April 28, 2014

MEMORANDUM TO: John Segala, Chief
Licensing Branch 1
Division of New Reactor Licensing
Office of New Reactors

FROM: Prosanta Chowdhury, Project Manager ***/RA/***
Licensing Branch 1
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: FEBRUARY 4 - 6, 2014, AUDIT OF PSEG POWER, LLC AND PSEG NUCLEAR, LLC EARLY SITE PERMIT APPLICATION HYDROLOGY ANALYSES

By letter dated May 25, 2010, PSEG Power, LLC and PSEG Nuclear, LLC (PSEG) submitted the PSEG Site Early Site Permit (PSEG Site ESP) application to the U.S. Nuclear Regulatory Commission (NRC). On October 29, 2012, the NRC staff issued to PSEG request for additional information (RAI) No. 67 related to hydrology storm surge. By letter dated November 27, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13339A864), PSEG submitted a response to this RAI.

The NRC staff reviewed documents at the PSEG Energy and Environmental Resource Center in Salem, New Jersey, on February 4 - 6, 2014 (see the Audit Plan at ADAMS Accession No. ML14024A169). The NRC staff discussed hydrologic engineering topics that included the site setting and the implementation of the joint probability method (JPM) analysis within the context of storm surge as presented in PSEG's Site Safety Analysis Report (SSAR) Section 2.4.5. Enclosed is a summary report of the audit.

Docket No.: 52-043

Enclosure: As stated

cc: See next page

CONTACT: Prosanta Chowdhury, NRO/DNRL
301-415-1647

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ADAMS Accession No. ML14106A081 *via email NRO-002

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DATE	04/21/2014	04/22/2014	04/25/2014	04/28/2014

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PSEG SITE EARLY SITE PERMIT APPLICATIONHYDROLOGY AUDIT SUMMARY

A. Background

PSEG Power, LLC and PSEG Nuclear, LLC (PSEG) submitted storm surge modeling information in Site Safety Analysis Report (SSAR), Section 2.4, "Hydrology," of the PSEG Site Early Site Permit (ESP) application. In the course of the NRC staff's review, request for additional information (RAI) No. 67, was issued requesting PSEG to provide a storm surge analysis consistent with the current state-of-the-art two-dimensional modeling methods within the context of coupled hydrodynamic ocean circulation and wave models (both being driven by a planetary boundary layer). On November 27, 2013, PSEG submitted a response to RAI No. 67 and a description of the methods utilized in a probabilistic treatment of the surge elevations in a revision to SSAR Section 2.4.5. The NRC staff reviewed the information in the RAI response and identified information needs that would promote a better understanding of the applicant's analyses and bases underlying the formal application of the applicant's methodology. Being the first such evaluation submitted by an NRC applicant or licensee, the NRC staff identified several information needs where further information would benefit the NRC staff's understanding of the methodology used by PSEG.

The purpose of the audit was for the NRC staff to review the storm surge models, supporting modeling documentations, and calculation packages, and discuss these issues with the applicant's staff, subject matter experts (SMEs), and contractors. The audit allowed the NRC staff to better understand the storm surge modeling results in order to make accurate safety conclusions concerning site characteristics and assess the consequences of storm surge flooding. The audit also assisted the NRC staff in identifying additional information that the staff will need during its review of SSAR Section 2.4.5 of the PSEG Site ESP application. The staff developed an initial list of 13 information need items, as discussed in the "Information Need" table below. At the end of the audit, a public meeting was conducted to discuss NRC staff's preliminary audit findings, and to gather any comments from the public; however, no members of the public participated.

B. Regulatory Audit Bases

This regulatory audit was based on the following:

- NUREG 0800, "Standard Review Plan," Section 2.4, "Hydrology"
- Review Standard (RS)-002, "Guidance for Processing Applications for Early Site Permits"
- Regulatory Guide (RG) 1.206, "Combined License Applications for Nuclear Power Plants"

C. Regulatory Audit Scope or Methodology

- The area of focus for the audit was the PSEG Site ESP application and supporting documentation.

