From: John Rycyna
Sent: Tuesday, February 17, 2009 10:22 AM
To: Poche, Robert; McQueeney, Jennifer
Cc: Alice Stieve; Sarah Gonzalez; Rebecca Karas; Clifford Munson; CCNPP3COL Resource; Joseph Colaccino; James Biggins; Adam Gendelman
Subject: Draft RAI No 71 RGS 1928.doc (PUBLIC)
Attachments: Draft RAI No 71 RGS 1928.doc

Rob,

Attached is DRAFT RAI No. 71. You have until March 5, 2009 to review it and to decide whether you need a conference call to discuss it. After the call or after March 5, 2009 the RAI will be finalized and sent to you. You then have 30 days to respond.

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Request for Additional Information No. 71
DRAFT
2/17/2009

Calvert Cliffs Unit 3
UniStar
Docket No. 52-016
SRP Section: 02.05.01 - Basic Geologic and Seismic Information
Application Section: 2.5.1

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

02.05.01-1

FSAR Figure 2.5-24 shows CEUS seismicity in the central eastern and northeastern U.S. from the EPRI, 1986 catalog. Subsequent figures show updated seismicity in the region from 1985 through 2006 from Table 2.5-2.

Please revise Figure 2.5-24 to include updated seismicity from Table 2.5-2 to facilitate comparison with the EPRI 1986 catalog.

02.05.01-2

FSAR Section 2.5.1.1.3.1.4 describes the Plio-Peistocene Upland stratigraphic unit as a, "…sediment sheet whose base slopes toward the southwest (Glaser, 1971) (Hansen, 1996). This erosion might have occurred due to differential uplift during the Pliocene or down cutting in response to lower base levels when sea level was lower during period of Pleistocene glaciation." Additionally, this FSAR Section states "[Quaternary Lowland] deposits occur in only a few places along the eastern shore of Chesapeake Bay". FSAR Section 2.5.1.2.3.3 makes similar statements.

The peninsula the CCNPP site occupies has highly asymmetric topography, steep to the northeast. Schlee (1957, GSA Bull. 68: 1371-1410) discusses the depositional setting of the Upland deposits and possible causes of the southwest dip of their basal contact and the asymmetric topography and concludes neotectonic tilting is strongly suggested. Furthermore, FSAR Figure 2.5-29B shows a progressive southwestward shifting of Quaternary paleochannels within Chesapeake Bay.

Please provide additional discussion with regard to the seismic hazard at the CCNPP site and possible Pliocene or Quaternary neotectonics, Pleistocene glacial effects, and the east-facing monoclines of McCartan (1995).

02.05.01-3

FSAR Section 2.5.1.1.4 quotes Johnston et al (1994) "…global review of earthquakes in [stable continental regions] SCRs shows that areas of Mesozoic and Cenozoic extended crust are positively correlated with large SCR earthquakes. Nearly 70% of SCR earthquakes with [magnitude] M 6 or greater occurred in areas of Mesozoic and Cenozoic extended crust..."

Schulte and Mooney (2005, Geophys. J. Int., 161: 707-721) reassessed whether earthquakes within SCRs are associated with rifted crust. The dataset for that study contained over 1300 magnitude ≥ 4.5 historic and instrumentally recorded crustal earthquakes. CCNPP is located in a SCR region that is also extended crust due to the Mesozoic rifting of Pangaea in the formation of the Atlantic Ocean. There are buried rift basins in the immediate vicinity of CCNPP. The Schulte and Mooney (2005) paper is a significant rework and analysis of the issue of earthquakes in SCRs that post-dates Johnston et al 1994.

Please provide a discussion of the relevance of the Schulte and Mooney paper for the CCNPP site.

02.05.01-4

FSAR Section 2.5.1.1.4 (Regional Tectonic Setting) states that there is no evidence for late Cenozoic seismogenic activity of any tectonic feature or structure in the site region based on the Quaternary feature databases of Crone and Wheeler (2000) and Wheeler (2005).

