From: Michael Scott
To: eddie.grant@exeloncorp.com; thomas.mundy@exeloncorp.com
Date: Thu, Jul 15, 2004 1:36 PM
Subject: DRAFT REQUESTS FOR ADDITIONAL INFORMATION

This e-mail is being sent on behalf of Nan Gilles.

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Please find attached a package of preliminary questions, in the form of draft requests for additional information (RAIs) for the Clinton ESP review. These questions pertain to the staff's review in the areas of seismology and geology. Exelon may request a phone call to seek clarification on the questions before they are issued by letter. Please contact Nan Gilles (contact info below) if you wish to arrange such a call or if you have other questions.

Nanette Gilles
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Office of Nuclear Reactor Regulation
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CC: Clifford Munson; Goutam Bagchi; Nanette Gilles; Raj Anand

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DRAFT
Exelon Early Site Permit Application
SSAR Section 2.5, Geology, Seismology, and Geotechnical Engineering
Requests for Additional Information

RAI 2.5.1-1
In characterizing the seismic hazard of the New Madrid seismic source zone, SSAR Appendix B (Sections 2.1.5.2.1, 4.1.1.2, and Tables 2.1-3 and 4.1-1) cites the preferred magnitudes of Bakun and Hooper (2003, in press) for the New Madrid main shocks of 1811-12 as M 7.2, 7.1, and 7.4. The work of Bakun and Hooper (2003, in press) has since been revised with magnitude estimates for the 1811-12 New Madrid main shocks as M 7.6, 7.5, and 7.8 (Bakun and Hooper, 2004, Bull. Seism. Soc. Am., v. 94, no. 1, p. 64-75). Please explain what changes these revised magnitude estimates may require in the weights listed in Table 4.1-2 for the size of the expected characteristic earthquake rupture for each fault within the New Madrid seismic zone. In addition, please quantify the effect of the revised magnitude estimates on the hazard at the site by providing a graph showing two long-period (1 Hz) hazard curves, one using the magnitudes of Bakun and Hooper (2003, in press) and the second one using the magnitudes of Bakun and Hooper (2004).

RAI 2.5.1-2
In characterizing the maximum-magnitude distribution for the Wabash Valley-Southern Illinois seismic source zone, SSAR Appendix B (Sections 2.1.5.2.2, 4.1.2, and Table B.1-1) cites electronic and personal communications from S.F. Obermeier and a USGS Open-File Report, which is in preparation. Please provide a copy or detailed summary of these communications and Open-File Report in order for the staff to evaluate the assumptions and conclusion made in SSAR Appendix B concerning the characterization of the Wabash Valley-southern Illinois seismic source zone.

RAI 2.5.1-3
SSAR Figure 2.1-13 in Appendix B shows earthquake locations in the study area (southern Illinois and Indiana, western Kentucky, and eastern Missouri) for the period 1974 to 1987. However, the ESP site is not shown in Figure 2.1-13. Please revise Figure 2.1-13 to show the ESP site together with the earthquake epicenters, using a projection that can easily be related to other figures.

RAI 2.5.1-4
SSAR Figures B-1-13, 14, 15 of Attachment 2 of Appendix B show paleoliquefaction features at three different locations. Some of the features described in Section 1.4 of Attachment 2 of Appendix B are not readily visible in these three Figures. Please provide sketches or better-labeled figures to allow the staff to identify the location and extent of the sand dikes up into the silt.

RAI 2.5.1-5
SSAR Attachment 1 to Appendix B summarizes Obermeier's paleoliquefaction studies and the recent Geomatrix field reconnaisance. The energy centers and their associated paleoliquefaction features from these studies are listed in Table B-1-1. Given the heterogeneous nature of till deposits, please explain how dike size can be reliably used to estimate the locations of the paleo-energy centers. In addition, the geo-environment (i.e., ground water level, compaction and overburden pressures) may have been significantly different from current conditions. Please explain how these potential differences in the environment are accounted for in the cyclic stress method, used by Obermeier to estimate the magnitude of paleoearthquakes.

