staff reviewed the associated effects parameters provided by the licensee and confirmed that the licensee's associated effects parameter results are reasonable for use in future assessments of plant response as discussed in NEI 12-06 (Revision 2), Appendix G (NEI, 2015), and outlined in COMSECY-15-0019 (NRC, 2015c).

4.4 Conclusion

Based upon the preceding analysis, NRC staff confirmed that the reevaluated flood hazard information defined in the Section 4 is an appropriate input to the additional assessments of plant response as described in the 50.54(f) letter (NRC, 2012a), COMSECY-15-0019, and associated guidance.

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms for the LaSalle site. Based on its review of available information provided in Exelon's 50.54(f) response (Exelon, 2014; Keigi, 2014; and Kaegi, 2015), the NRC staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

Based upon the preceding analysis, the NRC staff confirmed that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter, dated March 12, 2012. In reaching this determination, the NRC staff confirmed the licensee's conclusions that the reevaluated flood hazard results for LIP and storm surge flood-causing mechanisms are not bounded by the CDB flood hazard; additional assessments of plant response will be performed for the local intense precipitation and storm surge flood-causing mechanisms; and the reevaluated flood-causing mechanism information is appropriate input to the additional assessments of plant response as described in the 50.54(f) letter and COMSECY-15-0019.

The NRC staff has no additional information needs with respect to Exelon's 50.54(f) response related to flooding.

6.0 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.

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

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

Table 3.0-1. Summary of Controlling Flood-Causing Mechanisms

Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock Elevation (710.0 ft MSL)[1]	ELEVATION ft (MSL)
Local Intense Precipitation and Associated Drainage	710.8
Storm Surge[2]	
Lake Screen House	710.6
Inlet Structure	712.0

[1] Flood Height and Associated Effects as defined in JLD-ISG-2012-05.

[2] Combination of flood causing events including the 25-yr flood in stream, probable maximum surge and seiche with wind-wave activity, and the controlled water level in the cooling lake flood-causing mechanism

Table 3.1.1 Current Design Basis Flood Hazards (Exelon, 2014)

Mechanism	Stillwater Elevation	Waves/ Runup	Design Basis Hazard Elevation	Reference
Local Intense Precipitation				
LIP Zone 1 (North portion of the site)	710.1 ft MSL	Not Applicable	710.1 ft MSL	FHRR Section 2.2.1
LIP Zone 2 (South portion of the site)	710.3 ft MSL	Not Applicable	710.3 ft MSL	FHRR Section 2.2.1
Streams and Rivers				
Riverine	521.8 ft MSL	0.7 ft	522.5 ft MSL	UFSAR Revision 19 Section 2.4.3; FHRR Section 2.2.2
Failure of Dams and Onsite Water Control/Storage Structures	No impact on the site identified	No impact on the site identified	No impact on the site identified	FHRR Section 2.2.3
Storm Surge				
PMF on Lake at Dike	704.3 ft MSL	2.9 ft	707.2 ft MSL	FHRR 2.2.4
PMF on Cooling Lake at Plant	704.3 ft MSL	1.3 ft	705.6 ft MSL	FHRR 2.2.4
PMF on Cooling Lake at Lake Screen House	704.3 ft MSL	1.8 ft	706.1 ft MSL	FHRR 2.2.4
Seiche	Not Included In DB	Not Included In DB	Not Included In DB	FHRR Section 2.2.5
Tsunami	Not Included In DB	Not Included In DB	Not Included In DB	FHRR Section 2.2.6
Ice-induced Flooding	No impact on the site identified	No impact on the site identified	No impact on the site identified	FHRR Section 2.2.7
Channel Migrations/Diversions	No impact on the site identified	No impact on the site identified	No impact on the site identified	FHRR Section 2.2.8

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

Table 4.1-1: Reevaluated Flood Hazards for Flood-Causing Mechanisms Not Bounded by the CDB

