August 19, 2005

Ms. Marilyn Kray
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200 Exelon Way, KSA3-N
Kennett Square, PA 19348

SUBJECT: POTENTIAL OPEN ITEMS FOR THE SUPPLEMENTAL DRAFT SAFETY EVALUATION REPORT FOR THE EXELON EARLY SITE PERMIT APPLICATION

Dear Ms. Kray:

On September 25, 2003, Exelon Generation Company, LLC (Exelon), tendered its application for an early site permit (ESP) in accordance with Subpart A of Part 52 of Title 10 of the *Code of Federal Regulations* (10 CFR). The proposed site is co-located with the existing Clinton Power Station facility near Clinton, Illinois, and is hereafter identified as the Exelon Generation Company (EGC) ESP site. The U.S. Nuclear Regulatory Commission (NRC) formally accepted the application as a docketed application for an ESP on October 27, 2003.

The NRC staff issued the draft safety evaluation report (DSER) on February 10, 2004. The DSER did not include the staff's technical evaluation of seismology and geology because the Exelon ESP application included a previously unreviewed performance-based methodology for determining the safe shutdown earthquake (SSE) for the EGC ESP site. The NRC staff is developing a supplemental draft SER which will summarize the results of its technical evaluation of this new methodology.

In the process of reviewing information provided by Exelon in its ESP application and in responses to staff requests for additional information (RAIs), the staff has tentatively concluded that certain additional information is still needed for the staff to be able to complete its final SER. These items may be referred to in the supplemental DSER as "open items."

The most significant issue related to this new methodology is associated with the proposed SSE, which is based on the target seismic performance level of 10^{-5} for the annual probability of seismically-induced unacceptable performance. The staff believes that this target value and resulting SSE are not conservative for the EGC ESP site, in that the proposed SSE does not adequately reflect the local seismic hazard for the ESP site.

In accordance with the review schedule provided to you in a letter dated August 16, 2005, the staff plans to issue the supplemental DSER to Exelon by August 26, 2005. Exelon will have 14 days to review the supplemental DSER for proprietary information. After the 14-day proprietary review waiting period, the supplemental draft SER will be made publically available.

In the interest of expediting Exelon's response to the open items, we are enclosing, with this letter, a list and brief description of each open item tentatively identified by the staff (Enclosure 1). We emphasize that these open items are still under staff review, and, therefore, may be changed or deleted. Further, additional open items may be identified as a result of management review of the supplemental DSER before the supplemental DSER is issued. We are providing the tentative open items solely for your convenience and use as you see fit. To ensure that your responses address the staff-approved open items provided in the supplemental DSER, please do not respond to these open items before you receive the supplemental DSER. Also, because of the need to focus staff resources on timely completion of the supplemental DSER, we will not be able to meet with you to discuss any questions or concerns you may have on the tentative open items until after we issue the supplemental DSER.

We hope you find Enclosure 1 informative and useful. Please contact John Segala, the NRC's project manager for review of your ESP application, at (301) 415-1858 (or jps1@nrc.gov) if you have any questions or comments concerning this matter.

Sincerely,

/RA L. Dudes for:/

William D. Beckner, Program Director
New, Research and Test Reactors Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 52-007

Enclosure: As stated

cc w/o encls: See next page

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* See previous concurrence

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Exelon Early Site Permit Application
Supplemental Draft Safety Evaluation Report
Tentative Open Items (subject to change)

