PMHarrisCOL PEmails

From: Alice Stieve
Sent: Thursday, June 05, 2008 8:54 AM
To: Gerry Stirewalt; Clifford Munson; Rebecca Karas
Subject: My first PSER
Attachments: ALS_SHNPP_SER_sec251_rev5.doc

Gerry
Would you take a look at this document. It is the Harris PSER for the Geology section. It is not done yet but I would like input on whether there is enough or too much detail for the summary section. Also, I have embedded my possible RAIs within the section that the comment pertains to. The RAI is not in final form and is in a different text color so it stands out. Looking back on the document myself, it seems like I have a lot of RAIs. Are these comments too picky? Are there too many?

Thanks.

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Recipients:
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2.5 Geology, Seismology, and Geotechnical Engineering

Final Safety Analysis Report. The Final Safety Analysis Report (FSAR) Section 2.5, "Geology, Seismology, and Geotechnical Engineering," of the Shearon Harris Nuclear Power Plant (SHNPP) Units 2 and 3, COL Application is developed in accordance with requirements outlined in Regulatory Guide 1.206. FSAR, Section 2.5, describes geologic, seismologic, and geotechnical engineering properties of the SHNPP site. FSAR Section 2.5.0 summarizes the sub-sections 2.5.1, 2.5.2, 2.5.3, 2.5.4, 2.5.5 within Section 2.5. Sub-section 2.5.1, "Basic Geologic and Seismic Information," provides information on geologic and seismic characteristics of the SHNPP site and region surrounding the site. Sub-section 2.5.2, "Vibratory Ground Motion," describes the vibratory ground motion assessment for the site through a PSHA and develops the SSE ground motion. Sub-section 2.5.3, "Surface Faulting," evaluates the potential for surface tectonic and non-tectonic deformation at the site. Sub-sections 2.5.4, "Stability and Uniformity of Subsurface Materials and Foundations," 2.5.5, "Stability of Slopes," describe foundation and subsurface material stability at the site.

The applicant used several sources of information for the 2008 SHNPP unit 2 & 3 FSAR:

- Reports from the previous FSAR and FSER for SHNPP Unit 1.
- Review of published geologic literature and seismicity data from state and federal agencies, and from professional and academic journals
- Unpublished, and personal communications with researchers at universities and state agencies,
- New borehole data for the proposed SHNPP Units 2 and 3

The applicant defined the following four terms for areas in which investigations for the SHNPP ESP site occurred, as designated by Regulatory Guide 1.208:

- **Site region**: an area within 320 km (200 mi) of the site location.
- **Site vicinity**: an area within 40 km (25 mi) of the site location.
- **Site area**: an area within 8 km (5 mi) of the site location.
- **Site**: an area within 1 km (0.6 mi) of the proposed SHNPP Units 2 and 3 locations.

Regulatory Guide 1.208 also provides guidance on recommended levels of investigation for each of these areas.

The Electric Power Research Institute and Seismic Owners Group (EPRI-SOG) seismic hazard analysis for the existing Shearon Harris Nuclear Power Plant Unit 1 (HNP) site identified the Charleston seismic zone, the source of a large, geologically recent earthquake, as a significant seismic source at a distance of slightly more than 320 kilometers (km) (200 miles [mi.]). Updated information regarding the location, magnitude, and recurrence of this more distant, but significant, seismic source was incorporated into the updated seismic hazard analysis as described in Subsection 2.5.2.

Results of the investigations and analyses performed by the applicant for each of the FSAR Sections (2.5.1 to 2.5.6) provide information used to determine the SSE, as described in NRC Regulatory Guide 1.165 titled, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion."

Safety Evaluation Report. This Safety Evaluation Report (SER), developed by NRC staff, is divided into six main sections, 2.5.1 to 2.5.6, which parallel the six main sections included in the applicant's FSAR. Each of the six SER sections is then divided into four sub-sections:

(1) "Technical Information in the Application" that describes the contents of the FSAR, the investigations performed by the applicant, and the results;

(2) "Regulatory Basis" that provides a summary of the regulations and NRC regulatory guides used by the applicant to formulate the FSAR;

(3) "Technical Evaluation" that describes the staff's evaluation of what the applicant did, including any requests for additional information (RAI's), open items, and any confirmatory analyses performed by the NRC staff; and

(4) The final "Conclusions" sub-section for each main section that documents whether or not the applicant provided a thorough characterization for the site and if their results provide an adequate basis for the conclusions made by the applicant.