Crone and Wheeler (2000) and Wheeler (2005) compiled a database based on literature searches. These papers do not represent the original work. The literature searches may have missed some publications or there were unpublished works at that time. Therefore the databases do not actually support the statement that there is no evidence of active Quaternary faults and features.

Describe your investigation of other potential Quaternary faults or features for the site. In addition, for the geologic features identified by Crone and Wheeler provide your own assessment of their potential hazard for the CCNPP site.

02.05.01-5

FSAR Section 2.5.1.1.4.1.2 states “Northwest-southeast-directed postrift shortening, manifested in Mesozoic basin inversion structures, provides the clearest indication of this change in stress regime (Withjack, 1998).” On FSAR Figure 2.5-13 there is a shallow structural high at borehole CA Gd 60 (Solomons) that dies out with depth that is consistent with typical inverted grabens. Furthermore, the fault proposed by Kidwell (1997) referred to in FSAR Section 2.5.1.1.4.4.4.8 appears to coincide with this high.

Please discuss the potential for this feature to be an inverted Mesozoic fault.

02.05.01-6

FSAR Section 2.5.1.1.4.1.2 states “Many of the synrift normal faults are interpreted as Paleozoic thrust faults reactivated during Mesozoic rifting.”

However, it is equally possible that the Mesozoic rift faults are reactivated normal faults that formed during the latest Proterozoic-Cambrian rifting of Rodinia. This interpretation differs from the interpretation presented in the FSAR.

Please provide a discussion of the plausibility of both interpretations and how each may affect the seismic hazard at the proposed site.

02.05.01-7

FSAR Section 2.5.1.1.4.1.2 states “The Mesozoic basins are discussed further in Section 2.5.1.1.4.4.3 as well as the hypothesized Queen Anne basin shown as lying beneath the site (Figure 2.5-10).”

The cited figure shows a basin beneath the site, but the figure shows a bounding fault only along part of the northwest basin edge, 50 km and more north of the site. However, it is unclear from the FSAR descriptions and Figure 2.5-10 what, if any, structures control the southeastern boundary of the Queen Anne basin.

Please provide details about the nature of the southeastern boundary of the basin.

02.05.01-8

FSAR Section 2.5.1.1.4.1.3 contains the first mention of the North Anna site, which is mentioned several more times throughout FSAR Sections 2.5.1 through 2.5.3.

No figure in the FSAR shows the location of the North Anna site relative to the proposed Calvert Cliffs site.

Please add the location of the North Anna site to Figure 2.5-5, in order to show the regional geologic context of both proposed nuclear power plant locations.

02.05.01-9

FSAR Section 2.5.1.1.4.2 states “More recent assessments of lithospheric stress do not support inferences by some EPRI expert teams that the orientation of the principal stress may be locally perturbed in the New England area, along the east coast of the United States, or in the New Madrid region.”

Kim and Chapman (2005) state that “a regional stress model derived from the 2003 [Central Virginia Seismic Zone] (CVSZ) event and 11 previous events indicates thrust faulting with s_1 trending 133° (±12°).” This is a local rotation of s_1 in the CVSZ 68° clockwise relative to the ENA average of 65°.

Please discuss the results of this study and the significance of a local rotation of s_1 in the CVSZ with respect to the above quoted statement from FSAR Section 2.5.1.1.4.2.

02.05.01-10

FSAR Section 2.5.1.1.4.3.2 states “The [East Coast Magnetic Anomaly] ECMA is not directly associated with a fault or tectonic feature, and thus is not a potential seismic source.”

However, in FSAR Figures 2.5-18 and 2.5-19 faulting is illustrated in the ECMA. The above quoted statement and FSAR Figures 2.5-18 and 2.5-19 are contradictory.

Please provide an explanation regarding this contradiction and whether faults or tectonic feature are related to the ECMA. Revise the FSAR as appropriate in response to this apparent contradiction.