Mechanism	Stillwater Elevation	Associated Effects	Reevaluated Flood Hazard	Reference
Local Intense Precipitation				
LIP for entire site	710.8 ft MSL	Minimal	710.8 ft MSL	FHRR Section 3.1
Storm Surge				
Lake screen house	701.0 ft MSL	9.6 ft	710.6 ft MSL	FHRR Section 3.4.4
Inlet structure	701.0 MSL	11.0 ft	712.0 ft MSL	FHRR Section 3.4.4

Note 1: Reevaluated hazard mechanisms bounded by the CDB (see Table 3.1.1) are not included in this table.

Note 2: Reported values are rounded to the nearest one-tenth of a foot.

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

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Local Intense Precipitation and Associated Drainage	Provided[1]	1.1 hours	Minimal
Storm Surge	Not Applicable	Not Applicable	Not Applicable

Source: Exelon, 2014 and Kaegi, 2015 and Kaegi, 2016.

[1] The licensee stated that they would follow NEI 15-05 (NEI, 2015) to estimate the warning time necessary for flood preparation (Kaegi, 2016).

Table 4.3-1 Associated Effects Inputs for Flood-Causing Mechanisms Not Bounded by the CDB

	Flooding Mechanism	
Associated Effects Factor	**Local Intense Precipitation**	**Storm Surge**
Hydrodynamic loading at plant grade	3.94 lbs/ft (0.545 kg/m)	1,134 lb/ft (156.8 kg/m) at lake screen house and 4,759 lb/ft (658.0 kg/m) at CSCS inlet structure (FHRR, Table 4.0.4)
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	High winds (FHRR, Table 4.0.2)	High winds (FHRR, Table 4.0.4)
Groundwater ingress	Minimal	Minimal
Other pertinent factors (e.g., waterborne projectiles)	None	None

Source: Exelon, 2014 and Kaegi, 2015 and Kaegi, 2016

Figure 2.2.4-1 Flood Event Duration (NRC, 2012c)

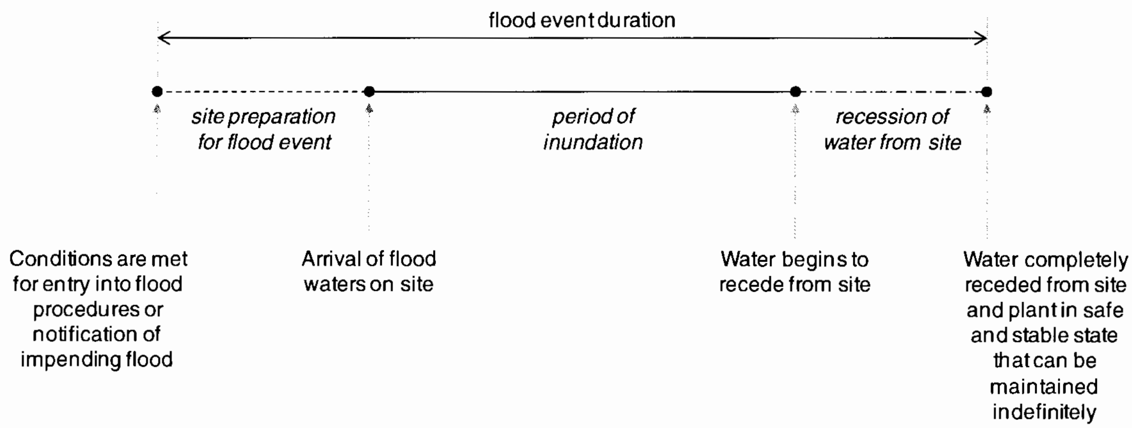

Figure 3.1-1: General LaSalle Site Map and Topography (Source: Exelon, 2014)

Figure 3.1-2: Site Layout and Topography (Source: Exelon, 2015)

LASALLE COUNTY STATION, UNITS 1 AND 2 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION DATED January 10, 2017

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