2.5.1 Basic Geologic and Seismic Information

FSAR Section 2.5.1 describes geologic and seismic characteristics of the Site. FSAR Section 2.5.1.1, "Regional Geology," describes the geologic and tectonic setting of the site region (within a 320 km (200 mi) radius), and FSAR Section 2.5.1.2, "Site Geology," describes the structural geology of the site area (within an 8 km (5 mi) radius).

2.5.1.1 Technical Information in the Application

2.5.1.1.1 Regional Geologic Description

"Regional Geology" (FSAR 2.5.1.1) presents the physiography, geologic history, stratigraphy, and tectonic setting within a 320 km (200 mi) radius of the SHNPP site. The applicant reviewed reports previously prepared for SHNPP Unit1, independently published geologic literature, and geophysical data in order to compile the updated, regional geologic model. This section also contains new information on potential seismic sources for the large-magnitude 1886 earthquake in the Charleston, SC area, just outside the 320 km (200 mi.) radius of the site.

The SHNPP site is located in the Triassic Deep River basin within the eastern Piedmont province of the Southern Appalachian Orogen. The Deep River basin is a complex set of wedge-shaped basins formed in Triassic time in the metamorphic and igneous rocks of the Piedmont geologic province.

The basins trend northeast to southwest along the east coast continental margin and are filled with rift related sediments. The southeastern margins are partially covered by the younger Coastal Plain sedimentary sequence.

The applicant concluded with the following statements that regional geologic characteristics pose no natural hazard safety issues that would impact the safe operation of SHNPP site:

- There is no potential for occurrence of nontectonic geologic events (e.g., landsliding, collapse or subsidence, or differential settlement) that would pose a hazard to the facilities.
- The site is not located in an area where large-scale crustal stresses related to glacial or erosional/depositional loading or unloading have occurred in recent geological time.
- The absence of reported shallow stress-relief features and the limited seismicity in the region suggest minimal unrelieved residual stresses in bedrock in the site vicinity.
- No human activities that would adversely affect the site.
- Reservoir-triggered seismicity has not occurred since filling of the Harris Reservoir, and there is no reason to expect it will occur in the future.
- There are no known mineral resources of economic significance at the HAR site. Oil and gas exploration in the 1980s within the Durham basin identified no oil or gas prospects.
- There is limited withdrawal of groundwater in the site area, and adverse effects from groundwater withdrawal and construction groundwater control are not expected to occur.

Physiography and Geomorphology

The regional physiography and geomorphology of the SHNPP site is described in FSAR Section 2.5.1.1.1. From northwest to southeast, the site region includes parts of the Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain physiographic provinces. The SHNPP site lies within the Piedmont province with continental margin sediments of the Coastal Plain province to the east and Blue Ridge province to the west. The Piedmont province is characterized by gently rolling, well-rounded hills and long low ridges.

The Triassic Deep River lowland surface where the SHNPP site is located is within the larger Piedmont province. This surface is generally 15 to 60 m (15- 20 ft) lower than areas bounding it to the east and west, the Coastal Plain and the Piedmont uplands, respectively. The lowland is therefore bounded by abrupt erosional escarpments. Local relief is less than 30 m (100 ft). Stream valleys are wider than in the Piedmont upland and flood plains associated with rivers are narrow in comparison.

(possible RAI; Figure 2.5.1-202 is cited in this section of the FSAR. The figure needs additional labeling to indicate where the Deep River basin lies with respect to other basins that are labeled on the figure.)

The Blue Ridge and Valley & Ridge provinces lie to the west of the Piedmont province and include the mountainous areas of the Appalachians. The elevations of the highest points in region are higher and the local relief is more extreme than in the Piedmont province.

To the west of the SHNPP site is the Coastal Plain province. Land surface is generally flat with gently rolling hills and shallow valleys. Elevations range from 120-180 m (400 to 580 ft). The Coastal Plain province has several distinct zones (6) within it. Two of those sections lie within the 320 km radius of the site: the embayed section to the north; the Sea Island section to the south. In the embayed section, estuarine embayments divide the Coastal Plain into broad peninsular tracts whereas the Sea Island section shows less marked drowning of valleys. The Sea Island section is characterized by youthful to mature terraced surfaces. Near the transition between the embayed and Sea Island sections, the emerged Coastal Plain has been tectonically active during the Cretaceous and Cenozoic ages. This is observed at the surface with the expression of the structural Cape Fear Arch.
(possible RAI; need a figure to illustrate the foregoing discussion since it refers to fairly young tectonic activity on continental margin. Also, text needs to explain significance of this feature to the SHNPP application. Without those 2 items, we might expect comments from an intervener and would not have a nice **documented** answer @ the ready.)

