August 3, 1981

Docket No. 50-219
LS05-81-08-011

Mr. I. R. Finfrock, Jr.
Vice President - Jersey Central
Power & Light Company
Post Office Box 388
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Dear Mr. Finfrock:

SUBJECT: SEP REVIEW TOPICS II-4, GEOLOGY AND SEISMOLOGY AND II-4.B, PROXIMITY OF CAPABLE TECTONIC STRUCTURES IN PLANT VICINITY

Enclosed is a copy of our evaluation for Systematic Evaluation Program Topics II-4, "Geology and Seismology," and II-4.B, "Proximity of Capable Tectonic Structures in Plant Vicinity." These assessments compare your site condition, as described in the docket and references with the criteria currently used by the staff for licensing new facilities. Please inform us if your site condition differs from the licensing basis assumed in our assessments.

Our review of these topics is complete and this evaluation will be a basic input to the integrated safety assessment for your facility unless you identify changes needed to reflect the existing site condition at your facility. These topic assessments may be revised in the future if NRC criteria relating to these topics are modified before the integrated assessment is completed.

Sincerely,

Dennis M. Crutchfield, Chief
Operating Reactors Branch No. 5
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Enclosure:
As stated

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SEP SAFETY TOPIC EVALUATION

OYSTER CREEK NUCLEAR POWER PLANT

TOPIC II-4, GEOLOGY AND SEISMOLOGY
TOPIC II-4.B, PROXIMITY OF CAPABLE TECTONIC STRUCTURES IN PLANT VICINITY

1 INTRODUCTION

1.1 Identification of Safety Issues

The SEP topics addressed in this chapter are the geology portion of Topic II-4, Geology and Seismology and Topic II-4.B, Capability of Faults in the Site Region. The seismology section of Topic II-4, Topics II-4.A, and II-4.C are addressed in "Site Specific Ground Response Spectra for SEP Plants Located in the Eastern United States" (letter from D. M. Crutchfield to SEP Owners, June 17, 1981).

1.2 Scope of the Review

The results of the Oyster Creek Construction Permit review by the Atomic Energy Commission (AEC), its advisors the U.S. Coast and Geodetic Survey (USC and GS) and the U.S. Geological Survey (USGS) is reported in the Safety Evaluation Report (SER) dated 23 September, 1964. In this analysis the staff and its advisors concluded that the geologic and seismic design bases were adequate. In its 23 December, 1968 SER, the AEC, based on advice of the USC&GS, concluded that 0.22g for the equivalent of the SSE and 0.11g for the OBE were acceptable. Since that time several other nuclear plant sites have been evaluated in the general area including Forked River, Newbold Island (relocated to Hope Creek), Salem, Summit, and Atlantic Generating Station. The SSE and OBE for those plants are 0.20g and 0.10g respectively.

In addition to work done in regard to reactor sites, research has been carried out in the area under the NRC sponsored New England Seismotectonic Investigations Program.

We have reviewed all of these new data and conclude that the SSE and OBE of 0.22g and 0.11g respectively are conservative; and there is no evidence of capable faulting in the site region.

During the SEP geology review the staff relied heavily on its experience in assessing the geology of the other sites in the region. Other documents utilized in this review included USGS quadrangle maps, aerial photographs, the Oyster Creek Hazard Analysis Report, Safety Evaluation Report for the Oyster Creek Nuclear Generating Station, the Preliminary Safeguards Summary Report, the Final Safety Analysis Report, a 4 February 1975 report by Woodward-Moorhouse & Associates, Inc. "Geotechnical Study Proposed Radwaste and Off-gas Buildings, Oyster Creek Nuclear Power Station", published documents of the NRC funded New England Seismotectonic Study, and other documents from the open literature. A list of references is included at the end of this report.

2 REVIEW CRITERIA

Current licensing criteria which governed our review of the safety issues addressed in this chapter include Appendix A to 10 CFR Part 100, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," and NUREG-0800, Standard Review Plan, Chapter 2.5, Sections 2.5.1, 2.5.2, and 2.5.3.

3 RELATED SAFETY TOPICS AND INTERFACES

The geotechnical engineering aspects of the site are closely related to the topics covered in this chapter. They are addressed under Topics II-4D, II-4E, and II-4F. Topic II-4F is dependent on information from this chapter.

4 REVIEW GUIDELINES

Appendix A to 10 CFR Part 100, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" was used in this review to provide guidance in defining tectonic provinces, and identifying and evaluating tectonic structures in the site region to determine whether or not any of them are capable.

Chapter 2.5.1 of NUREG-0800, Standard Review Plan guided the staff in its assessment of geologic features in the site area related to the potential for faulting, subsidence or collapse. landslides, weathering, or other foundation instabilities.

Chapter 2.5.3 of the SRP was utilized for guidance in considering the following subjects:

The structural and stratigraphic conditions of the site and vicinity (Subsection 2.5.3.1), any evidence of fault offset or evidence demonstrating the absence of faulting (Subsection 2.5.2.2), earthquakes associated with faults (Subsection 2.5.3.3), determination of age of most recent movement on faults (Subsection 2.5.3.4), determination of structural relationships of site area faults to regional faults (Subsection 2.5.3.5), identification and description of capable faults (Subsection 2.5.3.6), and zones requiring detailed fault investigations (Subsection 2.5.3.7).