D. Information and Other Material Necessary for the Regulatory Audit

- ESP Application, Revision 2, Section 2.4
- Information Needs (*See* ATTACHMENT)

E. Audit Team

The following are the audit team members:
Kenneth Erwin, NRC Audit Team Lead
Henry Jones, NRC Audit Team Member
Michelle Bensi, NRC Audit Team Member
Michael Lee, NRC Audit Team Member
Joseph Giacinto, NRC Audit Team Member
Kevin Quinlan, NRC Audit Team Member
Chris Bender, Taylor Engineering, Inc., NRC Audit Team Member
Michael Eudy, NRC Project Manager
Michael Takacs, NRC Project Manager

F. Logistics

Tuesday (02/04/14) – 8:30 a.m. – 4:30 p.m.

- Audit Opened – Meeting at PSEG offices
- Application overview – PSEG staff
- Breakout sessions – NRC Technical staff and PSEG Technical staff
- Daily debrief

Wednesday (02./05/14) – 9:00 a.m. – 4:30 p.m.

- Audit Opened – Meeting at PSEG offices
- Breakout sessions – NRC Technical staff and PSEG Technical staff
- Daily debrief

Thursday, (02/06/14) – 8:30 a.m. – 4:30 p.m.

- Audit Resumes
- Audit Concludes (11:30 a.m.)
- Audit Exit (12:30 p.m.) – Public Meeting Begins (Conference call format)
- Audit Exit (4:00 p.m.) – Public Meeting Adjourns

Location: PSEG Nuclear Development
Energy and Environmental Resource Center
244 Chestnut Street
Salem, New Jersey

Enclosure

Serial No.	SSAR Section	Information Need	Action (Post Audit)
1	2.4.5	Have available the following SWAN+ADCIRC Mesh documentation and knowledgeable SME to discuss: o Fort.13, Fort.14, Fort.15, Fort. 26 for mesh applied in PSEG analysis runs (FEMA Region 3 Coastal study provided base model) o Documentation that describes changes to FEMA Region 3 mesh and nodal attributes to improve representation around the PSEG facility. NRC staff notes: Discussion during Site Audit provided information on SWAN+ADCIRC model development (basis is FEMA Region 3 Coastal Study files) and execution. Pertinent SWAN+ADCIRC model files requested during Site Audit. Discussion indicated that two DVD's should be able to handle the files needed.	Possible RAI(s). SWAN+ADCIRC model data files not received as of April 8, 2014. If files not received soon, NRC staff will issue an RAI(s) in response to this item.
2	2.4.5	Have available the following SWAN+ADCIRC Validation documentation and knowledgeable SME to discuss: o Wind and pressure field files for validation storms (Isabel and Nor'easter Ida) o Documentation and calculation packages that shows the model validation results (tables and figures of measured versus modeled results for locations with water level, current, and/or wave data). NRC staff notes: Discussion and paper copies of calculations during Site Audit provided information related to the SWAN+ADCIRC model validation. Review of validation documentation showed reasonable results. However, the NRC staff did not receive certain wind and pressure files necessary to confirm validation of all variables.	Possible RAI(s). Model validation data files not received as of April 8, 2014. If files not received soon, NRC staff will issue an RAI(s) in response to this item.
3	2.4.5	Have available the following SWAN+ADCIRC JPM-OS Storm Evaluation documentation and knowledgeable SME to discuss: o Documentation and calculation packages that show the JPM-OS development and resulting JPM-OS storm suite. Specific information needed:	Possible RAI(s) / Open Item. Model stability questions from NRC staff are an open item. Model files not received as of

