PMSummerColpEM Resource

From: Ravindra Joshi
Sent: Wednesday, February 04, 2009 4:09 PM
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Cc: SummerCOL Resource; Gerry Stirewalt; Rebecca Karas; Clifford Munson
Subject: Draft RAI 1823 related to SRP section 2.5.1 for Summer Units 2 and 3
Attachments: RAI 1823.doc

To All,

Attached is a draft RAI (1823) related to SRP Section 2.5.1 for Summer Units 2 and 3. If you would like to schedule a conference call to discuss this RAI, please let me know before 5:00 PM on Monday February 9, 2009. If no request for a conference call is received, this RAI will be issued as Final.

Thanks,

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Request for Additional Information No. 1823

Virgil C. Summer Nuclear Station, Units 2 and 3
South Carolina Electric and Gas Company
Docket No. 52-027 and 52-028
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 Section 2.5.1.1.1 (pg. 2.5.1-2) references Figure 2.5.1-202 and states that the Blue Ridge and Piedmont physiographic provinces are further divided into different lithotectonic terranes. However, the cited figure does not include Blue Ridge lithotectonic sub-divisions, but only sub-divisions for a part of the Piedmont (i.e., the Carolina Zone of the Central Piedmont in which the site is located and the geologic/lithotectonic terranes therein). FSAR Sections 2.5.1.1.1.3 (pgs. 2.5.1-3 & 2.5.1-4) and 2.5.1.1.1.4 (pgs. 2.5.1-4ff) also reference Figure 2.5.1-202, but regional relationships between the adjacent geologic/lithotectonic terranes, the regional faults which separate them, and the Carolina Zone are not clearly distinguished in a single figure.

In order for the staff to completely understand the geologic setting of the Summer site in relation to regional geology and lithotectonic elements, please prepare a single figure that illustrates the geologic/lithotectonic subdivisions (including the Valley and Ridge, Blue Ridge, Western Piedmont, and Central Piedmont relative to the Coastal Plain physiographic province), the regional fault zones which separate them, and the Carolina Zone of the Central Piedmont in which the site is located. The aim should be to place them in the regional geologic/tectonic context before finer details of these subdivisions are presented in existing FSAR Figure 2.5.1-202 and discussed in the text.

02.05.01-2***

FSAR Section 2.5.1.1.1.4 (pg 2.5.1-6) uses Carolina “Zone” and Carolina “Terrane” interchangeably in the first paragraph discussing the Carolina Zone, while stating and illustrating in FSAR Figure 2.5.1-202 (Sheet 1) that specific individual terranes make up this zone, including the infrastructural Charlotte Terrane in which the site is located.

In order for the staff to clearly understand the geologic setting of the Summer site in relation to regional geology and lithotectonic elements, please correctly distinguish the area which contains the infrastructural Charlotte Terrane and other suprastructural terranes.

02.05.01-3***

FSAR Section 2.5.1.1.1.4 (pgs 2.5.1-6 and 2.5.1-7) describes the Carolina Zone of the Central Piedmont, including the Charlotte terrane of the Carolina Zone in which the

Summer site is located. The most recent reference cited is Hibbard et al (2002), while other references cited are substantially older. More recently-published references (e.g., from 2007) exist in which the lithologic, stratigraphic, and structural geologic characteristics of the site region, including the Carolina Zone, are discussed.

In order for the staff to assess whether or not information presented in the FSAR represents an up-to-date characterization of regional geology, please incorporate pertinent information from more recently-published references for description of the lithologic, stratigraphic, and structural geologic characteristics of the Carolina Zone of the Piedmont physiographic province in which the site is located.

02.05.01-4***

FSAR Sections 2.5.1.1.2.1 (pgs 2.5.1-11 and 2.5.1-12) and 2.5.1.1.2.4.2 (pgs 2.5.1-24 and 2.5.1-25) state that normal faults which bound Triassic basins may be listric into Paleozoic detachment faults, or may penetrate the crust as high-angle faults, but no definitive correlation of seismicity with Mesozoic normal faults has been demonstrated conclusively. FSAR Section 2.5.1.1.2.4.2 (pg 2.5.1-25) also states that Mesozoic basins have long been considered potential sources of earthquakes along the eastern seaboard, and were captured by most of the EPRI science teams in the definition of seismic sources. If these faults do penetrate the crust as high-angle structures, there may be increased potential for future seismicity, and no information is directly presented in the FSAR which precludes Mesozoic basin-bounding faults in the site region from extending deep into the crust.

In order for the staff to assess the hazard potential of Mesozoic basin-bounding normal faults in the site region, please summarize any published information which provides evidence to support an inference that these faults are either steep and deep or shallow listric structures.

02.05.01-5***

FSAR Section 2.5.1.1.2.3.1 (pgs. 2.5.1-14 and 2.5.1-15) refers to the “Piedmont gradient” of the regional gravity field, but appears to label this gradient as the “Appalachian gravity gradient” in FSAR Figures 2.5.1-207 and 2.5.1-208.

In order for the staff to completely understand regional gravity gradients being discussed for the site region and their potential relationship to geologic features, please clarify the reference to the Piedmont gradient in the text versus the Appalachian gravity gradient in Figures 2.5.1-207 and 2.5.1-208.

02.05.01-6***

FSAR Section 2.5.1.1.2.3.1 (pg 2.5.1-16) states that regional gravity data acquisition and modeling studies performed to date show no evidence for Cenozoic tectonic activity or specific Cenozoic structures. Similarly, FSAR Section 2.5.1.1.2.3.2 (page 2.5.1-18) states that regional magnetic data show no evidence for Cenozoic structures in the site region. However, no explanation is provided in regard to how regional gravity or magnetic data can be used to determine that a given tectonic feature is Cenozoic in age. Furthermore, FSAR Sections 2.5.1.1.2.3.1 (pg 2.5.1-16) and 2.5.1.1.2.3.2 (pg 2.5.1-18) state that, in general, most regional anomalies at both first-order and superimposed second-order scales equate to lithologic variations rather than regional structures.