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2.5.1.3.1 & 2.5.2.3.3	The staff considers the applicant's response to request for additional information (RAI) 2.5.1-1 to be an adequate assessment of the latest geologic literature concerning the magnitudes for New Madrid characteristic earthquakes. The applicant revised its magnitudes for rupture set number 3 to reflect the changes made by Bakun and Hooper (2004). In addition, the applicant added two new models based on its review of the latest literature and communications with researchers. The applicant assessed the impact of these additions and revisions by reevaluating its probabilistic seismic hazard analysis (PSHA) and found an increase (3 to 4 percent) in the 1 Hertz (Hz) ground motion hazard curve at the mean 10-4 and mean 10-5 hazard levels. However, the applicant did not incorporate this new information into its PSHA or subsequent safe-shutdown earthquake (SSE) ground motion spectrum and indicated that the ESP application did not need to be updated as a result of its response to RAI 2.5.1-1. The applicant's failure to incorporate this information into its PSHA or SSE, and to explain why it did not update the Site Safety Analysis Report (SSAR) to reflect the corrected magnitude estimates, renders its response to RAI 2.5.1-1 incomplete. This is Potential Open Item 1.
2.5.2.3.3	In RAI 2.5.2-3, the staff asked the applicant to describe how the recent Electric Power Research Institute (EPRI) ground motion study converted the distance measure used for each of the attenuation relationships to a common measure. Specifically, the 13 central and eastern United States (CEUS) attenuation relationships selected by the EPRI ground motion experts each use one of two different distance measures. In response to RAI 2.5.2-3, the applicant provided a description of the method it used to convert the "point-source" distance measure to the more commonly used Joyner-Boore distance measure. In EPRI ground motion clusters 1, 2, and 4, all but two of the individual models (Frankel et al. (1996) and Atkinson and Boore (1995)) use the Joyner-Boore distance, which is the closest distance from the site to the surface projection of the fault rupture in kilometers. The other two ground model attenuation relationships use the hypocentral distance, which is the distance from the site to the earthquake focus in kilometers. To convert the point-source distance to the Joyner-Boore distance, the applicant generated a simulated data set. However, the applicant's description of the EPRI study's distance conversion process is vague on several key points. The applicant did not adequately describe or provide the bases for (1) the simulated data set, (2) the functions that EPRI used to fit the simulated data set, (3) the point-source depth distributions for the CEUS proposed by Silva et al. (2002), and (4) the final "appropriate" functions used to provide ground

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	motion relationships in terms of Mw and Joyner-Boore distance. In addition, the applicant did not provide an overall or general explanation of the distance-conversion method nor any indication of the adequacy of the final distance conversion. The staff's request for further clarification and elaboration of the EPRI study distance-conversion method is Potential Open Item 2.
2.5.2.3.5	The staff reviewed the applicant's response to RAI 2.5.4-4 and found that the large variability in strength and stiffness of the site soils, as demonstrated by the S-wave velocities and standard penetration test (SPT) blowcounts from the relatively few borings taken at the Exelon Generation Company (EGC) early site permit (ESP) site, indicates a potentially large epistemic uncertainty in site profiles that cannot easily be captured directly by the randomization process. For the 60 realizations of the site soil column described in the applicant's response, the staff presumes that they were selected using a single base-case velocity profile with associated large values of sigma for the S-wave velocities. The probabilistic procedure in which a single base-case velocity profile is used based on the best estimate (or average) layer velocities generally leads to a mean surface response spectrum primarily controlled by the mean velocity profile. The influence of variability in the velocities (plus/minus one-sigma values) is generally of lower importance than the mean velocity profile in this calculation. For such cases in which large variability in layer S-wave velocities is encountered, it is better (especially for cases in which a small database is available to define mean properties) to use at least two base-case profiles in the calculations. For each base-case profile, a reasonable uncertainty in velocities should also be modeled. Both sets of data are then used to span the sparse data available for the site. The envelope of the site amplification functions from each base-case is then used to define the surface response. Because the site response is largely influenced by the mean velocity profile and not as much by the variability, the applicant needs to develop more than one bounding base-case site velocity model and use these models to evaluate their impact on the surface response spectrum to address the issue of site variability indicated in the available data. The guidance presented in Section 2.5.4.1 of Review Standard (RS)-002 specifies that an unambiguous representation of site conditions needs to be presented in the SSAR. On the basis discussed above, the staff finds that RAI 2.5.4-4 remains unresolved. This is Potential Open Item 3.
2.5.2.3.5	The staff finds that both of the issues it raised in RAI 2.5.4-7 were not adequately resolved by the applicant. The first issue is the impact of the highly plastic clay soils at the site on the assumption of the independence of the modulus reductions and material damping curves from the specific soil type. The second issue concerns the use of the 15 percent damping cutoff and its impact on the final site surface response spectra. The applicant should rerun its site response analysis using appropriate shear

