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December 20, 2012

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ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: UniStar Nuclear Energy, NRC Docket No. 52-016
Supplemental Response to Request for Additional Information for the
Calvert Cliffs Nuclear Power Plant, Unit 3,
RAI 322 and RAI 345, Vibratory Ground Motion

- References:
- 1) Surinder Arora (NRC) to Paul Infanger (UniStar Nuclear Energy), "FINAL RAI No. 322 RGS1 6031" email dated September 29, 2011
 - 2) Surinder Arora (NRC) to Paul Infanger (UniStar Nuclear Energy), "FINAL RAI No. 345 RGS1 6489" email dated June 4, 2012
 - 3) UniStar Nuclear Energy Letter UN#12-093 from Mark T. Finley to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI 345, Vibratory Ground Motion, dated September 12, 2012
 - 4) UniStar Nuclear Energy Letter UN#12-102 from Mark T. Finley to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAIs 284 and 322, Vibratory Ground Motion, and RAI 345, Vibratory Ground Motion, COLA Markups, dated September 27, 2012

The purpose of this letter is to provide supplemental information to our responses to the request for additional information (RAI) 322, Question 02.05.02-23, identified in the NRC e-mail correspondence to UniStar Nuclear Energy (UNE), dated September 29, 2011 (Reference 1), and RAI 345, Question 02.05.23-24, identified in the NRC e-mail correspondence to UNE, dated

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June 4, 2012 (Reference 2). Both RAIs 322 and 345 address Vibratory Ground Motion as discussed in Section 2.5.2 of the Final Safety Analysis Report (FSAR), as submitted in Part 2 of the Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 Combined License Application (COLA), Revision 8.

Reference 3, dated September 12, 2012, provided our original response to RAI 345 Question 02.05.02-24, which addressed the use of the EPRI/DOE/NRC 2012 Central and Eastern United States (CEUS) Seismic Source Characterization (SSC) in the Probabilistic Seismic Hazard Analysis (PSHA) of the CCNPP Unit 3 Site. Reference 4, dated September 27, 2012, provided our response to RAI 322 Question 02.05.02-23, which addressed the impact of the Mineral Virginia Earthquake (MVE) to the EPRI Seismic Owners Group (SOG) seismic source model.

This supplement is motivated by comments and discussions raised during a public meeting held between UNE and the NRC on November 20, 2012. Specifically, two questions were raised about the adequacy of the EPRI/DOE/NRC 2012 CEUS SSC for use in the PSHA of the CCNPP Unit 3 Site. The first relates to the potential impact of the MVE to the seismicity rates and to the seismic hazard at the Site, given the fact that the MVE postdates the cut-off year of the 2012 CEUS SSC earthquake catalog. A second question relates to the adequacy of the Atlantic Highly Extended Crust (AHEx) Seismotectonic source given that its area does not extend over the eastern portion of the 200 mile site region.

Enclosure 1 provides supplemental information to the response to RAI 322, Question 02.05.02-23. It provides the details of additional analyses that were performed to assess the impact of the MVE to the hazard at the CCNPP Unit 3 site.

Enclosure 2 provides supplemental information to the response to RAI 345, Question 02.05.02-24. It provides additional discussion related to the contributions to hazard of the AHEx Seismotectonic source zone.

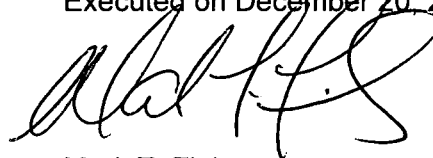
Revision to the COLA FSAR is not required as a result of this information.

This supplemental information does not include any new regulatory commitments. This letter does not contain any sensitive or proprietary information.

If there are any questions regarding this transmittal, please contact me at (410) 369-1907 or Mr. Wayne A. Massie at (410) 369-1910.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 20, 2012

A handwritten signature in black ink, appearing to read 'Mark T. Finley', is written over the typed name below.

Mark T. Finley

Enclosures:

- 1) Supplemental Response to the Request for Additional Information (RAI) No. 322, Question 02.05.02-23, Vibratory Ground Motion
- 2) Supplemental Response to the Request for Additional Information (RAI) No. 345, Question 02.05.02-24, Vibratory Ground Motion

cc: Surinder Arora, NRC Project Manager, U.S. EPR Projects Branch
Laura Quinn-Willingham, NRC Environmental Project Manager, U.S. EPR COL Application, (w/o enclosures)
Amy Snyder, NRC Project Manager, U.S. EPR DC Application, (w/o enclosures)
Patricia Holahan, Acting Deputy Regional Administrator, NRC Region II, (w/o enclosures)
Silas Kennedy, U.S. NRC Resident Inspector, CCNPP, Units 1 and 2, (w/o enclosures)
David Lew, Deputy Regional Administrator, NRC Region I (w/o enclosures)

Enclosure 1
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Enclosure 1

**Supplemental Response to the Request for Additional Information (RAI) No. 322,
Question 02.05.02-23, Vibratory Ground Motion**

IMPACT OF THE MINERAL VIRGINIA EARTHQUAKE (MVE)