In order for the staff to determine the adequacy of the geologic interpretations based on regional gravity and magnetics data provided in the FSAR, please discuss the criteria applied for determining the presence of Cenozoic tectonic structures based on regional gravity and magnetic data.

02.05.01-7***

According to FSAR Section 2.5.1.1.2.3.2 (pg 2.5.1-16) and FSAR Figure 2.5.1-207 (northeast of the Summer site), the Western Piedmont between the Brevard Zone and the Central Piedmont shear zone (CPSZ) is characterized by a relatively uniformly varying magnetic field around a background of approximately -500 nT. However, Figure 2.5.1-208 (southeast of the Summer site) appears to indicate a varying magnetic field about a background closer to 0 nT for this same area.

In order for the staff to determine the adequacy of the geologic interpretations based on regional magnetics data provided in the FSAR, please discuss the importance of this apparent difference in magnetic signature between these two profiles.

02.05.01-8***

FSAR Figure 2.5.1-209 illustrates site vicinity gravity and magnetic profiles and discusses the information reflected in these profiles in Sections 2.5.1.1.2.3.1 (pg 2.5.1-15) and 2.5.1.1.2.3.2 (pg 2.5.1-17) with reference to the Central Piedmont and Modoc shear zones. However, neither the Central Piedmont shear zone (CPSZ) nor the Summer site is located in the profiles to enable correlation of gravity and magnetic anomalies in the site vicinity with regional geologic structures. Furthermore, as illustrated in the profiles of Figure 2.5.1-209, the relatively short wavelength magnetic high near 20 km (12.43 mi), which appears to correspond with a gravity high, and the magnetic low from about 50-70 km (31.07-43.5 mi), which corresponds with a gravity high, are not explained in relation to regional features which may cause these anomalies.

It is also not clearly stated in FSAR Sections 2.5.1.1.2.3.1 (pg 2.5.1-15) and 2.5.1.1.2.3.2 (pg 2.5.1-17) whether the site vicinity gravity and magnetic profiles represent data collected at that scale or are extrapolated from regional gravity and magnetics data. However, the reference cited in Figure 2.5.1-209 (Daniels, 2005) would seem to indicate that these site vicinity data are extracted from gravity and magnetic maps produced for the State of South Carolina and, therefore, the data is at a scale less than the regional scale but greater than the site vicinity scale.

In order for the staff to determine the adequacy of the geologic interpretations based on site vicinity gravity and magnetics data provided in the FSAR, please locate the site and the CPSZ on Figure 2.5.1-209 and discuss the significance of these two magnetic anomalies as they may relate to the gravity anomalies and geologic structures or lithlologies in the site vicinity. Please also clarify whether the site vicinity gravity and magnetic profiles represent data collected at that scale or are extrapolated from regional gravity and magnetics data or a statewide database. Finally, please summarize any pertinent points discussed by Daniels (2005) related to the anomalies as they may bear on geologic structures in the site vicinity.

02.05.01-9***

FSAR Section 2.5.1.1.2.3.2 (pg 2.5.1-17) discusses magnetic anomalies in the site vicinity which are associated with the Modoc shear zone and are shown in FSAR Figure 2.5.1-209. This section equates these high-amplitude, short wavelength anomalies with both (a) “a susceptibility contrast across a dipping structural contact” and (b) “sub-vertical interleaved tabular bodies of varying magnetic susceptibility”. The FSAR cites the same reference (i.e., Cumbest and others, 1992) for both seemingly different interpretations. However, no explanation is offered to indicate how these two interpretations are related or which may be preferred.

In order for the staff to determine the adequacy of the geologic interpretations based on site vicinity magnetics data provided in the FSAR, please discuss these two interpretations relative to their apparent differences and specify which interpretation is preferred.

02.05.01-10***

FSAR Figure 2.5.1-206 shows prominent regional aeromagnetic lows within the Summer site vicinity; Figure 2.5.1-207 illustrates these lows in a regional profile; and Figure 2.5.1-209 shows magnetic lows and highs in a profile drawn at the site vicinity scale. The low regional magnetic anomalies are not discussed in the FSAR even though the magnetic highs are discussed (pg 2.5.1-17).

In order for the staff to determine the adequacy of the geologic interpretations based on regional magnetics data provided in the FSAR, please discuss the significance of the regional magnetic lows as they may relate to geologic structures or lithologies in the site vicinity.

02.05.01-11***

FSAR Section 2.5.1.1.2.3.2 (pg 2.5.1-18) states that regional magnetic data do not have sufficient resolution to identify border faults along Triassic basins, while Section 2.5.1.1.2.4 (pg 2.5.1-18) states that most Mesozoic structures are both geophysically and geologically recognizable. These two statements do not appear to be compatible.

In order for the staff to determine the adequacy of the geologic interpretations based on regional magnetics data provided in the FSAR, please clarify whether or not Mesozoic structures can be identified using geophysical data, including regional magnetic data.

02.05.01-12***

FSAR Section 2.5.1.1.2.4.1 (pg 2.5.1-20) discusses the Gold Hill fault extension. This section states, based on structural correlations with the Deal Creek shear zone and cross-cutting relationships with igneous bodies as defined by West (1998), that the Gold Hill fault extension is between 400-325 my old. The data from West (1998) on which this interpretation is based are not presented in the FSAR. Furthermore, the Deal Creek shear zone is not discussed in the FSAR, and publications (e.g., Hibbard and others, 2007; Allen, 2007) presenting more recent information on the Gold Hill shear zone are not mentioned.

In order for the staff to completely understand geologic setting of the Summer site in relation to regional tectonic structures, please discuss the suggested age constraint for the Gold Hill fault based on relationships with the Deal Creek shear zone, including a summary of the information from West (1998) that make this interpretation possible. Please also provide a discussion of the Deal Creek shear zone and factor in more recent published information for discussion of the Gold Hill shear zone.