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	modulus and damping curves for the clay soils and at the same time implement the 15 percent damping cutoff. The combination of these two unresolved issues, described above, constitute Potential Open Item 4.
2.5.2.3.6	To determine the appropriateness of the target 10^{-5} annual performance goal and performance-based approach for the Clinton ESP site, the staff reviewed the applicant's final SSE. The final SSE using the performance-based approach is calculated by multiplying the DF and 10^{-4} surface uniform hazard response spectrum (UHRS). Since, by definition, the design factor (DF) is at least 1.0, the final SSE ground motion spectrum will be at least the 10^{-4} UHRS and higher, depending on the value of the amplitude ratio (AR) for the 10^{-4} and 10^{-5} hazard curves. For the Clinton ESP site, the DF values from 2.5 to 100 Hz are very close to 1.0, implying that the final SSE, while meeting the target 10^{-5} annual performance goal, is essentially the 10^{-4} surface UHRS. Because the performance-based SSE is essentially the 10^{-4} surface UHRS, the corresponding controlling earthquakes for the ESP site are mb 6.5 at 83 km (52 mi) (high frequency) and mb 7.2 at 320 km (199 mi) (low frequency). These two earthquakes correspond to events in the Wabash Valley/Southern Illinois seismic zone (WVSZ) and New Madrid seismic zone (NMSZ), respectively. Both of these events are somewhat distant from the ESP site. In contrast, the mean 10^{-5} high-frequency controlling earthquake (mb 6.2 at 24 km (15 mi)) represents a local earthquake from the central Illinois seismic zone. Figure 4.2-19 in SSAR Appendix B shows the 10^{-4} and 10^{-5} UHRS together with the ground motion response spectra for these two sets of controlling earthquakes. Since, as shown in Figure 4.2-19 in SSAR Appendix B, the high-frequency 10^{-5} controlling earthquake ground motion response spectrum from a local earthquake in the central Illinois seismic zone is significantly larger than the SSE ground motion response spectrum, the staff believes that the final performance-based SSE does not adequately represent the seismic hazard for the ESP site. The seismic hazard for the central Illinois basin/background source zone, which encompasses the ESP site, is dominated by the Springfield earthquake. Paleoliquefaction studies in the area have found evidence that one or, more likely, two prehistoric earthquakes occurred 5900 to 7400 years ago near Springfield, Illinois, approximately 30 mi southwest of the ESP site (McNulty and Obermeier, 1999). These earthquakes were large enough to generate liquefaction features, with magnitude estimates ranging between 6.2 and 6.8 for the larger event and at least 5.5 for the second event. In addition to the Springfield events, geologists have discovered paleoliquefaction features further south near Shoal Creek. The estimated magnitude and date for this event is about 6.5 and 5700 years before present (BP). In addition to the above liquefaction features, the applicant also found smaller liquefaction features along the banks of streams closer to the ESP site. Finally, a magnitude 5.4

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	earthquake occurred in 1968 in the Illinois basin. Each of these earthquakes has occurred well within the 100,000-year median return period, corresponding to the median 10^{-5} reference probability recommended by Regulatory Guide (RG) 1.165, as well as the 10,000 year mean return period, corresponding to the mean 10^{-4} hazard level. The combination of these results from regional and local liquefaction studies, as well as the historical seismicity, indicate that there is a significant seismic hazard within the central Illinois basin/background seismic source zone. This seismic hazard is quantified by the ground motion from the 10^{-5} high-frequency controlling earthquake, appropriately scaled to the 5- and 10-Hz hazard curves, with a magnitude of 6.2 at a distance of 24 km (15 mi) from the site. The opening paragraph of 10 CFR 100.23 states the following: > This section sets forth the principal geologic and seismic considerations that guide the Commission in its evaluation of the suitability of the proposed site and adequacy of the design bases established in consideration of the geologic and seismic characteristics of the proposed site, such that, there is a reasonable assurance that a nuclear power plant can be constructed and operated at the proposed site without undue risk to the health and safety of the public. In addition, General Design Criteria (GDC) 2 in Appendix A to 10 CFR Part 50 states the following: > Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components, shall reflect: (1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, . . . It is the staff's position that the SSE developed by the applicant using the target 10^{-5} annual performance goal and performance-based approach does not provide a design-basis ground motion that adequately reflects the seismic characteristics of the proposed site. Furthermore, the applicant's SSE does not represent ground motion from the most severe local earthquake as required by GDC 2. The staff does not view the use of the phrase "historically reported" in GDC 2 as limiting the use of paleoliquefaction features as legitimate indicators of earthquake activity or as limiting the size of the design basis ground motion for prospective