02.05.01-11

FSAR Section 2.5.1.1.4.3.2 states “Discrete magnetic lows associated with the Richmond and Culpeper basins are discernible on the 2002 North America magnetic anomaly map (Bankey, 2002) (Figure 2.5-22).” The same page states “The distinctive, elongate magnetic anomalies associated with these igneous bodies within the synrift basins of the Piedmont are also used beneath the Coastal Plain to delineate the Taylorsville, Queen Anne, and other synrift basins (e.g., (Benson, 1992)).”

(a) These basins are not labeled in FSAR Figure 2.5-22. Please provide an edited Figure 2.5-22 that labels these basins.

(b) Please explain why only the basin interpretations of Withjack et al. (1998) are shown in Figure 2.5-22, instead of both Withjack et al. and those of Benson (1992), as in Figure 2.5-10. If warranted, edit Figure 2.5-22 to also include the basin interpretations of Benson, or provide an additional figure showing Benson’s basins and the magnetic anomalies from Figure 2.5-22.

02.05.01-12

FSAR Section 2.5.1.1.4.3.2 states “A magnetic profile along an approximately west-northwest to east-southeast transect through central Pennsylvania (Glover, 1995b) (Figure 2.5-17) indicates that paired high and low magnetic anomalies are associated with the western margins of crustal units truncated by thrust faults.” Thrust ramps truncate their footwalls, but may or may not truncate their hanging walls.

Please clarify the statement; does the quotation refer to eastern margins instead of western, does the statement refer to the footwalls or hanging walls of the thrust faults?

02.05.01-13

FSAR Sections 2.5.1.1.4.4 and 2.5.1.1.4.4.4 discuss the Eocene Chesapeake Bay Impact Structure (CBIS). FSAR Section 2.5.1.1.4.4 states “Based on the absence of published literature documenting Quaternary tectonic deformation and spatially associated seismicity, we conclude that this feature is not a capable tectonic source (Section 2.5.1.1.4.4.4).’’

However, the FSAR does not cite any literature documenting the lack of Quaternary tectonic deformation associated with this feature.

(a) Please explain which, if any, seismograph networks have monitored for seismicity on the CBIS (including time periods of monitoring and minimum magnitude of their earthquake detection threshold).

(b) The spatial association between a normal-faulted passive margin and a large impact crater is also present at the Charlevoix seismic zone, Quebec. In light of this similar spatial association, please provide a discussion of the seismic potential of the Chesapeake Bay impact crater.

(c) FSAR Section 2.5.1.1.4.4.4 states “Primarily middle Miocene to Quaternary sediments thicken and sag into the primary and secondary craters.” Please explain how these relations differ from the classic description of a growth fault, in which the faulting would be the same age as the inward-thickening sediments.

02.05.01-14

FSAR Section 2.5.1.1.4.4.1 states “Extended crust of the Iapetan passive margin extends eastward beneath the Appalachian thrust front approximately to the eastern edge of Mesozoic extended crust….” The FSAR concludes the Grenville crust that was extended by Iapetan rifting is no closer to the site than about 113 km (70 mi).

However, the interpreted eastern limit of extended Grenville crust is actually only the eastern limit of largely intact Grenville crust, which has undergone only slight extension by Iapetan faulting (Wheeler, 1996, Fig. 2). Wheeler (1996) cites interpretations of published seismic-reflection profiles. The interpretations indicate that more intensely extended and thinned Grenville crust extends at least another 40-80 km eastward.

Please discuss how this may impact hazard assessment at the site.

02.05.01-15

FSAR Section 2.5.1.1.4.4.2 states “The majority of these structures dip eastward and sole into one or more levels of low angle, basal Appalachian decollement (Figure 2.5-17). Below the decollement are rocks that form the North American basement complex (Grenville or Laurentian crust).”

(a) There are several levels of detachment but only one basal decollement. Please clarify the quoted sentence.

(b) Iapetan (Rodinia rifting) normal faults are expected in this basement complex, and the figure shows them schematically. Please include these probable structures in the discussion.