02.05.01-13***

FSAR Section 2.5.1.1.2.4.1 (pgs 2.5.1-19 and 2.5.1-20) discusses the Paleozoic Central Piedmont shear zone (CPSZ) which forms the western boundary of the Carolina Zone in which the site is located. FSAR Section 2.5.1.1.1.4 (pg 2.5.1-5) describes the CPSZ as a complex series of fault zones, including at least the Lowdensville, Kings Mountain, and Eufola fault zones. FSAR Figure 2.5.1-202 (Sheet 2) labels more faults northward along strike which may also be a part of the CPSZ. It is not clear whether the Paleozoic Beaver Creek shear zone, discussed in FSAR Section 2.5.1.1.2.4.1 (pg 2.5.1-20), or the Deal Creek shear zone shown in FSAR Figure 2.5.1-211, may be part of the CPSZ or lie south of that zone. Finally, FSAR Section 2.5.1.1.2.4.1 (pg 2.5.1-20) describes the CPSZ as “a late Paleozoic thrust” based on Hibbard and others (1998 and 2002), a description that would appear not to reconcile with the interpretation that this zone is comprised of a complex series of multiple faults.

In order for the staff to completely understand the geologic setting of the Summer site in relation to regional tectonic structures, please define the faults which comprise the CPSZ, include these faults in a single figure (such as that requested in RAI 2.5.1-1), and discuss interpretations related to the complexity of the zone in regard to hazard potential for the site.

02.05.01-14***

FSAR Section 2.5.1.1.2.4.1 (pg 2.5.1-20) discusses a postulated unnamed fault near Parr which, if it exists, occurs about 4.8 km (3 mi) south-southwest of the Summer site. A trace length of about 9.7 km (6 mi) is shown for this fault on the site area geologic map of FSAR Figure 2.5.1-224, although the FSAR states that evidence for the fault included shear fabrics in only a single exposure and it probably does not extend to the northeast. This FSAR section further states that the boundary of the Winnsboro pluton is not offset along the projected northeast trace of this unnamed fault as proof that it does not extend northeastward to the site location. Physical characteristics of the fault are not discussed (e.g., dip of the fault; whether the feature may exhibit a mylonitic fabric indicative of deep-seated, older ductile deformation or is clearly a later-stage brittle shear zone;

amount and type of displacement), although its strike appears to generally parallel that of the three northeast-trending shear zones mapped in the Unit 1 excavation.

In order for the staff to assess the hazard potential of this unnamed fault which has been postulated to occur within the site area, please provide information on characteristics of this fault which may bear on age of faulting, including whether the boundary of the Winnsboro pluton has been mapped accurately enough to preclude any offset along the fault. Please also provide information on fault characteristics and discuss whether the fault could be related to the northeast-trending system of minor faults represented by the dated shear zones mapped in the Unit 1 excavation. Finally, please provide the logic for illustrating the fault with a trace length of 9.7 km (6 mi) in Figure 2.5.1-224 if it was only mapped in a single exposure.

02.05.01-15***

FSAR Section 2.5.1.1.2.4.1 (pgs 2.5.1-20 and 2.5.1-21) discusses the Cross Anchor fault and states that the fault is assigned a Paleozoic age based on cross-cutting and structural relationships. However, these relationships are not summarized to document the conclusion that this fault is Paleozoic in age.

In order for the staff to completely understand the geologic setting of the Summer site in relation to regional tectonic structures, please provide a summary of the information to document a Paleozoic age for the Cross Anchor fault.

02.05.01-16***

FSAR Section 2.5.1.1.2.4.1 (pgs 2.5.1-21 and 2.5.1-22) discusses the Modoc shear zone and the Augusta fault, indicating that both these structural features show ductile and later-stage brittle deformation fabrics. This FSAR section (pg 2.5.1-21) further states that the Modoc shear zone may have experienced movement in Mesozoic (i.e., Triassic) time. While age relationships for the two fabrics are discussed, this FSAR section does not summarize the salient logic used for clearly documenting that both fabrics are old and the brittle fabric does not represent late-stage faulting which may pose a hazard for the site. In addition, Nystrom (2006) indicates that the Modoc shear zone and the Augusta fault are part of the Eastern Piedmont fault system which may exhibit movement extending into the late Cenozoic.

In order for the staff to assess the hazard potential for these two regional structures, please summarize the logic used to document that both fabrics are old and the brittle fabric does not represent late-stage faulting. Please include an assessment of the interpretation by Nystrom (2006) that faults in the Eastern Piedmont fault system, which includes the Augusta fault and Modoc shear zone, may exhibit late Cenozoic movement.

02.05.01-17***

FSAR Section 2.5.1.1.2.4.1 (pg 2.5.1-22) discusses the Augusta fault and lists the observations made by Maher (1987) used to document a hanging-wall-down, oblique sense of displacement along this fault. However, other researchers have interpreted different types of displacement along the fault, including possible normal displacement during the Mesozoic. FSAR Section 2.5.1.1.2.4.1 does not explain how these observations prove the type of displacement suggested by Maher (1987). This FSAR section (pg 2.5.1-22) also states that Maher (1994) interprets some extension to have occurred in pre-Mesozoic time during late stages of the collisional Alleghanian orogeny.

In order for the staff to completely understand the hazard potential for the Augusta fault and whether extension along the fault occurred in Mesozoic or pre-Mesozoic time, please provide a summary of the details behind the list of observations made by Maher (1987) that document a hanging-wall-down, oblique sense of displacement for the fault, as well as the details to document his interpretation (Maher, 1994) of late stage Alleghanian, rather than Mesozoic, extension.