The report "Central and Eastern United States Seismic Source Characterization for Nuclear Facilities," sponsored by the Electric Power Research Institute (EPRI), the U.S. Department of Energy (DOE), and the U.S. Nuclear Regulatory Commission (NRC) (EPRI/DOE/NRC, 2012), provides a seismic source characterization (SSC) model for the Central and Eastern United States (CEUS) developed following a level 3 process in the context of NUREG/CR-6372 (Senior Seismic Hazard Analysis Committee (SSHAC), 1997) and NUREG-2117 (NRC, 2012). As stated in the "Sponsor's Perspective," specific benefits of the new model include:

- Consistency in regional source characterization for application to multiple sites;
- Stability because of the involvement of the technical community, regulators, and other stakeholders;
- Greater longevity through the reasonable assurance provided by the use of the SSHAC Level 3 process that the model reflects the center, body, and range of technically defensible interpretations of the available data, models, and methods.

The 2012 CEUS SSC has been used in the CCNPP3 Probabilistic Seismic Hazard Analysis (PSHA). The question to be addressed is whether the occurrence of the moment magnitude (M_w) 5.8 earthquake at Mineral, Virginia on August 23, 2011 impacts the seismic hazard at the CCNPP3 site, which is located about 80 miles (140 km) away.

The MVE is consistent with the EPRI/DOE/NRC (2012) CEUS SSC model. Given the understanding of seismic sources in the CEUS, the occurrence of the MVE is not unexpected; its occurrence does not suggest that the EPRI/DOE/NRC (2012) model should be revised.

The EPRI/DOE/NRC (2012) CEUS SSC model includes alternative interpretations of seismicity at the location of the MVE. Four alternative distributed seismicity source zones host the earthquake epicenter: the Study Region M_{max} source zone, the Mesozoic-and-younger extended crust (narrow interpretation) (MESE-N) M_{max} source zone, the Mesozoic-and-younger extended crust (wide interpretation) (MESE-W) M_{max} source zone, and the Extended Continental Crust-Atlantic Margin (ECC-AM) seismotectonic source zone. Previous seismicity in the vicinity of the MVE was known and taken into account in developing the various distributed source zone interpretations and configurations. The concentration of seismicity in the vicinity of Mineral, VA has often been referred to as the Central Virginia Seismic Zone (e.g., EPRI, 1988).

In characterizing a recurrence rate for distributed seismicity source zones, the EPRI/DOE/NRC (2012) CEUS SSC model adopts the concept of spatial stationarity. The spatial distribution of future earthquakes is based on the pattern of past earthquakes. EPRI/DOE/NRC (2012) cites studies by Kafka (2007, 2009) that demonstrate the reasonableness of this interpretation. A smoothing algorithm is used to translate the pattern of past seismicity into a prediction of the location, rate, and magnitude distribution of future seismicity. Because past earthquakes are concentrated in the Central Virginia Seismic Zone, it is not unexpected that a significant earthquake would occur there.

The size of the MVE is also consistent with the EPRI/DOE/NRC (2012) CEUS SSC model. As part of the CEUS SSC, the maximum magnitude that is expected to occur in each distributed

seismicity source zone is assessed. The moment magnitude of the MVE (5.8) is lower than the entire maximum magnitude distribution (Table 1) for each of the alternative source zone interpretations hosting the earthquake. Thus, the magnitude of the MVE is well bounded by the maximum magnitude characterization from the EPRI/DOE/NRC (2012) CEUS SSC.

TABLE 1
MAXIMUM MAGNITUDE DISTRIBUTION FOR DISTRIBUTED SEISMICITY SOURCE ZONES
HOSTING THE 2011 MINERAL, VA EARTHQUAKE

WEIGHT	STUDY REGION MMAX ZONE	MESE-N MMAX ZONE	MESE-W MMAX ZONE	ECC-AM SEISMOTECTONIC ZONE
0.101	6.5	6.4	6.5	6.0
0.244	6.9	6.8	6.9	6.7
0.310	7.2	7.2	7.3	7.2
0.244	7.7	7.7	7.7	7.7
0.101	8.1	8.1	8.1	8.1

With respect to the recurrence rate of an earthquake of M_w 5.8 at the location of the MVE, the fit of observed rates to those predicted for the EPRI/DOE/SSC (2012) CEUS SSC model on a source zone basis are not significantly affected. This conclusion takes into account the standard deviation of the estimated observed earthquake counts and the observation that, for the existing model, not all observed counts are within one standard deviation of the predicted counts (e.g., Figure 7.5.2-4 through 7.5.2-6 for the ECC-AM source zone in EPRI/DOE/NRC, 2012).

Rupture characteristics of the MVE are also consistent with the EPRI/DOE/NRC (2012) CEUS SSC model. The MVE occurred at a focal depth of 6 km and was caused by reverse faulting on a plane striking N28E and dipping 50° to the east-southeast (Horton and Williams, 2012). These characteristics are generally consistent with the representation of future rupture characteristics for the EPRI/DOE/NRC (2012) CEUS SSC model. The focal depth of 6 km is less than the alternative values of seismogenic thickness; reverse faulting is part of the distribution of expected faulting styles; for reverse faulting the observed dip of 50° lies within the assessed range of 30 to 60°. While a strike of N28E is not identified as a specific value in the discrete distribution of strikes, a value of N35E, which is assessed with the highest relative frequency, is close to the observed value.