Geologic History

FSAR Section 2.5.1.1.2 describes the regional geologic history within the subheadings of geologic era: Late Proterozoic & Paleozoic; Mesozoic; and Cenozoic geologic history.

Late Proterozoic and Paleozoic Geologic History. The FSAR section 2.5.1.1.2.1 describes the oldest portion of the geologic history within the site region based on information derived from a large variety of professional, published literature.

The FSAR briefly covers the Grenville orogeny (collision); the formation of the Iapetus ocean (rifting); the development of the Laurentian Margin; and the Closing of the Iapetus ocean with the Paleozoic orogenies (collisions). Grenville deformed rocks are mostly buried beneath Laurentian margin, Appalachian Orogen allochthons, cropping out at surface only in the Goochland Terrane of Virginia and the Raleigh Belt of North Carolina. The passive, Laurentian margin accumulated siliclastic sediments followed by a thick carbonate shelf sequence throughout early Cambrian period. The Appalachian orogens ultimately closed the Iapetus Ocean and formed the supercontinent of Pangea throughout the Paleozoic Era from Ordovician through Permian periods. The FSAR presents a brief discussion of the Penobscottian, Taconic, Acadian and Alleghanian orogenies in the formation of autocthonous and allochthonous terranes found in North American east coast geology.

(possible RAI; There are only 2 figures that are map views illustrating the discussion in this section. Typically, a sequence of cartoon x-sections is presented as well to help illustrate the complex history of opening and closing tectonic systems.)

(possible RAI; A large portion of this section is heavily based on Faill 1997a, 1997b and 1998. However, Faill's work is focused on the North Central Appalachian Orogen. This is relevant for the Calvert Cliffs COLA but not so relevant to the Southern Appalachian evolution including the SHNPP site. The SHNPP FSAR needs to include geologic references that are more specific to the southeast. I have noticed that the Calvert Cliffs COLA has heavily referenced Faill in their FSAR. This is appropriate for CCNPP. I wonder if the applicant's contractor just cut and pasted from the CCNPP to the SHNPP.)

(possible RAI; Figure 2.5.1-203 and 2.5.1-204 need to correspond with each other with respect to labels used on each. Suggest you add terrane names from the map view to the column view so the reader can connect the features in space and time, such as Carolina Magmatic arc and Laurentian rift and drift cover.)

Mesozoic Geologic History. The FSAR section 2.5.1.1.2.2 describes the Mesozoic history of the east coast continental margin based on information taken largely from one cited paper, Whitjack and others, 1998. The text briefly describes the rifting of Pangea at the beginning of the Triassic period and the opening of the Atlantic Ocean during the subsequent drift phase of the extensional tectonic regime. The FSAR points out numerous rift basins formed in the continental margin all along the North American east coast margin prior to the drift phase taking dominance with the Atlantic basin. One of these is the Deep River basin where the SHNPP site is located. Rifting reactivated older Paleozoic faults that were oriented favorably (northeast to southwest) to the new stress direction. There is also evidence in the geologic record that the stress direction rotated and a second phase of extension occurred during the early Jurassic. Faults formed with north-south and northwest-southeast strikes. In addition basalt flows occurred and diabase dikes intruded the rifted basins. Rifting ceased by 200 Ma in the southeastern US and the drift phase became dominant. The stress direction rotated to NE-SW and became compressive. Northeast-striking normal faults, some associated with the earlier formed rift basins, reactivated in reverse movement.
(Possible RAI; Figure 2.5.1-206. How do the 5 x-sections on this figure fall out onto the 3 map views on same figure? The labels are insufficient.)

Cenozoic Geologic History. Cenozoic history is described in section 2.5.1.1.2.3 of the FSAR. Erosional and depositional processes have dominated the southeast US continental margin since rifting ceased. The Blue Ridge and Piedmont regions have been uplifted and eroded with the formation of the current mountainous regions and local colluvial deposits in stream valleys. The coastal Plain region reflects sedimentation of near shore marine deposition in large-scale transgressive-regressive cycles of sea level changes.