02.05.01-18***

FSAR Section 2.5.1.1.2.4.1 (pg 2.5.1-22) discusses “other Paleozoic faults” in the site region, but includes only a partial list of the named Paleozoic geologic structures found in the region and shown in FSAR Figure 2.5.1-211. For example, the Deal Creek shear zone, Bowens Creek fault, Fries fault, Great Smokey fault, Hyco shear zone, and Silver Hill fault are labeled in Figure 2.5.1-211 but are not listed or discussed on pg 2.5.1-22. Consequently, all named faults are not qualified as Paleozoic in age based on field data.

In order for the staff to completely understand the geologic setting of the Summer site in relation to regional tectonic structures, please include named faults found in the site region in the discussion of other Paleozoic faults and qualify them as Paleozoic in age.

02.05.01-19***

FSAR Section 2.5.1.1.2.4.2 (pg 2.5.1-23) discusses regional Mesozoic tectonic structures. This section states that the minimum age of displacement on the Wateree Creek fault is constrained to be Triassic based on cross-cutting dikes which are not offset, and the Summers Branch and Ridgeway faults are both interpreted to be Triassic structures on the basis of their association with the Wateree Creek fault.

In order for the staff to assess the hazard potential for these three faults, please summarize the information on the relationship of the Summers Branch and Ridgeway faults to the Wateree Creek fault that is used to document that all three faults are Triassic in age.

02.05.01-20***

FSAR Section 2.5.1.1.2.4.2 (pg 2.5.1-24) discusses the Longtown fault, stating that Jurassic age diabase dikes cross-cut, and are not offset by, the fault. However, this FSAR section then states that post-Mesozoic slip along the fault cannot be precluded by the available data.

In order for the staff to assess the hazard potential of the Longtown fault, please explain why the cross-cutting dikes of Jurassic age do not preclude post-Mesozoic displacement along the fault.

02.05.01-21***

FSAR Section 2.5.1.1.2.4.2 (pg 2.5.1-24) discusses the Mulberry Creek fault, indicating it is Mesozoic in age based on an association with other similar silicified breccias described by West (1998), although the legend symbol shown in FSAR Figure 2.5.1-212 indicates it is Paleozoic in age. However, Nystrom (2006) discussed field occurrence of silicified breccias in the site region and suggested that they may occur along faults exhibiting late Cenozoic movement in the Eastern Piedmont fault zone. In addition, there is no explanation in the figure legend for the “diagonal line” symbol shown on the map which appears to designate shear zones in some cases (e.g., the Modoc shear zone) but not in others (e.g., the Kings Mountain and Boogertown shear zones).

In order for the staff to completely understand the geologic setting of the Summer site in relation to regional tectonic structures, please qualify the age of the Mulberry Creek fault and summarize the logic presented by West (1998) that silicified breccias are indicative of Mesozoic age fault displacements in light of the interpretation by Nystrom (2006) that late Cenozoic movement may have occurred along some structures in the site region which are marked by silicified breccias. Please also explain the meaning and use of the “diagonal line” symbol in Figure 2.5.1-212.

02.05.01-22***

FSAR Section 2.5.1.1.2.4.2 (pgs 2.5.1-24 and 2.5.1-25) states that Mesozoic rift basins are areas of extended crust that potentially contain the largest earthquakes, but there is no definitive correlation of seismicity with Mesozoic normal faults. However, although FSAR Section 2.5.1.1.2.4.2 makes this statement, FSAR Section 2.5.3.1.5 (pgs 2.5.1-4 and 2.5.1-5) indicates that two September 2006 earthquakes, which occurred near Bennettsville, SC, more than 144.84 km (90 mi) east-northeast of the Summer site, were spatially associated with a small Mesozoic extensional basin lying beneath the Coastal Plain as mapped by Benson (1992). If the September 2006 earthquakes are best explained as having occurred on faults related to a buried Mesozoic rift basin, the presence of such basins in the site region may have implications for the existence of potentially capable tectonic structures. Furthermore, Chapman and Beale (2008) present data which they interpret as showing Cenozoic compressional reactivation of a Mesozoic extensional fault near the intersection of the inferred Sawmill Branch and Woodstock faults which occur within the currently seismic meizoseismal area of the 1886 Charleston earthquake (i.e., within the Middleton Place-Summerville seismic zone).

In order for the staff to assess the hazard potential of Mesozoic rift basins in the site region, please include earthquake epicenters on an appropriate figure to show their locations relative to areas of Mesozoic extended crust. Also, in light of information presented in FSAR Section 2.5.3.1.5 regarding spatial association of two earthquakes with a small Mesozoic basin and the recent data presented by Chapman and Beale (2008) for the Middleton Place-Summerville seismic zone, please summarize the logic for not interpreting Mesozoic structures in the site region as potential capable tectonic sources.

02.05.01-23***

FSAR Section 2.5.1.1.2.4.3 (pgs 2.5.1-25 and 2.5.1-26) discusses the Camden fault under Cenozoic age regional structures, stating in one sentence that age of most recent slip is uncertain and, in another, that age of displacement along the Camden fault is constrained because overlying Tertiary deposits are not offset. There is no indication which interpretation is preferred, and pertinent information from the original cited source (Knapp and others, 2001) related to the constrained age interpretation is not summarized to document a pre-Quaternary age for this fault.

In order for the staff to assess the hazard potential for the Camden fault, please clarify whether the age of this fault is considered to be constrained or is uncertain, and summarize the information used by Knapp and others (2001) to suggest the fault is pre-Quaternary in age.

02.05.01-24***

FSAR Section 2.5.1.1.2.4.3 (pg 2.5.1-26) discusses arches and embayments but does not show the location of the Yamacraw Arch on Figure 2.5.1-211 on which the Cape Fear Arch is located. This section states that late Cretaceous through Pleistocene (i.e., as young as 1.8 my to 10,000 yrs in age) differential tectonic movement is indicated by these features, although Crone and Wheeler (2000) label them as Class C features. Furthermore, FSAR Section 2.5.1.1.2.4.4 (pg 2.5.1-29), mentions the Cape Fear Arch, but not the Yamacraw, in relation to potential regional Quaternary tectonic structures.