Considering the various attributes of the MVE with respect to the EPRI/DOE/NRC (2012) CEUS SSC model, it is concluded that the earthquake is consistent with the model.

Because recurrence parameters for the EPRI/DOE/NRC (2012) CEUS SSC distributed seismicity source zones are based on the catalog of observed earthquakes, the occurrence of the MVE potentially affects the calculated a- and b-values. To investigate the size of this effect and its impact on seismic hazard for the CCNPP3 site, a quantitative sensitivity exercise was performed. Using the EPRI/DOE/NRC software program ABSMOOTH14, recurrence rates were calculated both with and without the MVE included in the EPRI/DOE/NRC (2012) CEUS SSC earthquake catalog. For this simple one-off test, no other earthquakes that have occurred since 2008 (the time cut-off in the EPRI/DOE/NRC (2012) CEUS SSC catalog) are included.

Also, equivalent completeness periods defined in EPRI/DOE/NRC (2012) as a function of region and magnitude are used without update. In addition, the moment magnitude of the MVE is used as reported by the United States Geological Survey (USGS).

Recurrence parameter values are tested for the Study Region, MESE-N, and MESE-W Mmax zones, and for the ECC-AM seismotectonic zone. First, recurrence parameters are calculated using the original EPRI/DOE/NRC (2012) CEUS catalog and compared to the published values. Then, using rates determined with the inclusion of the MVE, the hazard at the CCNPP3 site is calculated for comparison to the base case.

For the Study Region, MESE-N, and MESE-W source zones, rates determined using ABSMOOTH14 and the original catalog consistently match those from the EPRI/DOE/NRC (2012) CEUS SSC model within a few percent. For the ECC-AM zone, however, the results vary depending on the initial conditions of the analysis. Some realizations match, some are higher, and some are lower than those given in EPRI/DOE/NRC (2012).

Because of this effect, two actions are taken. First, for evaluation of the impact on hazard of the MVE at the CCNPP3 site, both rates with (sensitivity case) and without (base case) the MVE are determined using the Paul C. Rizzo Associates, Inc. (RIZZO) implementation of ABSMOOTH14. Second, for the ECC-AM seismotectonic source zone, three realizations of rate determination are used: one that is similar to the rates given in the EPRI/DOE/NRC (2012) model, one that is higher, and one that is lower.

Inclusion of the MVE has a small effect on the hazard computed at the CCNPP3 site. The comparison is carried out in terms of the uniform hazard response spectrum (5 % damped) (UHRS) from each source zone for frequencies of exceedance of 10^{-4} , 10^{-5} , and 10^{-6} . Hazard at the site from the Study Region zone for the sensitivity case is within 3 percent (absolute values) of hazard for the base case. For the MESE-N and MESE-W source zones, the UHRS for the sensitivity case are within 4 percent of the base case. For the ECC-AM source zone, the UHRS for the sensitivity case is within 9 percent of the base case for two realizations and within 4 percent for the other realization. Thus, the impact of the MVE on hazard at the CCNPP3 site, as assessed from this simple test, is small relative to the precision of seismic hazard calculations.

The analysis of the effects of the MVE indicates that the 2012 EPRI/DOE/NRC CEUS SSC is adequate for the evaluation of the Seismic Hazard at the CCNPP Unit 3 Site.

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SSHAC (Senior Seismic Hazard Analysis Committee), 1997. *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*, NUREG/CR-6372, U.S. Nuclear Regulatory Commission, Washington, D.C.

COLA Impact

Revision to the COLA FSAR is not required as a result of this supplemental response.

Enclosure 2
UN#12-162

Enclosure 2

**Supplement to the Response to the Request for Additional Information (RAI) No. 345,
Question 02.05.02-24, Vibratory Ground Motion**

ADEQUACY OF THE ATLANTIC HIGHLY EXTENDED CRUST (AHEX) SEISMOTECTONIC SOURCE ZONE

It is relevant to assess the adequacy of the AHEX Seismotectonic source given that its area does not extend over the eastern portion of the 200 mile site region. Thus, using the EPRI/DOE/NRC (2012) CEUS SSC model results in a small area near the edge of the site region that is interpreted to have no likelihood of earthquake occurrence. It is therefore meaningful to elaborate on the impact of a hypothetical extension of the seismic zone that would completely encompass the region.

The contribution to total hazard from the AHEX source zone, taken as published in the CEUS SSC model, is about four orders of magnitude below the total hazard for 1-Hz and 10-Hz SA. Expanding the zone within the CCNPP3 site region with a similar seismicity rate to that seen within the current extent of the source zone will, therefore, have a negligible impact on total hazard at the site. It is therefore concluded that the EPRI/DOE/NRC 2012 CEUS SSC is adequate for the evaluation of the CCNPP Unit 3 PSHA.

COLA Impact

Revision to the COLA FSAR is not required as a result of this supplemental response.