The continental glacial cycles found in the northern latitudes (≥40°N) did not extend to into the site region.

Stratigraphy

The FSAR Section 2.5.1.1.3 provides a discussion of the regional stratigraphy and geochronology of the Piedmont, Blue Ridge, Coastal Plain Valley and Ridge , and Appalachian Plateau geologic provinces. The focus was North Carolina stratigraphy but it included the adjoining states of Virginia, Tennessee, South Carolina, West Virginia and Kentucky to fully describe the stratigraphy within the 320 km (200mi) radius around SHNPP.
(Possible RAI: The entire section 2.5.1.1.3 should be organized and discussed by lithotectonic provinces or geologic belts. The boundaries for each lithotectonic province (fault systems) should be identified and then the internal stratigraphic relationships can be presented. As it is there is a convoluted discussion of rock types mixed in with rock ages and there is no boundary identified between the provinces. This is particularily an issue for the Piedmont. Mesozoic rift basin stratigraphy needs to be pulled out and presented in its own province.)

Piedmont Stratigraphy.
The FSAR section 2.5.1.1.3.1 states that the North Carolina piedmont is predominantly underlain by crystalline and volcano-clastic rocks of Precambrian and Paleozoic age. Metamorphic grade generally decreases from west to east within the province, from upper amphibolite to lower amphibolite and greenschist facies. The FSAR indicates the Charlotte and Raleigh belts contain lower amphibolite grade rocks while the Carolina slate and Eastern slate belts contain metavolcanic and metasediments at greenschist facies. There are several Triassic rift basins superimposed within the Piedmont province with sediments characteristic of that tectonic regime. Coastal Plain sediments overlap the southeastern boundary of the Piedmont.
(Possible RAIs:

- The Piedmont should be defined as a stand alone litho-tectonic terrane. A description of the northwestern and southeastern boundary of the Piedmont is not clearly stated. The tectonic boundaries help keep the discussion of stratigraphic relationships within a terrane in a manageable presentation.
- The Mesozoic rift basins should be in a separate section. The rift basins are of importance in this FSAR because of the location of the SHNPP site.
- Figure 2.5.1-210: explanation on figure does not correspond to patterns on map.
- Coastal Plain sediments that cover Paleozoic Piedmont should be discussed in the coastal Plain section. These sediments come from a different tectonic regime.
- Because the youngest sediments in the area are so important to determine the presence of surface deformation or tectonic movement, a separate section needs to be established so that it can be readily found by reviewers.)

Blue Ridge Stratigraphy.
The FSAR section 2.5.1.1.3.2 provides a description of the western and eastern zones within the Blue Ridge province. The FSAR indicates that the western zone represents the Laurentian margin

while the eastern zone represents one or more exotic terranes (allochthonous). The rocks in this province include Grenville basement and other Neoproterozoic to early Paleozoic rocks.

(Possible RAIs:

- This section lacks a description of regional stratigraphic relationships within the lithotectonic terrane of the Blue Ridge province. Further there are no figures or maps illustrating these relationships. The section lacks a concise description of the northwest and southeast boundaries to the Blue Ridge.

- Reference 2.5.1-208 is a WEB site of the Maryland Geological survey. The FSAR must have substantial, peer reviewed references. There are very few references of any kind in this section and the interpretation statements are very wide reaching and beg for documentation of the original source of investigation and information.

- In section 2.5.1.1.3.2.1, Geochronology of Blue Ridge, there are three sentences presented about southern Appalachian basement rocks in general with no relationship to the preceding discussion of Blue Ridge stratigraphy. Define basement rock with respect to the rocks discussed in previous section.

- The Mars Hill terrane is introduced for the first time in the geochronology section. This discussion needs to be incorporated into the stratigaphy section. A geologic map is needed to illustrate the significance of this terrane.)

Coastal Plain Stratigraphy.

The FSAR section 2.5.1.1.3.3 provides a description of the Coastal Plain section that is immediately to the southeast of the SHNPP site. The applicant described three subdivisions within the Coastal Plain that essentially parallel the Atlantic coastal margin and are separated by escarpments: the upper, middle and lower Coastal Plain. The upper Coastal Plain includes Cretaceous and Tertiary sediments that formed in delta to marine shelf environments. The middle Coastal Plain includes Pliocene marine sediments with local Quaternary sediments of eolian , lacustrine, colluvial and alluvial origin. The lower Coastal Plain contains Quaternary aged marine, estuarine, fluvial and eolian deposits.