In order for the staff to assess the hazard potential for these two arches, please locate the Yamacraw Arch on Figure 2.5.1-211 and include a discussion of this arch in FSAR Section 2.5.1.1.2.4.4, as was done for the Cape Fear Arch. Please also refer to primary sources of data which render the conclusions about these features plausible rather than relying on the compiled information presented by Crone and Wheeler (2000).

02.05.01-25***

FSAR Section 2.5.1.1.2.4.4 (pg 2.5.1-27) states that, based on a review of published literature, field reconnaissance, and work performed as part of the North Anna ESP application, the Fall Lines of Weems (1998) are interpreted to be erosional features related to contrasting erosional resistances of adjacent rock types and are not tectonic in origin.

In order for the staff to assess the basis for the conclusion that the Fall Lines of Weems (1998) are erosional in nature, please summarize the pertinent information which leads to this conclusion by presenting pertinent data from primary sources which render this conclusion plausible.

02.05.01-26***

FSAR Figure 2.5.1-215 illustrates locations of 14 proposed Quaternary features which occur in the site region. However, with the exception of the Falls Lines of Weems (1998), strike trends of these features are not shown in the figure to enable an assessment of linear trends of the features.

In order for the staff to assess the hazard potential for the 14 proposed Quaternary features, please indicate strike trends and fault lengths for these features in Figure 2.5.1-215.

02.05.01-27***

FSAR Section 2.5.1.1.2.4.4 (pgs 2.5.1-27 and 2.5.1-28) discusses the Belair Fault and indicates that this structure may be a tear fault or lateral ramp in the hanging wall of the Augusta fault zone. If the Belair fault is associated with the Augusta fault zone in this manner, then movement on the Belair may be related to movement on the larger, regional-scale Augusta fault. The FSAR indicates that information exists (Prowell and O'Connor, 1978) which constrains the age of last movement on the Belair Fault to sometime between post-late Eocene and pre-26,000 years ago, rendering this fault to be a structure in the site region interpreted to show possible evidence of Quaternary movement.

In order for the staff to assess the hazard potential for the Belair fault, please discuss how the inference of possible Quaternary movement on this fault, coupled with its potential relationship to the regional-scale Augusta fault zone, could affect seismic hazard at the Summer site.

02.05.01-28***

FSAR Section 2.5.1.1.2.4.4 (pg 2.5.1-28) discusses the Pen Branch fault and concludes that it is not a capable tectonic structure. The FSAR refers to studies performed for the Vogtle ESP application, but does not summarize the evidence taken from these studies used to conclude that the Pen Branch fault is not a capable structure.

In order for the staff to assess the hazard potential for the Pen Branch fault, please summarize the information presented in the cited original source which was used to conclude that the Pen Branch fault is not a capable tectonic structure.

02.05.01-29***

FSAR Section 2.5.1.1.2.4.4 (pg 2.5.1-29) discusses the postulated Hares Crossroads and Stanleytown-Villa Heights faults, interpreting them to be the result of landsliding, and therefore of non-tectonic origin. This FSAR section cites the data compilation paper by Crone and Wheeler (2000), who classified these faults as Class C features, but does not summarize information from original data sources to document the conclusion that these faults are non-tectonic in origin.

In order for the staff to assess the hazard potential for these faults, please summarize the evidence from primary data sources used to conclude that the faults formed in response to a non-tectonic, landslide mechanism, rather than referring only to the compiled data presented by Crone and Wheeler (2000).

02.05.01-30***

FSAR Section 2.5.1.1.2.4.4 (pgs 2.5.1-29 and 2.5.1-30) discusses the postulated Pembroke faults which are classified as Class B structures (i.e., possible Quaternary faulting) by Crone and Wheeler (2000). However, no information is provided on fault geometry or fault length, and the FSAR states that it is unclear whether they are of tectonic origin or are the result of dissolution collapse.

In order for the staff to assess the hazard potential for these faults, please summarize information on fault geometry and fault length and present lines of evidence related to whether these features are tectonic or non-tectonic in origin as derived from primary data sources, rather than relying only on the compiled information presented by Crone and Wheeler (2000).

02.05.01-31***

FSAR Section 2.5.1.1.2.4.5 (pg 2.5.1-31) indicates that the New York-Alabama Lineament (NYAL) is shown on both Figures 2.5.1-211 and 2-5-1-212. However, the NYAL is not shown on Figure 2.5.1-212 as this FSAR section implies.

In order for the staff to assess the accuracy of the regional geologic characterization provided in the FSAR in relation to geophysical anomalies and lineaments, please include the NYAL in Figure 2.5.1-212 if it is to be cited as showing it, or refer to the correct figure(s) in which it is shown.

02.05.01-32***

FSAR Section 2.5.1.1.2.4.5 (pgs 2.5.1-32 and 2.5.1-33) discusses the Appalachian thrust front and states that it is interpreted to be a major fault splay off the regional Appalachian detachment. However, no details of this structural relationship are presented. In addition, the importance of the Appalachian detachment in the site region, the age of this regional structure, and the pertinence of the detachment surface for constraining seismicity in the site region are not discussed.

In order for the staff to assess the adequacy of the regional geologic characterization provided in the FSAR, please provide details regarding the suggested relationship between the Appalachian thrust front and the Appalachian detachment. Please also discuss the importance of the Appalachian detachment in the site region, including how it may constrain seismicity, and the age of this regional structure.

02.05.01-33***

FSAR Section 2.5.1.1.2.4.5 (pg 2.5.1-33) discusses the Grenville Front, but does not state the age of this regional feature.

In order for the staff to assess the adequacy of the regional geologic characterization provided in the FSAR, please qualify the age of the Grenville Front.