Serial No.	SSAR Section	Information Need	Action (Post Audit)
		▪ methods to determine JPM-OS storm parameters (track angles, intensities, radius to maximum winds, intensity, etc.) ▪ method to produce JPM-OS winds ▪ method applied to simulate JPM-OS storms in SWAN+ADCIRC ▪ method to analyze SWAN+ADCIRC storm surge data to produce various return period water levels ▪ method to include uncertainty (aleatory and epistemic) o Wind and pressure field files for SWAN+ADCIRC model runs that produced the highest five surge levels at the PSEG facility o Documentation that shows the model results (tables and figures of modeled water level, current, and/or wave data for locations analyzed near the PSEG facility) o Documentation that discusses any changes to modeling approach to handle instances of SWAN+ADCIRC model instability found during simulation of JPM-OS storms <u>NRC staff notes:</u> Discussion during site audit covered the above bulleted topics to varying degrees. The discussion confirmed the model stability during the simulations before peak water levels; however, some model instability was observed following the model's calculation of the peak water levels. Discussion also occurred on how the wave runup analysis applied the model water level and wave data. Wind and pressure field files for the SWAN+ADCIRC model runs that produced the highest five surge levels at the PSEG facility are necessary to confirm the levels produced by the most significant storms.	April 8, 2014. Requires further NRC staff review of input files (Serial No.1).

Serial No.	SSAR Section	Information Need	Action (Post Audit)
4	2.4.5	Have available the following wave runup evaluation documentation and knowledgeable SME to discuss: o Documentation and calculation packages that detail the approach, analysis, and results of wave runup calculations at the PSEG facility. o Documentation of pertinent facility structure slopes, roughness, and heights as applied in the wave run-up calculations o Documentation of how SWAN wave heights and periods were applied within wave run-up calculations ▪ Significant wave height versus maximum wave height, or other wave height level ▪ Peak period, mean period, or other wave period level NRC staff notes: Discussion during the site audit and review of calculation packages provided during the audit detailed the procedure to develop the wave runup estimates. The discussion clarified the application of the wave heights and period applied and the overall methodology, however, some files and supplemental information were not available in the electronic reading room and will need further review by the NRC staff.	Possible RAI(s) / Open Item. Pending NRC staff review of supplemental information (SWAN+ADCIRC model control files and data) and information in electronic reading room regarding setup, extraction, and processing of wave data.
5	2.4.5	Have available the following total water level calculation documentation and knowledgeable SME to discuss: o Documentation and calculation packages that detail the approach, analysis, and results of total water level calculations at the PSEG facility (SWAN+ADCIRC plus wave run-up) NRC staff notes: Discussion during the site audit reviewed the general approach to include wave run-up in the total water level calculation. Review of calculation package during the site audit provided additional details of total water level calculation; however, some files and supplemental information were not available in the electronic reading room and will need further review by the NRC staff.	Possible RAI(s) / Open Item. Pending NRC staff review of supplemental information (SWAN+ADCIRC model control files and data) and information in electronic reading room to regarding model setup, extraction, and processing of water level and wave data calculations.

Serial No.	SSAR Section	Information Need	Action (Post Audit)
6	2.4.5	Have available the following probabilistic characterization of storm surge documentation and knowledgeable SME to discuss: o Documentation and calculation packages that detail the approach, analysis, and results of probabilistic water level calculations. Specific information needed: ▪ determination of water levels input into probabilistic model ▪ how tides, river discharge, Holland B, forward velocity handled within method ▪ treatment of uncertainty within the calculations NRC staff notes: Discussions on methods to determine JPM-OS parameters distributions, uncertainty effects, treatment of error, passing of variables between separate portions of the calculation packages, and return period water levels were held between the NRC staff and the applicant. Discussion was also held regarding how some portion of the ranges of some variables used to calculate the response function and hazard curves were pre-selected by the applicant using expert judgment. The applicant stated that this pre-selection is necessary due to the long amount of computing time required to complete all of the variables and range of values; and that the variables preselected were done using conservative storms. Discussions regarding treatment of uncertainty and error were also held for the portions of each variable that were estimated using expert judgment.	Possible RAI(s)
7	2.4.5	Have available appropriate documents and references as well as an SME who is knowledgeable about the probabilistic characterization of storm surge to discuss the following: o Interpretation of the annual exceedance probability (AEP) of 10^{-6} in light of the use of deterministic models and any associated potential bias inherent in those models NRC staff notes: The NRC staff discussed this item with PSEG during the audit and during the public exit meeting. During those discussions, PSEG indicated that they were attempting to develop unbiased deterministic models for use in conjunction with	Possible RAI(s)