(Possible RAIs:

- There is no stratigraphic column illustrating relationships.
- The text begins by breaking out the upper, middle and lower Coastal Plain. The following text does not break out the formations according to those introduced categories.
- Define constructional topography.)

Valley and Ridge Stratigraphy.

The FSAR section 2.5.1.1.3.4 briefly points out the presence of a thick section Paleozoic sedimentary rocks to the west of the Piedmont terrane. The section is 30,000 to 40,000 ft thick and is folded and thrust faulted into plunging anticlines and synclines.

Appalachian Plateau Stratigraphy.
The FSAR section 2.5.1.1.3.5 briefly points out the presence of the plateau region that is to the west of the Valley and Ridge Province with a description that it contains clastic sediments of later Paleozoic age (Mississippian and Pennsylvanian age). These sediments are not characteristically deformed or metamorphosed.

Regional Tectonic Setting

The applicant introduced the Regional Tectonic Setting (FSAR section 2.5.1.1.4) by stating that the seismotectonic framework of a region forms the foundation for assessments of seismic sources. The nature and character of tectonic features integrated with contemporary stress orientation and seismicity was the basis for the EPRI source models developed for the CEUS in 1988. Since then additional scientific data and interpretation have become available and a summary of that knowledge is presented in the SHNPP FSAR and further summarized in this section of the PSER. Based on published information, the applicant presented the following information related to:

- Contemporary Tectonic Stress
- Regional Tectonic Structures (includes seismic zones)
- Significant Seismic Sources at distance greater than 320 km (200mi).
- Regional Gravity and Magnetic Data

Contemporary Tectonic Stress

Based on published literature, FSAR section 2.5.1.1.4.1 places the SHNPP site in a compressive midplate stress province (Zoback & Zoback, 1980; 1989; Richardson & Reding, 1991; Zoback, 1992) that is characterized by reverse and strike-slip faulting on appropriately oriented faults. CEUS earthquakes occur primarily in strike-slip motion (Zoback, 1992). The data used in the various research includes earthquake focal mechanisms, stress-induced elliptical borehole breakouts; hydraulic fracturing stress measurements; and offsets of young faults and alignments of volcanic vents. Research leads to the conclusion that the stress orientation is likely caused by absolute plate motion and ridge push direction from the North Atlantic Ridge (Zoback & Zoback, 1989; Richardson & Reding, 1991).

Regional Tectonic Structures

FSAR section 2.5.1.1.4.2 presents the principal tectonic structures within the SHNPP site region in five categories based on age of formation or reactivation: Late Proterozoic to early Paleozoic, Paleozoic, Mesozoic, Cenozoic, or Quaternary.

Late Proterozoic to early Paleozoic Structures. The FSAR provides a discussion of normal faults that formed in Grenville aged crust during rift related events during the opening of the Iapetan Ocean in late Proterozoic time (~700MA). Later, Paleozoic collision related thrust faulting buried and deformed the thinned Iapetan margin along with many of these normal faults. These faults are now concealed beneath the Blue Ridge décollement and are inferred based on gravity and magnetic data; deep seismic reflection profiles; historical seismicity and surface geological data (Hatcher & Lemiszki, 1998; Hatcher et al, 1998; Wheeler, 1996; Bollinger & Wheeler, 1988; Hutchinson & Hatcher, 1988; Hutchinson et al, 1983). However, some of the normal faults in Iapetan margin were not deformed beyond recognition or reactivation. Wheeler, 1996, concludes that northwest of a regional boundary defined by the Appalachian gravity gradient, the Iapetan margin faults are largely intact and capable of being reactivated. He makes the correlation between these intact Iapetan faults and southern Appalachian seismic zones such as the Giles Co.,Va and the Eastern Tennessee Seismic Zone.
(Possible RAI: The FSAR does not provide a very well defined northwest boundary to the Iapetan normal fault zone. Because of the potential for location of seismic sources, both the northwest and southeast boundary of this zone needs to be illustrated with the location of SHNPP site included.)

(Possible RAI: The text discusses the findings of Hatcher & Lemiszki, 1998 and Hatcher et al, 1998 with respect to faults formed beneath the Blue Ridge thrust. However, there is no indication where these faults are with respect to Wheeler's southeast or northwest boundary of intact Iapetan faults. These faults and boundaries need to be presented in an illustration.)