02.05.01-34***

FSAR Section 2.5.1.1.3.2.1 describes potential source faults in the Charleston area, including the postulated Sawmill Branch fault (pg 2.5.1-37). FSAR Section 2.5.1.1.3.2.1 (page 2.5.1-37) states that the Sawmill Branch fault trends northwest, but the fault is shown with two different strike directions: a northwest strike on Figure 2.5.1-219 and a northeast strike on Figure 2.5.1-218. Furthermore, FSAR Section 2.5.1.1.3.2.1 indicates it is a segment of the Ashley River fault and offsets the Woodstock fault. However, Figure 2.5.1-219 shows it crossing the Ashley River fault while Figure 2.5.1-218 shows that it intersects, but does not cross or offset, the Woodstock fault.

In addition, based on their interpretation that conjugate normal faults occur in the walls of Colonial Fort Dorchester, Bartholomew and Rich (2007) proposed the Dorchester fault in the area south of the Ashley River fault zone, seemingly near the vicinity of the Sawmill Branch fault. Under the discussion of the Sawmill Branch fault in FSAR Section 2.5.1.1.3.2.1 (pg 2.5.1-37), observed displacements in the walls of Fort Dorchester are equated with seismic shaking and not fault rupture, and there is no indication that information presented by Bartholomew and Rich (2007) was taken into account. Talwani and others (2008) proposed that displacement along the Sawmill Branch fault is the cause of the suggested conjugate faults in the walls of Fort Dorchester, and they reported a previously undiscovered paleoliquefaction feature as well. The Dorchester fault and its possible relationship to the Sawmill Branch fault are not described in FSAR Section 2.5.1.1.3.2.1, and the Dorchester fault is not located in a figure illustrating potential Charleston tectonic features (e.g., Figures 2.5.1-218 and 2.5.1-219).

In order for the staff to assess the hazard potential of the Sawmill Branch fault, please provide a corrected figure to illustrate location, orientation, and cross-cutting character of this fault. Please also discuss the proposed Dorchester fault, locate this structure on the appropriate map, and clarify the interpreted relationships between the Sawmill Branch, Ashley River, Woodstock, and Dorchester faults taking into account information presented in the recent literature.

02.05.01-35***

FSAR Section 2.5.1.1.3.2.1 (page 2.5.1-38) discusses the Middleton Place-Summerville seismic zone which includes the Sawmill Branch fault which FSAR Figure 2.5.1-218 shows as striking northeast. This seismic zone is not defined on the cited figure (i.e., Figure 2.5.1-219), but only on Figure 2.5.1-218. Based on recent data, Dura-Gomez and Talwani (2008) propose that the Sawmill Branch fault strikes northwest parallel to the Ashley River fault, is the most active fault in the Summerville area, and offsets the Woodstock fault. Furthermore, Chapman and Beale (2008) present data which they interpret as showing Cenozoic compressional reactivation of a Mesozoic extensional fault near the intersection of the inferred Sawmill Branch and Woodstock faults.

However, these two new information sources are not discussed in regard to faulting within the Middleton Place-Summerville seismic zone.

In order for the staff to assess the most recent geologic literature and determine if the information presented in the FSAR represents an up-to-date characterization of the Sawmill Branch fault and the Middleton-Summerville seismic zone, please incorporate recent data from the two 2008 published sources which discuss faulting in the Middleton-Summerville seismic zone.

02.05.01-36***

FSAR Section 2.5.1.1.3.2.1 (page 2.5.1-38) discusses the Adams Run seismic zone and cites Figure 2.5.1-219 as showing the location of this zone. The Adams Run seismic zone is not labeled in Figure 2.5.1-219, although the Adams Run fault, which is separately discussed in FSAR Section 2.5.1.1.3.2.1 (page 2.5.1-33), is located on that figure. Neither discussion directly relates the seismic zone to the fault, although they appear to be the same feature.

In order for the staff to assess the hazard potential of the Adams Run seismic zone and understand the specific relationship of this zone to the Adams Run fault, please clearly define the relationship between these two features which are currently discussed separately and locate the seismic zone relative to the fault on the appropriate figure(s).

02.05.01-37***

FSAR Section 2.5.1.1.3.2.1 (page 2.5.1-39) discusses paleoliquefaction features in coastal South Carolina. Talwani and others (2008) have reported discovery of another paleoliquefaction feature associated with the Sawmill Branch fault well, and it is not clear whether this feature is considered in this discussion.

In order for the staff to assess seismic hazard potential for the Summer site as inferred from paleoliquefaction features, please discuss the paleoliquefaction feature associated with the Sawmill Branch, as was reported by Talwani and others (2008), and any bearing this feature may have on magnitude and recurrence interval for earthquakes in the site region.

02.05.01-38***

FSAR Section 2.5.1.1.3.2.2 (pgs 2.5.1-40 and 2.5.1-41) discusses the six EPRI/SOG team source zones and corresponding M_{max} values for the Eastern Tennessee Seismic Zone (ETSZ). The FSAR (pg 2.5.1-41) specifies the upper-bound maximum range of the EPRI/SOG teams M_{max} values as **M** 6.3 to 7.5 (converted from m_b values 5.2 to 7.2). Although the FSAR (pg 2.5.1-41) states that more recent estimates of M_{max} are captured in the range of M_{max} values used by the EPRI/SOG teams, the FSAR cites post-EPRI/SOG M_{max} estimates of **M** 6.3 (Bollinger, 1992) and **M** 7.5 (Frankel and others, 2002) but not the alternate higher estimate of **M** 7.8 by Bollinger (1992) which is presented in FSAR Section 2.5.2.2.2.5 (pg 2.5.2-33).

In order for the staff to assess the information presented in the FSAR on the ETSZ, please clarify why FSAR Section 2.5.1.1.3.2.2 does not include the Bollinger (1992) M_{max} estimate of **M** 7.8 since this value is not captured in the range of M_{max} values used by the EPRI/SOG teams as claimed.