Serial No.	SSAR Section	Information Need	Action (Post Audit)
		the probabilistic characterization of storm surge. However, PSEG noted that engineering judgment and experience suggests that there are known (though not quantified) sources of conservatism in the model. Any new deterministic models developed by the applicant will need to be reviewed by the NRC staff.	
8	2.4.5	Have available relevant documentation and an SME who is knowledgeable about the probabilistic characterization of storm surge to discuss the following: o Probability distributions (distribution models and parameters) associated with storm parameters and error terms in the JPM-OS integral o Basis for distribution models and parameters selected, including any analyses performed using historical data or expert judgment, or based on existing studies (including copies of reports and draft reports taken as final) o Approach to account for epistemic uncertainty in the characterization of selected distributions and their parameters (including potential alternate interpretations of available data) o The effect of limited historical record on the characterization of distribution models and parameters o Approach account for epistemic uncertainty in model selection and characterization of inputs (e.g., bathymetry, topography) o Treatment and incorporation of aleatory uncertainty o The distribution parameters for the composite error term NRC staff notes: The NRC staff discussed the above modeling decisions and methods with PSEG throughout the audit. Consequently, the audit served to provide the NRC staff with a better understanding of the process used by the applicant and the assumptions and modeling decisions that were made to support the probabilistic storm surge analysis. The audit also brought to light several areas for further review in the applicant's documentation and raised several questions related to the applicant's documentation of their analyses. For example, the NRC staff	Possible RAI(s) / Open Items. Pending review of supplemental information in the electronic reading room, further NRC staff analysis, and any revisions to the SSAR to address limited or inconsistent documentation.

Serial No.	SSAR Section	Information Need	Action (Post Audit)
		observed the following: o The applicant's documentation does not fully describe all of the assumptions and steps that the applicant completed for their probabilistic storm surge analysis in calculating the design basis at the PSEG Site using the JPM-OS methodology. This lack of documentation of large portions of the methodology did not provide sufficient information to allow confirmatory analysis or sensitivity studies to be performed by NRC staff. o Inaccuracies and inconsistencies were identified in analysis documentation. Often, the applicant staff or contractor personnel would correct these inconsistencies verbally; however,, several items were identified for further review by the NRC staff. o Some modeling assumptions were based on engineering judgment by the applicant or their contractors. These assumptions were not thoroughly documented in the SSAR, and in some cases, not fully documented as part of the supporting calculation packages. o Some modeling assumptions were based on conclusions presented in draft reports produced by other federal agencies. At the time of the audit, these reports had not been finalized and are not publically available. Thus, the NRC staff was not able to determine if the conclusions presented by the applicant (on behalf of the Federal agency) were subject to change by the Federal agency prior to finalization. Further, the NRC staff was unable to determine if these conclusions had been subject to peer review by the scientific community outside of these agencies. Finally, the NRC staff was unable to determine whether some of the assumptions regarding return periods made by the Federal agencies (evaluating 100-500 year return periods) were applicable to the overall return period being evaluated by the applicant (evaluating $1x10^{-6}$ return periods) During the audit and by follow-up email on February 20, 2014, the NRC staff requested that the applicant add several items to their Electronic Reading Room (ERR), including: (1) probability mass functions associated with each storm parameter; (2) joint probability mass functions associated with each combination of storm parameters; and (3) distribution parameters associated with the storm	