(Possible RAI: The faults defined by the Lawrence and Hoffman paper are Paleozoic-age faults. Are they located incorrectly in this section? Please explain is discrepancy.)

Paleozoic Tectonic Structures. FSAR section 2.5.1.1.4.2.2 provided a brief discussion of some of the major fault systems in the Piedmont province immediately to the west of the SHNPP site that formed or last moved during the Paleozoic. This section covers the regional fault systems of the Blue Ridge Thrust sheet, the Brevard fault zone and the Central Piedmont suture. The applicant states that the Paleozoic structures discussed are associated with the Alleghanian orogeny. The Piedmont province also extends to the east of the SHNPP site, buried beneath the Coastal Plain sediments.

The Blue Ridge Thrust (BRT) is described as a large composite, crystalline thrust sheet formed during the collision of North America and Africa during the Alleghanian orogeny. The applicant reported that this large scale detachment fault drove the foreland deformation in front of it and carries Late Proterozic and early Palezoic sedimentary sequences, Paleozoic basement and other large faults. Data for various interpretations comes from exploration boreholes, geophysical data (gravity, magnetic, seismic reflection) and surface mapping.

The FSAR described the Brevard Fault zone as a major fault carried within the BRT. The Brevard Fault zone has a complex history that includes dip slip and strike-slip displacement during the Paleozoic.

The Central Piedmont structure is described as the suture that brings the volcanic island-arc of the Avalon-Carolina terrane up against the Inner Piedmont terrane.

(Possible RAI: One figure (Fig 2.5.1-214) called out in this section shows that the Piedmont suture is closer to SHNPP than either the Brevard fault zone or the BRT yet the discussion of this system is limited to the geographic location and not about the timing of movement or how it relates to other large fault systems with the 200 mile radius of the SHNPP. On the map this fault is shown to truncate against the Nutbush Creek fault and the Brevard fault essentially terminates against this fault. Please provide information about how this fault system is described in the most recent literature, how it relates to the Nutbush Creek fault and to the Brevard fault zone.)

(Possible RAI: The Brevard fault zone discussion refers the reader to models of the Brevard fault zone. Please provide a discussion of the conceptual models in the FSAR.

(Possible RAI: On Figure 2.5.1-211 there are several regional faults located within the 200 mile radius of the site whose age of movement are not indicated on the figure nor are discussions provided in the text. Please provide discussion of these faults and the likely age of movement. These faults include: Nubush Creek fault, Augusta fault, Modoc zone, faults in the vicinity of the Sauratown Mtn Window, the Gold Hill and Silver Hill faults.)

Mesozoic Tectonic Structures. The applicant stated that most of the HAR site region is located within the Atlantic Coast tectonic province. FSAR section 2.5.1.1.4.2.3. goes on to provide a discussion of the formation of Triassic rift basins within the 200 mile radius of the site. Post-Paleozoic tectonic activity within the Appalachian orogen is related directly to the breakup of the supercontinent Pangaea and the subsequent opening of the Atlantic Ocean. Rifting during the Triassic and early Jurassic resulted in the formation of more than 25 rift basins along the Atlantic margin of North America.
(Possible RAI: FSAR states that most of the HAR site is located within the Atlantic Coast tectonic province. Please define this tectonic province and cite recent literature. Zoback and Zoback, 1989 indicate that there is no separate stress province for the Atlantic Coastal plain.)

(Possible RAI: As indicated in several figures of the FSAR, the SHNPP is actually sited within the boundaries of a Mesozoic rift basin that formed in the eastern Piedmont lithotectonic province. See Figures 2.5.1-215, -213,-209 for some examples. Seismic wave propagation may be impacted by these structures so it is important to properly characterize their position with respect to SHNPP.)

The FSAR points out that the SHNPP is located within the Deep River basin, the southern most exposed rift basin along the Atlantic coastal margin. There are additional buried basins further south and east. The FSAR also describes the two bands or belts of rift basins within North Carolina: the eastern and the western bands. The Deep river basin and the SHNPP are included in the eastern band. The applicant stated that the Deep River basin is bounded on the east by the Jonesboro fault system and on the west by the Chatham fault system. The Deep River basin is made up of three sub-basins: Durham, Sanford, and Wadesboro basins. The Colon cross structure separates the Durham basin from the Sanford basin. The applicant points out that this feature is located where the Deep River basin narrows significantly.