02.05.01-39***

FSAR Section 2.5.1.1.3.2.2 (pg 2.5.1-40) states that a lack of seismicity in the relatively shallow Appalachian thrust sheets implies that seismogenic structures in the ETSZ are unrelated to surficial geology of the Appalachian orogen. The FSAR also states (pg 2.5.1-44) that the lack of seismicity in the shallow Appalachian thrust sheets, estimated to be about 3.2-5.6 km (2-3.5 mi) thick, implies that seismogenic structures in the Giles County seismic zone are also unrelated to surficial geology of the Appalachian orogen.

In order for the staff to assess the interpretation that seismogenic structures in the ETSZ and the Giles County seismic zone are unrelated to surficial geology, please provide the following information:

(a) Document any direct evidence available from seismograms for constraining earthquakes in the ETSZ to depths between 4.8-25.7 km (3-16 mi), precluding a possible association with known shallow faults.

(b) Summarize the available evidence supporting the statement that the basal Appalachian detachment, into which thrust faults in the ETSZ sole out, has a maximum depth of 4.8 km (3 mi).

(c) Given the degree of uncertainty in [1] phase identification present in most seismic network data (particularly for distances corresponding to stations in the ETSZ), [2] distance to the nearest station, [3] seismograph station density, and [4] velocity structure and its relationship to models used in routine hypocenter determination, please discuss what modifications to some or all of these uncertainties would be necessary to enable location of some of the earthquake hypocenters on one of the mapped faults shown in Figure 2.5.1-212 and whether this modification is in the zero to one sigma uncertainty bound.

02.05.01-40***

FSAR Section 2.5.1.1.3.2.3 (pg 2.5.1-42) states that the January 23, 1812, earthquake in the New Madrid seismic zone was associated with strike-slip displacement along the East Prairie fault located in the northern portion of that seismic zone. Existence of the East Prairie fault is not documented by references.

In order for the staff to completely understand the geologic setting of the Summer site in relation to well-defined zones of seismicity within the site region, please provide references to document the location of the east Prairie fault within the New Madrid seismic zone.

02.05.01-41***

FSAR Section 2.5.1.1.3.2.3 (pgs 2.5.1-42 and 2.5.1.-43) discusses the Central Virginia seismic zone (CVSZ), including two paleoliquefaction sites identified within the seismic zone. This section states further that, while the paleoliquefaction features reflect pre-historic seismicity within the CVSZ, they "do not indicate the presence of a capable tectonic source". This statement results in confusion because the distinction between the seismic zone (which does contain paleoseismic features indicating pre-historic faulting and resultant seismicity) and a fault acting as the specific tectonic source within the zone (to which the paleoseismic features can be related) is not clearly made.

In order for the staff to assess the information presented in the FSAR on the CVSZ, please make a clearer distinction between the seismic zone and a fault acting as the specific tectonic source within the zone.

02.05.01-42***

FSAR Section 2.5.1.1.3.2.2 (pgs 2.5.1-44 and 2.5.1-45) discusses the Pembroke faults of probable Quaternary age which occur within the Giles County seismic zone, and concludes that these shallow faults are unrelated to seismicity within the seismic zone. There is no discussion regarding whether the Pembroke faults could represent shallow tectonic structures which were triggered by deeper faulting within the Giles County seismic zone.

In order for the staff to assess the hazard potential for the shallow Pembroke faults, please discuss whether they could have been triggered by deeper faulting within the Giles County seismic zone.

02.05.01-43***

FSAR Section 2.5.1.2.2 (pg 2.5.1-46) states that the Central Piedmont shear zone (CPSZ) is located about 24.14 km (15 mi) northwest of the Summer site. However, this regional shear zone is not shown on the site vicinity geologic map presented in FSAR Figure 2.5.1-220, and locating it would help to define the northwestern extent of the Charlotte Terrane in which the site is located. In addition, other faults mapped in the site vicinity (e.g., the Cross Anchor, Summers Branch, Wateree, and #67 faults and the unnamed fault near Parr) are not labeled in Figure 2.5.1-220. Furthermore, the along-strike length of the Chappells shear zone appears to be inaccurate based on how this feature is represented as extending west-southwestward from the site in FSAR Figure 2.5.1-212.

In order for the staff to completely understand the geologic setting of the Summer site in relation to regional tectonic structures, please locate the CPSZ on the site vicinity geologic map presented in Figure 2.5.1-220. Please also label other faults mapped in the site vicinity, and define the northwestern boundary of the Charlotte Terrane on Figure 2.5.1-220. Please indicate the along-strike extent of the Chappells shear zone west of the site.

02.05.01-44***

FSAR Section 2.5.1.2.2 (pgs 2.5.1-46 and 2.5.1-47) lists 10 geologic events that affected rocks in the site area. This FSAR section states that definition of these 10 events was based on results of radiometric age dating analyses performed for Unit 1, which implies that these events are arranged in a chronologic sequence. However, although absolute age dates are presented for three other geologic events in a separate list, those three events are not keyed to the longer list of 10 events. Therefore, the radiometric age dates alluded to in FSAR Section 2.5.1.2.2 (pg 2.5.1.46) are not provided for the 10 geologic events to clarify event chronology and constrain the timing of faulting and folding for the site area. In addition, no references are cited to document the sources of the radiometric age data. Finally, the amount of displacement related to "minor" and "very minor" movement along northeast and northwest-trending joints is not specified.

In order for the staff to understand the geologic setting of the Summer site in relation to geologic events which occurred within the site area, including complex faulting and folding of the Charlotte Terrane, please add the radiometric age dates to the list of events. Please combine the two separate lists, if they are related, to present the information concisely. Please also summarize the specific age dating information used to constrain faulting in the site area; provide references to document the sources of the radiometric age data; and quantify the amount of displacement related to "minor" and "very minor" movement along the two joint systems.