02.05.01-16

FSAR Section 2.5.1.1.4.4.3 states “The rift-bounding normal faults are interpreted by some authors to be listric at depth and merge into Paleozoic low angle basal decollement (Manspeizer, 1989). Other authors interpret rift-bounding faults to penetrate deep into the crust following deep crustal fault zones (Figure 2.5-19).”

(a) Both sentences refer to “authors” but only one paper is cited. Please add citations to demonstrate that each alternative is favored by more than one person.

(b) Please provide a discussion of any deep reflection lines across these rift basins to determine which model is correct.

02.05.01-17

FSAR Section 2.5.1.1.4.4.3 states “Aside from the global finding of Johnson et al. (1994) that areas of Mesozoic extended crust are correlated with large magnitude earthquakes within stable continental regions (i.e., New Madrid seismic zone), there are no specific Mesozoic basin-bounding faults that have demonstrable associated seismic activity or evidence for recent fault activity (Figure 2.5-10 and Figure 2.5-24).”

Please place the Mesozoic basin-bounding faults, from both the Benson (1992) and the Withjack et al. (1998) sets of Mesozoic basins, and depth-coded epicenters together on FSAR Figure 2.5-24 to justify the above statement.

02.05.01-18

FSAR Section 2.5.1.1.4.4.4.5 states, “Based on seismic reflection data, collected about 9 mi (15 km) west-southwest of the site, the [Hillville] fault zone consists of a narrow zone of discontinuities that vertically separate basement by as much as 250 ft (76 m) (Hansen, 1978).” In FSAR Figure 2.5-27 seismic line St M-1 is located across the Hillville fault.

Please provide the seismic line St M-1 for inspection and the Hansen (1978) profile, if different. Was the Hillville fault seen in any Chesapeake Bay marine data?

02.05.01-19

FSAR Section 2.5.1.1.4.4.4.6 (Unnamed fault beneath northern Chesapeake Bay, Cecil County, Maryland) cites the unnamed fault as having its southwest side up, but near the mouth of the Susquehanna River the west side is downthrown. The unnamed fault is mapped in FSAR Figure 2.5-25 as submarine. The east coast of the Chesapeake Bay along the southern projection of the unnamed fault is very straight in FSAR Figure 2.5-25.

(a) Please explain the apparent contradiction between the two senses of displacement.

(b) Is there any new submarine information about this possible fault?

(c) Please evaluate the hypothesis that the straight eastern coast line of the Chesapeake Bay might be a result of young faulting, and present the evidence and reasoning for your evaluation.

02.05.01-20

FSAR Section 2.5.1.1.4.4.4.7 states "The observation that the west side of Chesapeake Bay is elevated and dissected, and that approximately 37 ka estuarine deposits are approximately 6 feet above sea level is compelling evidence for recent (late Quaternary) uplift. Similar elevated, dissected topography and approximately 37 ka estuarine deposits are observed over broad portions of the Coastal Plain along the eastern seaboard east and west of Chesapeake Bay. These surfaces of apparent anomalous elevations have recently been attributed to the presence of a glacial fore-bulge developed outboard of the Laurentide ice sheet (Scott, 2006)." Scott (2006) is a thesis and, therefore, not readily available to all reviewers.

It is not clear if the glacial forebulge referred to is associated with the last Wisconsin glacial advance circa 20 ka and if the said forebulge has not collapsed completely enough to let 37 ka-old estuarine deposits back down to their original elevation. Please elaborate on this issue and alternative tectonic explanations and the implications of de-glacial and tectonic epeirogeny to seismic potential.

02.05.01-21

FSAR Section 2.5.1.1.4.4.4.7 states "McCartan (McCartan, 1995) show[s] east-facing monoclinal structures bounding the western margin of Chesapeake Bay 1.8 and 10 mi (2.9 and 16 km) east and southeast, respectively, of the site (Figure 2.5-25)." The monocline is not shown on FSAR Figure 2.5-25. Please revise FSAR Figure 2.5-25 to include the monocline.