(Possible RAI: The Colon cross structure and the Peking cross structures are not define or describe in the text yet they are significant features in the Deep River basin. Define and describe these structures.)

The Jonesboro fault system is the master fault that caused the formation of the basin. The FSAR describes the geometry of this fault as west dipping, high-angle with a minimum displacement of 1.8 to 2.8 miles with dip-slip direction. Four fault segments are identified along the fault. The SHNPP site is located between the Durham segment and the Holly Springs segment. The applicant states that more details about these structures are discussed in section 2.5.1.2.4.

(Possible RAI: The applicant states that the Jonesboro fault was probably seismologically similar to modern-day segmented, active basin-bounding normal faults in extensional tectonic settings. Please provide the basis for that statement and provide a discussion of the relevance to the SHNPP and any evidence for historic seismicity on this structure.)

Cenozoic Tectonic Structures. Cenozoic structures are presented in FSAR section 2.5.1.1.4.2.4 and include; the broad areas of uplift and subsidence that have been identified as arches, embayments and troughs; post rift faulting in the Atlantic Coastal Plain; and a wrench zone system. The arches represent uplift, tilting and or subsidence on the Atlantic margin that influenced sedimentation. The FSAR identifies the Cape Fear arch, the Neuse hinge, the Onslow and Albermarle blocks in eastern North Carolina coastal plain sediments. The Cape Fear Arch is defined by stratigraphy and influenced sedimentation from late Cretaceous to late Tertiary. Similarily the Neuse hinge, further to the north affected Paleogene and possibly Neogene sediments.

(Possible RAI: The FSAR introduces the Neuse hinge and Onslow and Albermarle blocks but then does not define what they are or describe where they are in any figure. Please include further details for these features.)

Grainger's wrench zone is described in the FSAR as two different, cross-cutting fault systems that are located in the eastern North Carolina Atlantic Coastal Plain. Paleocene activity on northeast trending faults overprint Cretaceous and early Paleocene, east-west faults. This results in a set of basins or fault blocks. The latest movement within the zone is into the Holocene and is down to the east with component of strike slip. The FSAR indicates that surface expression of these faults is observed in topographic features along the zone; faultline scarps, and triangular facets on hill sides. However, the applicant states that there is no direct evidence of Quaternary faulting and these faults are not included in regional compilations of Crone and Wheeler, 2000 or Wheeler, 2005.

(Possible RAI: The FSAR has not distinguished between the Grainger's wrench zone and the Grainger's basin area. Please clarify.)

Quaternary Tectonic Structures. Section 2.5.1.1.4.2.5 of the FSAR provides a discussion of Quaternary faults, folds and earthquake-induced liquefaction sites for the eastern United States based on the USGS compilation and database (Crone & Wheeler, 2001; Wheeler, 2005). The features discussed in this section are also presented in a map to provide a large scale understanding of distribution and distance from the SHNPP site. The applicant discussed:

1. Central Virginia Seismice Zone
2. Charleston Liquefaction features
3. Georgetown Liquefaction features
4. Pembroke Faults
5. Post East Coast fault zone
6. Fall Line of Weems.

In addition, the applicant referred the reader to more details in up-coming sections 2.5.1.1.4.2.6 and 2.5.2.

The Central Virginia Seismic zone is about 130 miles north of the SHNPP site. It is roughly a 90 mile diameter circular area of low level seismicity. There is some geologic evidence for faulting and earthquakes in two Holocene-aged, paleoliquefaction sites found within the zone. The applicant reported that about 75% of the earthquakes in this zone are located in the upper 7 miles of crust. The largest historical earthquake in the zone occurred in 1875 near the center of the zone; the intensity was MMI VII with an estimated moment magnitude (M) 4.8. Neither surface rupture nor liquefaction were reported from the 1875 event. (FSAR Reference 2.5.1-258).

Possible RAI: The discussion in the FSAR about the lineament in the Shenandoah Valley of Central Virginia is based on an abstract from GSA. There are numerous speculative statements about the nature and significance of the feature. It is also just drop into the section about the Central Virginia Seismic zone. If the feature is a recent tectonic feature and is associated with the Central Virgina Seismic zone a more explanation is required. What is the data, where are the uncertainties. What is the significance to the seismicity in the area.