02.05.01-45***

FSAR Section 2.5.1.2.3 (pg 2.5.1-49) refers to amphibolite-grade meta-igneous and meta-sedimentary rocks of the Carolina Zone which occur within the site area, but does not clarify whether these units specifically occur in the Charlotte Terrane of the Carolina Zone.

In order for the staff to completely understand the geologic setting of the Summer site and site area in relation to regional geology and lithotectonic elements, please clarify whether the specific units being discussed under FSAR Section 2.5.1.2.3, page 2.5.1-49 (as well as other rock units discussed under this FSAR section), occur within the Charlotte Terrane of the Carolina Zone.

02.05.01-46***

FSAR Section 2.5.1.2.4 (pgs 2.5.1-51 and 2.5.1-52) discusses three minor shear zones which were mapped in the Unit 1 excavation and constrained by radiometric age dating results to be likely no younger than Mesozoic or Early Cenozoic in age. However, there is no discussion of sample controls for the unsheared minerals extracted from the shear zones to ensure that they were collected in the part of the shear zone which experienced the last movement. This FSAR section (pg 2.5.1-51) states that minor shears of this type are common in rocks of the Piedmont, but no reference is cited to document this statement. This FSAR section (pg 2.5.1-52) also indicates, based on investigations performed for Unit 1, that an evaluation was performed regarding the potential for movement along the shear zones due to filling of the Monticello Reservoir. The conclusion drawn is that reservoir impoundment would not adversely affect the shears; that both northwest and northeast-striking shears existed although the dominant set trends northeast; and that these shears were not observed to penetrate the soil profile.

No details, however, are provided to document either of these three additional statements.

In order for the staff to assess the adequacy of the information presented in the FSAR related to faults mapped in the Unit 1 excavation (which may also be expected to occur at Units 2 and 3), please do the following:

(a) Please discuss sample controls which were implemented for collecting the unsheared minerals to ensure that they were collected in the part of the shear zone which experienced the last movement, and add the sampling location(s) to the map shown in FSAR Figure 2.5.1-230.

(b) Please provide references to document the statement that minor shears of the type mapped in the Unit 1 excavation are common in rocks of the Piedmont.

(c) Please summarize information used to conclude that impoundment of the Monticello Reservoir would not adversely affect the shear zones based on evaluation results.

(d) Please clarify the statement that shears trending both northeast and northwest occur in the Unit 1 excavation in light of the fact that only three northeast-trending shear zones with offsets are shown in the map of FSAR Figure 2.5.1-230.

(e) Please clarify the statement that shears did not penetrate the soil profile, when it is likely that they may have penetrated saprolite overlying hard rock due to the interpreted timing of formation.

02.05.01-47***

FSAR Section 2.5.1.2.4 (pgs 2.5.1-52 and 2.5.1.53) discusses three faults mapped within the site area (the Wateree Creek fault, Summers Branch fault, an unnamed fault near Parr, and the Chappels shear zone) and cites FSAR Figure 2.5.1-225. This figure does not show the site area as inscribed by an 8-km (5-mi) radius circle around the site for reference, but FSAR Figure 2.5.1-224 does. FSAR Figure 2.5.1-224 also shows several unnamed faults within the site area that are not discussed in FSAR Section 2.5.1.2.4, some of which are apparently silicified. Neither FSAR Figure 2.5.1-224 nor FSAR Figure 2.5.1-225 locates the Chappels shear zone, although it is shown on Figure 2.5.1-212.

In addition, the contact for the Winnsboro plutonic complex shown on FSAR Figure 2.5.1-224 is different between the two maps combined in that figure (i.e., Horton and Dicken, 2001 and Secor, 2007). Since this contact is used to constrain fault ages in some cases (e.g., for the proposed unnamed fault near Parr which, if it exists, occurs in the site area), it should be represented correctly.

In order for the staff to completely understand the geologic setting of the Summer site in relation to faults mapped in the site area, locate all four structures discussed in FSAR Section 2.5.1.2.4 on the site area geologic map of Figure 2.5.1-224, and include a circle defining the site area on Figure 2.5.1-225. Please also discuss the other faults shown within the site area on both Figures 2.5.1-224 and 2.5.1-225, and address the pertinence of the fact that some fault zones are apparently silicified while some are not in relation to any potential age implications for the silicified faults. Finally, please explain why the contact of the Winnsboro plutonic complex is different between the maps produced by different workers and represent it correctly in FSAR Figure 2.5.1-224.

02.05.01-48***

FSAR Section 2.5.1.2.5 (pg 2.5.1-53) states that northeast and northwest-striking, near-vertical shear zones mapped in Unit 1 excavations parallel joint systems which occur in the area and region. However, no summary of regional or local joint orientations (e.g., as could be presented in stereonet plots) is included to document that the shear zones parallel trends of joints which exhibit no offset.

In order for the staff to assess the adequacy of the structural interpretation of shear zones which occur in Unit 1 excavations, please provide information on orientations of regional and local joint systems to document that the shear zones reflect regional orientations of joints along which no displacement has occurred.

02.05.01-49***

FSAR Section 2.5.1.2.6 (pg 2.5.1-54) states that no published reports indicate the presence of paleoseismic features in the site area, and that extensive studies of outcrops in the site area showed no evidence for post-Miocene earthquake activity. However, whether these studies were performed specifically for Units 2 and 3 is not clear. Furthermore, there is no indication of the types of materials examined during these studies and no information indicating where the studies were performed to document the area in which no paleoliquefaction features were found.

In order for the staff to assess seismic hazard potential for the site as inferred from a lack of paleoliquefaction features, please clarify whether or not the new studies were conducted specifically for Units 2 and 3. Please also indicate the types of materials examined and provide information regarding where the studies were performed to document the area in which no paleoliquefaction features were discovered.