02.05.01-22

FSAR Section 2.5.1.1.4.4.5.4 states "The Ramapo fault system is located in northern New Jersey and southern New York State, approximately 130 mi (209 km) north-northeast of the CCNPP site (Figure 2.5-31). This fault system consists of northeast-striking, southeast-dipping, normal faults that bound the northwest side of the Mesozoic Newark basin." Later, the FSAR Section states "…approximately half of the reported earthquakes occur near the margins of the Newark Basin, far from the Ramapo fault…."

However, the Ramapo fault is a master boundary fault for the Newark Basin.

Please clarify the apparent contradiction between these two statements about the distance between the Ramapo fault and the Newark basin.

02.05.01-23

FSAR Section 2.5.1.1.4.4.5.4 states about the Ramapo fault, "In addition, a reassessment of the eastern U.S. stress field demonstrated that the present-day stress field is oriented east-southeast (Zoback, 1989a), which would be inconsistent with the previously inferred reverse reactivation of the fault."

This statement contradicts section 2.5.1.1.4.2 that states, "To summarize, analyses of regional tectonic stress in the CEUS since EPRI (1986) have not significantly altered the characterization of the northeast-southwest orientation of the maximum compressive principal stress."

Please explain how east-southeast compression is inconsistent with reverse slip on a northeast-striking fault. Please also explain the seeming contradictions between the two quoted stress orientations.

02.05.01-24

FSAR Sections 2.5.1.1.4.4.5.4 and 2.5.1.1.4.4.5.5 cite FSAR Figure 2.5-31 as showing the Ramapo, Kingston, and New York Bight faults.

However, the figure is a regional summary and shows the faults only as small circled numbers.

Please provide one or more separate figures showing the fault traces and the map relations that are described in the text, including the relations of the New Jersey and Long Island shorelines to the New York Bight fault.

02.05.01-25

FSAR Section 2.5.1.2.4 states "Although the basement beneath the site has not been penetrated with drill holes, regional geologic cross sections developed from geophysical, gravity and aeromagnetic, as well as limited deep borehole data from outside of the CCNPP site area, suggest that Precambrian and Paleozoic crystalline rocks and, less likely, Mesozoic rift-basin deposits are present at about 2,500 ft (762 m) msl (Section 2.5.1.2.2)."

This statement summarizes a change in tone midway through the application such that the argued age of the crust under the site changes from Mesozoic to Paleozoic. For example, FSAR Figures 2.5-10, 2.5-11, 2.5-12, 2.5-15, and 2.5-16b indicate Mesozoic crust at or near the site. Please provide further explanation and revise text and/or figures as necessary.

02.05.01-26

FSAR Section 2.5.1.2.4 suggests that no basin-related fault or faulting is known directly beneath the site area.

FSAR Figure 2.5-10 summarizes mapping that indicates that a border fault on the northwestern side of the Taylorsville basin crops out about 50 km northwest of the site, and that the border fault on the northwestern side of the postulated Queen Anne basin crops out 10-15 km northwest of the site. Both faults dip southeastward under their basins. Such master faults are generally assumed to flatten downward. Furthermore, the normal faulting that formed the basins requires that the entire hanging-wall block and all upper crust southeast of it must slip southeastward on a Mesozoic detachment fault.

Please evaluate whether or not the border fault of either basin is likely to extend beneath the site and what the implications for hazard might be. Please provide further discussion about the presence of a Mesozoic basin directly beneath the site.

02.05.01-27

FSAR Section 2.5.1.2.4 refers to elevation differences across a postulated fault within 2 km of the site (Kidwell, 1997). The applicant stated: "…these can be readily explained by channeling and highly irregular erosional surfaces. Field and aerial reconnaissance, coupled with interpretation of aerial photography and LiDAR data (Section 2.5.3.1 for additional information regarding the general methodology) conducted as part of this CCNPP Unit 3 study revealed no features suggestive of tectonic deformation developed in the surrounding Pliocene and Quaternary surfaces."