(Possible RAI: Figure 2.5.1-216. The Norfolk Arch is on the map. However, it is not discussed in text, yet the Cape Fear Arch is. What is the distinction? The Neuse hinge, Onslow and Albermarle Blocks are discussed in text and are not indicated on this map. The features under discussion in the text are focused on a small crowded portion of the map. Why not zoom in on the features being discussed in the text? The largest historical quake recorded for the CVSZ should be singled out on the map)

Charleston Liquefaction Features

Georgetown Liquefaction Features

Pembroke Faults

Postulated East Coast Fault System

Fall Lines of Weems

Seismic Zones. Section 2.5.1.1.4.2.6 of the FSAR provides a discussion of

Significant Seismic Sources at Distance Greater than 320 km (200mi).

FSAR section 2.5.1.1.4.3 presents the …….

Site Area Geologic Description

Site Area Structural Geology

Site Area Earthquakes and Seismicity

Site Area Non-Tectonic Deformation Features

Human-Induced Effects on Site Area Geologic Conditions

Site Area Engineering Geology Evaluation

2.5.1.2 Regulatory Evaluation

The acceptance criteria for identifying basic geologic and seismic information are based on meeting the relevant requirements of 10 CFR Part 52.17 and 10 CFR Part 100.23. The staff considered the following regulatory requirements in reviewing the applicant's discussion of basic geologic and seismic information:

! 10 CFR 52.17(a)(1)(vi), which requires that an application contain a description of the geologic and seismic characteristics of the proposed site.

- 10 CFR 100.23(c), which requires an applicant to investigate geologic, seismic, and engineering characteristics of a site and its environs in sufficient scope and detail to permit an adequate evaluation of the proposed site; to provide sufficient information to support evaluations performed to determine the SSE Ground Motion; and to permit adequate engineering solutions to actual or potential geologic and seismic effects at the proposed site.

- 10 CFR 100.23(d), which requires that geologic and seismic siting factors considered for design include a determination of the SSE Ground Motion for the site; the potential for surface tectonic and non-tectonic deformation; the design bases for seismically-induced floods and water waves; and other design conditions including soil and rock stability, liquefaction potential, and natural and artificial slope stability. Siting factors and potential causes of failure to be evaluated include physical properties of materials underlying the site, ground disruption, and effects of vibratory ground motion that may affect design and operation of the proposed power plant.

The basic geologic and seismic information assembled by the applicant in compliance with the above regulatory requirements should also be sufficient to allow a determination at the COL stage of whether the proposed facility complies with the following requirements in Appendix A to 10 CFR Part 50:

- GDC 2, which requires that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

To the extent applicable in the regulatory requirements cited above, and in accordance with RS-002, the staff applied NRC-endorsed methodologies and approaches (specified in Section 2.5.1 of NUREG-0800) for evaluation of information characterizing the geology and seismology of the proposed site as recommended in RG 1.70, Revision 3 and RG 1.165.

2.5.1.3 Technical Evaluation

This SER section presents the staff's evaluation of the geologic and seismic information submitted by the applicant in FSAR Section 2.5.1. The technical information presented in FSAR Section 2.5.1 resulted from the applicant's surface and subsurface geologic, seismic, and geotechnical investigations, which were undertaken at increasing levels of detail moving closer to the site. Through its review, the staff determined whether the applicant had complied with the applicable regulations and conducted these investigations at the appropriate levels of detail within the four circumscribed areas designated in RG 1.165 which are defined based on various distances from the site (i.e., circular areas drawn with radii of 320 km (200 mi), 40 km (25 mi), 8 km (5 m), and 1 km (0.6 mi) from the site).

FSAR Section 2.5.1 contains geologic and seismic information collected by the applicant in support of the vibratory ground motion analysis and site SSE spectrum provided in FSAR Section 2.5.2. RG 1.165 indicates that applicants may develop the SSE ground motion for a new nuclear power plant using either the EPRI or Lawrence Livermore National Laboratory (LLNL) seismic source models for the CEUS. However, RG 1.165 recommends that applicants update the geologic, seismic, and geophysical database and evaluate any new data to determine whether revisions to the EPRI or LLNL seismic source models are neceFSARy. Consequently, the staff focused its review on geologic and seismic data published since the late 1980s to assess whether these data indicate a need for changes to the EPRI or LLNL seismic source models.

To thoroughly evaluate the geologic and seismic information presented by the applicant, the staff obtained the assistance of the USGS. The staff and its USGS advisors visited the site to confirm interpretations, assumptions, and conclusions presented by the applicant related to potential geologic and seismic hazards.