Serial No.	SSAR Section	Information Need	Action (Post Audit)
		track angle and the "storm track window" used to compute the percent of storms affecting the site. The NRC staff received some of the above information during the audit, but the information was received near the end of the audit and, therefore, the NRC staff did not have time to sufficiently review the information.	
9	2.4.5	Have available relevant documentation and an SME who is knowledgeable about the probabilistic characterization of storm surge to discuss the following: o Sensitivity studies performed related to exclusion of parameters or certain ranges of parameters from the JPM-OS integration o Treatment of the Holland B parameter through modification of the standard deviation of the error term NRC staff notes: The NRC staff discussed this item with PSEG during the audit, but some information required by the NRC staff was not available in the electronic reading room. The NRC staff requested this information during the audit, but received only some of the information requested. This issue requires further NRC staff analysis.	Possible RAI(s) / Open Item. Pending NRC staff review of information in electronic reading room and further staff analysis.
10	2.4.5	Have available (1) computer codes, relevant input/output files (including subroutines), and calculation packages used to perform or validate JPM-OS integration and associated calculations and (2) an SME who is knowledgeable about the code, files, and calculations. NRC staff notes: During the audit, the NRC staff reviewed calculation package 2013-10436, which contains documentation and computer codes supporting the probabilistic evaluation of storm surge. The calculation package is also available in the PSEG electronic reading room. However, the NRC staff noted that several subroutines required to support the evaluation are not included in the calculation package and, thus, not available for NRC staff review. During the audit and by follow-up email on February 20, 2014, the NRC staff requested that the applicant add to the ERR any subroutines or other supporting calculations used as part of the probabilistic evaluation of storm surge that are not	Possible RAI(s) / Open Item. Pending NRC staff review of information in electronic reading room and further NRC staff analysis.

Serial No.	SSAR Section	Information Need	Action (Post Audit)
		included in the calculation package 2013-10436.	
11	2.4.5	Have available relevant documentation and an SME who is knowledgeable about the probabilistic characterization of storm surge to discuss the following: o The basis and implication of the selected discretization scheme for the JPM-OS integration NRC staff notes: The NRC staff discussed this item with PSEG during the audit, but this issue requires further NRC staff review and analysis.	Possible RAI(s) / Open Item. Pending NRC staff review of information in electronic reading room and further NRC staff analysis.
12	2.4.5	Have available a table of the storm parameters and resulting surge levels used to develop the surge response surface. NRC staff notes: During the audit, the NRC staff requested that PSEG provide a tabulation of the response surface (including values generated using numerical models, a pressure-differential relationship, interpolation, and extrapolation) for each combination of storm parameters. o The NRC staff received the requested information near the end of the audit and, therefore, did not have time to sufficiently review the information. During the audit and by follow-up email on February 20, 2014, the NRC staff requested that the applicant add a tabulation of the response surface (including values generated using numerical models, a pressure-differential relationship, interpolation, and extrapolation) for each combination of storm parameters to the ERR. o As part of the audit, the NRC staff identified several modeling assumptions that had the potential to be mathematically non-conservative. The NRC staff discussed these assumptions with the applicant staff and contractors during the audit, and the applicant prepared several graphics to support the discussion. During the audit and by follow-up email on February 20, 2014, the NRC staff requested that the licensee add to the ERR these supplemental graphics to support the NRC staff review.	Possible RAI(s) / Open Item. Pending NRC staff review of information in electronic reading room and further NRC staff analysis.

Serial No.	SSAR Section	Information Need	Action (Post Audit)
13	2.4.5	Have available the following Design Basis Level Calculation documentation and knowledgeable SME to discuss: o Data applied to determine the potential Sea Level Rise (SLR) at the PSEG facility o Rationale for selecting 10^{-6} as the annual exceedance probability water level for the design basis flood level NRC staff notes: The SLR discussion during the site audit confirmed the method and value applied (confirmed with National Oceanic and Atmospheric Administration (NOAA) website review). Discussion of the acceptance criteria of the 10^{-6} annual exceedance probability water level for the design basis flood level will require further NRC staff review.	Possible RAI(s) / Open Item. Application of the 10^{-6} annual exceedance probability water level for the design basis flood level requires further review and analysis of the probabilistic approach applied.

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