Kidwell (1997) describes the details of sedimentary facies at Calvert Cliffs. Many channel deposits are defined in the paper, and it seems unlikely that overlooked channels can account for the multiple stratigraphic contacts that are offset. Furthermore, on FSAR Figure 2.5-26 Moran Landing is at the northeast end of a fairly linear stream valley trending northeast that may be a fault or fracture zone trace.

Please provide additional surface and subsurface data across this feature to show that each of the geologic contacts that are down-dropped at the proposed fault contain channel deposits in the lows.

02.05.01-28

FSAR Section 2.5.1.2.6.4 states "There is no evidence of earthquake-induced liquefaction in the State of Maryland.", citing Crone and Wheeler (2000) and Wheeler (2005).

Crone and Wheeler (2000) and Wheeler (2005) compiled a database based on literature searches. These papers do not represent the original work. The literature searches may have missed some publications or there were unpublished works at that time. Therefore the databases do not actually support the statement that there is no evidence of earthquake-induced liquefaction in the State of Maryland. Please revise the FSAR statement/citation.

Were potential liquefaction features investigated as part of your geologic investigation for the site? If so please provide the details.

02.05.01-29

FSAR Figure 2.5-15 is an important figure for this application because of the world wide association of extended continental margin crust and seismic activity. However, the figure is confusing and unclear.

It is unclear whether “Age of crust” refers to the age of deformation, or to the age of the deformed rocks. The three different shades of blue in the Explanation do not correspond to the map (2 shades of blue, with or without pattern). The darkest blue shown under “Age of crust” seems to correspond to the map location of folded, thrust-faulted Paleozoic rocks (2-5 km thick section), but the underlying crust may be Proterozoic (Grenville) in age. The green area is Grenville and older rocks that were metamorphosed and intruded during the Grenville orogeny. The “Extended Crust” components in the Explanation do not specify an age, but the patterning appears to identify only Mesozoic extended crust.

Please revise FSAR Figure 2.5-15 to: a) clarify the explanation, define highly and slightly extended crust, b) list the maps and references from which the figure was compiled or simplified, c) indicate the limits of Iapetan normal faulted crust, d) indicate the western limits of Mesozoic rift basins, and e) provide additional illustrations as needed to indicate the geologic and geophysical basis for the boundaries.

02.05.01-30

FSAR Section 2.5.3.1 summarizes the field, aerial, and office investigations that were performed within 40 km of the site, largely to detect surface rupture.

However, along the United States east coast, large earthquakes tend not to rupture the surface, but to produce liquefaction features instead. Thus, East coast paleoseismology includes a thorough, detailed search for liquefaction features throughout large areas. The FSAR provides no information about a liquefaction survey completed for the site vicinity (40 km around the site).

Please provide liquefaction information for the area of the site along with methods used and a summary of the findings.

02.05.01-31

FSAR Section 2.5.3.1 describes field reconnaissance of the site and site vicinity and how the geologists recorded their findings and field locations. However, the extent of the fieldwork is unclear.

Please provide details of the field reconnaissance preformed at the site and within the site vicinity. Include maps of field stations and photos of any features considered for discussion or analysis.

02.05.01-32

FSAR Section 2.5.3.2.2 refers to an east-facing monocline 3.2 km east of the site reported by McCartan et al. (1995) and states “If the feature does exist, the Miocene St. Mary’s Formation is not depicted (USGS, 1995) to be deformed. Therefore, the inferred monoclines (USGS, 1995) are older than Late Miocene in age and do not represent a surface-fault rupture or deformation hazard at the CCNPP site.”

FSAR Figure 2.5-40 shows that the St. Mary’s Formation has been removed by erosion at the location of the monocline, so that it is not continuous enough to determine it is unfolded.

Please reconcile the quotation with what USGS (1995) does and does not show. Explain the hazard consequences if the monocline were to be younger than Miocene.