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	nuclear sites. RG 1.165, which describes the geologic investigations necessary to meet the requirements of 10 CFR 100.23, defines capable earthquake sources as the "presence of surface or near-surface deformation of landforms or geologic deposits of a recurring nature within the last approximately 500,000 years or at least once in the last approximately 50,000 years." Both of these dates extend far back into the prehistory of the North American continent. In addition, RG 1.165 recommends that the design-basis ground motion (SSE) be determined using a reference probability of median 10^{-5}, which corresponds to a median ground motion return period of 100,000 years. To determine ground motions with this return period in the CEUS requires the use of paleoliquefaction features to estimate prehistoric earthquake magnitudes and locations. In conclusion, the staff finds that the applicant's SSE does not represent a ground motion of adequate severity to represent the seismic hazard for the ESP site. Based on this conclusion, the staff does not accept the use of the performance-based threshold with the target 10^{-5} annual performance goal as a suitable method for the determination of the SSE for the Clinton ESP site. This is Potential Open Item 5.
2.5.2.3.6	The staff has the following comments and concerns resulting from the staff's review of RAI 2.5.2-7: • Justify the assumption of a linear hazard curve in logarithmic space and the appropriateness of solely using the 10^{-4} to 10^{-5} interval to determine the amplitude ratio AR. • Justify why a b value of 0.4 was used and show how the DF varies with different b values over the range of amplitude ratios. • Clarify the meaning of "onset of significant inelastic deformation" (OSID), specifically the words "onset" and "significant," OSID with regard to the failure of SSCs and core damage, and the relationship of OSID to "essentially elastic" behavior. • Justify the long-term stability of the target performance goal 10^{-5} in comparison to the hazard-based approach (reference probability) in RG 1.165, as both values require the use of PSHAs for several CEUS nuclear sites. • Since the target performance goal 10^{-5} is based on seismic probabilistic risk assessments (PRAs) for current light water reactors (LWRs), justify the use of this value for advanced reactor designs, which may differ considerably from current LWRs. • Since systems, structures, and components (SSCs) for nuclear power plants are designed using the seismic criteria in the

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	Standard Review Plan (SRP), clarify how the design criteria in American Society of Civil Engineers (ASCE)/Structural Engineering Institute (SEI) Standard 43-05 are similar enough that SSCs designed following the SRP would also achieve a 1 percent or lower probability of unacceptable performance. Without further elaboration by the applicant concerning the above issues, the staff is unable to determine the acceptability of the assumptions and equations underlying the performance-based approach. This is Potential Open Item 6.
2.5.4.3.2	The staff reviewed the applicant's comparison of the soil properties between the two sites in Section 5.2 of SSAR Appendix A. The staff's review included a comparison between SPT blowcount values, in situ dry density, moisture content, Atterberg limits, compressibility and strength characteristics, P- and S-wave velocities, and modulus and damping properties. In addition, the staff also reviewed the tabulated statistical summaries of the geotechnical test results that the applicant provided in response to RAI 2.5.4-1. Figures 5-7 through 5-18 in SSAR Appendix A provide an excellent visual comparison of the engineering properties between the CPS and ESP sites. While there are some outliers, for the most part the staff concurs with the applicant's conclusion that the subsurface conditions are similar between the two sites. As such, the staff concludes that the applicant has sufficiently sampled the ESP site subsurface in order to establish the similarity between the Clinton Power Station (CPS) and ESP sites. The staff notes that 76 locations were drilled and sampled by the licensee for the CPS site investigation and that some of these locations (10) overlapped with the ESP site area. Regarding future subsurface investigations for the ESP site, the applicant stated the following: The work being carried out for the EGC ESP was being done before reactor plant design had been selected. Therefore, some of the spacing and depth requirements given in Appendix C of Regulatory Guide 1.132 could not be established. Once a reactor plant design is selected, then the requirements in Appendix C of Regulatory Guide 1.132 will be reviewed again during the COL stage, along with the design requirements of the reactor plant design, to determine whether additional drilling and sampling is needed. Concerning the appropriate spacing of borings or soundings, RG 1.132 states that for favorable uniform geologic conditions, at least one boring should be made at the location of every safety-related structure. Where variable conditions occur, RG 1.132 states that the spacing between borings should be smaller. For larger, heavier structures, such as the containment and auxiliary buildings, RG 1.132 recommends a boring spacing of at least 100 ft with a number of additional borings along the

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	periphery, at corners, and other selected locations. Regarding the appropriate depth for borings, RG 1.132 states that all borings should extend at least 33 ft below the lowest part of the foundation. With regard to these recommendations in RG 1.132, the staff cannot accept the applicant's concluding statement to review RG 1.132 at the combined license (COL) stage to "determine whether additional drilling and sampling is needed" as sufficient. While the staff's review of the applicant's geotechnical field and laboratory test results confirmed the similarity between the CPS and ESP subsurface soil layers and properties, this similarity does not eliminate the need for further soil borings during the COL stage. There are enough variations in the soil properties within the ESP site itself to necessitate further exploration at the COL stage. Examples include variations in SPT blowcount values, S-wave velocities, and other static and dynamic properties, which may indicate localized areas of variable subsurface material. This is Potential Open Item 7.