RAI 2.5.2-1

SSAR Section 2.5.2 describes the results of Exelon's determination of ground motion at the ESP site from possible earthquakes. Regulatory Guide 1.165 (RG 1.165) provides a method acceptable to the NRC staff with respect to the probabilistic evaluations that can be conducted to address the uncertainties associated with the Safe Shutdown Earthquake (SSE) determination. RG 1.165 specifies a target or reference probability (median 10^{-5} per year) that is used to determine the controlling earthquakes and subsequent site ground motion.

Please provide the following information related to the approach used to obtain the results in Section 2.5.2:

a) The approach described in SSAR Section 2.5.2 uses a Uniform Hazard Spectrum (UHS) at the mean 10^{-4} per year probability level as its starting point. Please justify the selection of mean 10^{-4} per year as the appropriate starting point.

b) Please provide site-specific response spectra from the controlling earthquakes at the reference probability level (median 10^{-5} per year) and demonstrate that the SSE envelops the response spectra from the controlling earthquakes at the reference probability level, or justify why this information is not needed in determining the site-specific SSE. Please also justify any reference probability level used other than median 10^{-5} per year. Appendix B to RG 1.165 discusses situations in which an alternative reference probability level may be appropriate.

c) The approach described in SSAR Section 2.5.2 incorporates component capacity or performance parameters into a scale factor used to compute the final SSE. Please justify the incorporation of equipment performance into determination of the final SSE.

RAI 2.5.2-2

SSAR Figure 2.2-2 in Appendix B shows a comparison between three older attenuation relationships (McGuire et al., 1988; Boore and Atkinson, 1987; Nuttli, 1986-Newmark and Hall, 1982) used for the 1989 EPRI study and the four model clusters developed by the EPRI 2003 ground motion study. However, SSAR 2.2.2 in Appendix B states that Figure 2.2-2 shows the Toro et al. (1997) and Atkinson and Boore (1995) ground motion models in comparison with the original ground motion models used for the 1989 EPRI study. Please clarify this discrepancy.

RAI 2.5.2-3

SSAR Section 2.2 in Appendix B describes the EPRI 2003 ground motion study. Many of the ground motion relationships that make up the four clusters use different distance measurements. Since the exact distance measure used by a ground motion model can make a large difference in ground motion estimates for small distances, please clarify the original distance measure used for each attenuation relationship and the assumptions used to convert each distance measure to a common measure.

RAI 2.5.2-4

SSAR Section 4.1.3 of Appendix B describes a Bayesian estimation of the maximum magnitude (M_{max}) for the central Illinois basin-background source that surrounds the site. The prior distribution for the Bayesian analysis comes from the global database of stable continental region (SCR) earthquakes of Johnston et al. (1994) and specifically from SCR earthquakes in non-extended continental crust like that of the central Illinois basin-background source. The prior distribution is adjusted for bias to imply a mean M_{max} of 6.3 with a standard error of 0.5. The prior distribution is then updated with likelihood functions developed from the paleoseismological record of the central Illinois basin-background source. The resulting posterior distribution has a mode at M_{max} 6.5. According to the database of Johnston et al. (1994), the two largest SCR earthquakes from non-extended crust through 1990 are (1) the Accra, Ghana earthquake of 1862 (M 6.75 + 0.35) and (2) the Meeberrie, Western Australia earthquake of 1941 (M 6.78 + 0.25). The reason for using Johnston's database is to increase the number of geologically analogous, seismologically indistinguishable terranes within which the rare largest possible earthquakes for those terranes have been included within the global historical record.

a) If central Illinois, Accra, and Meeberrie are seismologically indistinguishable, please explain why M_{max} for central Illinois should not be set at 6.8 and why the Bayesian analysis is necessary.

b) Please explain the bias that must be adjusted for in the database of Johnston et al. (1994) for non-extended crust and how the bias-adjusted estimate of M_{max} was calculated.

c) Does updating of the prior distribution require the assumption that the paleoseismological record of central Illinois is long enough to include the M_{max} earthquake? If yes, please explain why the assumption is valid. If updating does not require the assumption, explain why not.

d) Please explain the effect on the site hazard of estimating M_{max} for the central Illinois background source using the Bayesian analysis (i.e., with a distribution having a mode at M 6.5), as opposed to fixing M_{max} at M 6.8. Show the results of this sensitivity analysis in a graph with two short-period (10 Hz) hazard curves, one computed with the Bayesian analysis and the other using a M_{max} 6.8.

RAI 2.5.2-5

In Attachment B, Section 4.1.1.3, page B-4-7, the SSAR states that the New Madrid paleoseismological data of Tuttle et al. (2002)

> indicate that the RF has ruptured in all three sequences, but the NN and NS sources may not have produced large earthquakes in all three

sequences. These observations were used to set the relative frequency of event sequences on the central New Madrid fault sources. The model used consists of: ruptures of all three sources NN, RF, and NS one third of the time, rupture of the NN and RF one third of the time, and rupture of the NS and RF one third of the time.

However, Tuttle et al. (2002) conclude that all three sources (RF, NN, and NS) ruptured in each of the three sequences, but that one third of the time the NN rupture may have been smaller than in 1811-1812, and one third of the time NS may have been smaller than 1811-1812. Tuttle et al. (2002) also conclude that these smaller earthquakes are at least M 7 events. Please clarify this discrepancy.

RAI 2.5.2-6

SSAR Attachment 2 of Appendix B indicates that Geomatrix performed reconnaissance-level investigations of streams within about 30 miles of the ESP site. Along Salt Creek, they identified four sites with features considered likely to be seismic in origin, with the closest being 11.5 miles from the ESP site. No other sites with paleoliquefaction features were identified in the study area. The consultants concluded that, given how few features there were, the exposure was sufficient to suggest that there have been no repeated moderate- to large-magnitude events in the vicinity of the ESP site in latest Pleistocene to Holocene time and that the late Holocene record in particular is sufficient to demonstrate the absence of such events in the past approximately 6 to 7 thousand years.

a) Given the proximity of the Salt Creek paleoliquefaction sites to the ESP site, please provide a detailed map showing where exposure was present and the quality of the exposure (such as bank heights, material, and lengths of the exposures).

b) Explain why the streams northwest and southeast of the ESP site were not examined in this study.

c) Were other sites, besides river bank exposures, used to confirm the absence of liquefaction features in the vicinity of the ESP site? If so, please describe these sites. If not, please justify your conclusion that there have been no repeated moderate- to large-magnitude events in the vicinity of the ESP site in latest Pleistocene to Holocene time.

d) The geographic distribution of the Henry Formation appears to have been an important guide to which stream reaches were searched for paleoliquefaction features. Please explain the characteristics and importance of the Henry Formation, including describing where it belongs in the time-distance diagram of SSAR Figure B-1-9.

RAI 2.5.2-7

SSAR Subsection 2.5.2.6 describes an alternative approach to that recommended in Regulatory Guide 1.165 for determining the Safe Shutdown Earthquake (SSE) ground motion spectrum. Please provide the following information regarding this approach:

a) The approach described in SSAR Section 2.5.2 uses a Uniform Hazard Spectrum (UHS) at the mean 10^{-4} per year probability level as its starting point. Please justify the selection of mean 10^{-4} per year as the appropriate starting point.

b) The approach described in SSAR Section 2.5.2 targets a performance goal of mean 10^{-5} per year of "unacceptable performance of nuclear structures, systems and components as a result of seismically initiated events." Please justify the selection of mean 10^{-5} per year as an appropriate performance goal and describe in detail what this probability represents.

c) The approach described in SSAR Section 2.5.2 starts with the risk equation and ends with a scale factor multiplier that is used to achieve the target performance goal. Please provide the details of this derivation and describe how the use of the scale factor achieves the target performance goal. In addition, please provide the details (beyond those provided in NUREG/CR-6728 and the ASCE Draft Standard, SSAR References 118 and 119) of the assumptions made for each of the key parameters such as the seismic margin ratio, combined standard deviation, amplitude ratio, and hazard curve slope.

RAI 2.5.4-1

SSAR Chapter 3.1 in Appendix A states that, due to the expected consistency between the ESP and CPS sites, the scope of the drilling and sampling program consisted of two boreholes drilled to 100 ft below ground surface on the perimeter of the ESP footprint and two deep boreholes drilled into rock at the center of the footprint. In addition, four Cone Penetrometer Tests (CPT) were also performed between the borehole locations. Section 3.1.1 states, "If any significant soil property variations (for example, different soil types or different blowcounts from the SPT) had been revealed during the drilling and sampling program, additional explorations would have been added to resolve the observed difference." Please describe the criteria used to determine whether the difference in soil properties was significant enough to require additional exploration. In addition, provide a table showing a comparison between the static and dynamic soil properties for the CPS and ESP sites. For each soil property provide the sample size, average value, standard deviation, and range of values.

RAI 2.5.4-2

Section 2.5.4.2 of the SSAR states that the EPRI modulus and damping curves were used for the site response calculations, because a much larger database was used to develop the EPRI curves and, therefore, average EPRI results are expected to be representative of conditions at the EGC ESP site. It is the staff's understanding that the EPRI soil nonlinear property curves were primarily based on the results of regression studies of recorded ground motions at California soil sites, not on the results of laboratory test data. In addition, the EPRI curves are typically considered to be appropriate for sands and non-plastic (low PI) silts. In view of these two observations, please provide a detailed justification for using the EPRI modulus and damping curves for the ESP site. Also, the laboratory test data (Figure 5-21 of Appendix A) for hysteretic damping appears to be relatively high at low strain compared to the generic data from the EPRI report. Please comment on these results.

RAI 2.5.4-3
Section 2.5.4.10 (Page 2.5-29) of the ESP SSAR states that, while static stability considerations are not explicitly addressed for the EGC ESP site, high allowable bearing values and low compressibility are expected at the EGC ESP site because of the similarity in soil conditions to those occurring at the CPS site. The static stability discussions in the CPS USAR indicate that allowable bearing pressures range from 25 to 60 tsf. Based on the bearing values given in the CPS USAR, the minimum site characteristic value for bearing pressures at the EGC ESP site is 25 tsf. This value is listed in the PPE table (Table 1.4-1). Please provide more detail regarding the method(s) used to determine the bearing capacities for the CPS site. Specifically, discuss how the minimum value of 25 tsf was determined.

RAI 2.5.4-4
In Table 5-2, "Summary of Shear and Compression Wave Velocity Test data," of Appendix A, "Geotechnical Report," to the SSAR, the range in shear wave velocities for some of the stratigraphic units is large. In addition, as indicated in Figure 5-6 of Appendix A, the SPT blow counts for Borings B1 and B4 (not shown in Figure 5-5) appear to be significantly different from those of B2 and B3 in the upper 100' of the site. Please justify the appropriateness of using a single "average" soil column for the site response analyses used to develop the site DRS rather than including a number of different base-case soil columns.

RAI 2.5.4-5
The data shown in Table 5-3, "Comparison of Laboratory Shear Wave to in situ Velocity," of Appendix A to the SSAR indicate that the ratio of the shear wave velocity measured from the laboratory test to that measured in the field is 0.68 for the till. Based on the staff's experience, this implies that the laboratory sample may have been overly disturbed. Please comment on this possibility.

RAI 2.5.4-6
Section 6.1 of Appendix A describes the method used to determine the potential for soil liquefaction at the ESP. Please provide a copy of a sample liquefaction analysis from one of the four ESP Site borehole locations and clearly show how the Factor of Safety (FOS) was determined for the different soil layers. Since each of the four boreholes sampled soil layers with FOS less than 1.1, provide a description of the methods that will be used to mitigate the potential for liquefaction. In addition, describe the extent (i.e., depth below ground surface, and thickness) of the non-cohesive (silts and sands) soil layer over the site area, particularly the ESP footprint.

RAI 2.5.4-7

Appendix B of the ESP application describes the process used to generate the soil surface design ground response spectrum. In particular, Figures 4.2-14 through 4.2-18 present the results of the randomizations for soil shear modulus degradation and hysteretic damping curves used for the site response calculations. Please explain how these curves were used in the randomization process with respect to both the different depth ranges and the soil types occurring within those depth ranges. For example, the boring logs indicate that some soils are clays and some soils are silty sands over a particular depth range. Secondly, the damping curves used in the calculations do not incorporate the 15% damping cutoff as recommended in SRP Section 3.7.2. Since the calculations are nonlinear, and since some of the randomizations can lead to relatively high strains, it is not clear how this influenced the computed site amplification factor. Please provide clarification regarding the use of high strain values in the randomization process.