5 EVALUTATION

5.1 Geology

The site is located on the Coastal Plain Physiographic Province (Fenneman 1938) along the New Jersey coast about 32 miles (51 kilometers) north-northeast of Atlantic City. The emerged Coastal Plain Province is from 100 to 200 miles (160 to 320 kilometers) wide and elevations are generally well below 500 feet (155 meters). The topography is flat to gently hilly with extensive marshlands. An additional part of the Coastal Plain is submerged offshore and is part of the Continental Shelf. It is about the same width as the emerged portion and extends to depths of 500 to 600 feet (155 to 186 meters) below sea level.

The Coastal Plain is underlain by southeast dippings beds of semiconsolidated to unconsolidated sand, clay, silt and gravel ranging in age from Cretaceous through Tertiary and Quaternary (135 million years before present (mybp) to present). Non-marine sediments of possible Jurassic age (195 mybp to 136 mybp) have been found beneath Cretaceous sediments in borings at Cape Hatteras, North Carolina near Summerville, South Carolina; Ocean City, Maryland; Cape May, New Jersey and the Cost B-2 well on the New Jersey outer Continental Shelf. The Coastal Plain slopes to the north, in the site region and is completely underwater northeast of Cape Cod. Valleys in the northern Coastal Plain are drowned, forming the Raritan, Chesapeake and Delaware Bays and Long Island Sound. The northeast-southwest regional structural trend which characterizes the Appalachian Mountains to the west is also present in the basement beneath the Coastal Plain. Superimposed on this trend is a major northwest-southeast regional trend as reflected by depressions and highs in the basement surface such as the Southeast Georgia Embayment, the Cape Fear Arch, the Salisbury Embayment, and the Raritan Embayment. The site overlies the Raritan Embayment.

The Piedmont Province is about 35 miles (56 kilometers) northwest of the site at it closest approach. The Fall Zone is the physiographic boundary between the Piedmont and Coastal Plain Provinces. The Piedmont lies within the much larger Appalachian mountain system. In addition to the Piedmont, the Appalachian mountain system encompasses from southeast to northwest, the Blue Ridge, Valley and Ridge and the Appalachian Plateau physiographic provinces.

The Piedmont, from the Hudson River in southern New York to the Alabama Coastal Plain, is nearly 840 miles (1350 kilometers) long. It varies in width from 20 miles (35 kilometers) at the narrowest in northern Virginia, to a maximum of 150 miles (240 kilometers) in the Carolinas. The Piedmont is underlain by metamorphic, volcanic, and sedimentary rocks forming complex structures truncated by a pre-Triassic (225 mybp) erosion surface. The rocks are mostly Paleozoic and older (more than 250 mybp) gneisses and schists, some marble, and quartzite derived from the metamorphism of older sedimentary and volcanic rocks. In Pennsylvania and Maryland the carbonates form valleys while the gneiss, schist, quartizite and granitic rocks form uplands. In addition to the igneous and metamorphic rocks, about five percent of the Piedmont consists of unmetamorphosed sedimentary rocks of Triassic age (Hunt 1967). These rocks fill down-faulted blocks or basins within the crystalline rocks and are mainly sandstones, conglomerates and siltstones.

The nearest Triassic basin to the site is the Newark Basin, located about 40 miles (64 kilometers) northwest of the site at its closest approach.

Complex fault blocks similar to the Triassic-Jurassic basins exposed in the Piedmont have also been identified beneath the sediments of the Coastal Plain and Atlantic Continental Shelf (Marine and Siple, 1974; Rankin et al, 1977; Ballard and Uchupi, 1975; Brown et al, 1972; Sheridan, 1974; Roper, 1980; Grim et al, 1980; and Mullins and Lynts, 1976.

The Oyster Creek site is underlain by approximately 2000 feet of unconsolidated Coastal Plain sediments. The uppermost units from ground surface down consists of 10 feet and less of man-made sand fill, 15 feet of sand of the Late Pleistocene Cape May Formation (35,000 years old); 15 feet thick upper clay layer of Late Pleistocene to Late Miocene (35,000 years to 10 mybp), 60 feet of Cohansey sand of Miocene age (+10 mybp); and more than 100 feet sand of the Miocene (+10 mybp) Kirkwood formation (Woodward and Moorehouse, 1975).

Investigations of these soils were made in 1964, 1968 and 1973-1974, and included core borings and laboratory testing of undisturbed samples. Investigations were also conducted in similar materials at the Forked River site 1/2 mile to the west of the site. The plant is founded on dense to very dense sand of the Cohansey formation which has been demonstrated to be adequate to support it (Woodward and Moorehouse 1975).

5.2 II-4 B CAPABILITY OF FAULTS IN THE SITE REGION

The closest known major fault to the site is the Cream Valley-Huntingdon Valley fault, which extends northeast from West Chester, Pennsylvania to Trenton, New Jersey, and is about 45 miles (72 kilometers) from the site at its closest approach. This fault is in Wissahickon and other crystalline rocks, and is considered to be of Paleozoic age (570 mybp to 225 mybp). Minor earthquakes have occurred in the vicinity of this fault system, for example the 11 March, 1980 magnitude 3.7 event but there is no evidence that the fault is capable. It does not displace Cretaceous sediments.

A major, deep-seated, east-west wrench fault, the Cornwall-Kelvin fault, was postulated by Drake and Woodward (1963) to explain the curvature of the Appalachian system in southeastern Pennsylvania and the Kelvin seamount trend in the Atlantic Ocean. The trend of this postulated fault would project beneath the Coastal Plain and pass approximately 40 miles (64 kilometers) north of the site. The fault, if it exists, is pre-Mississippian (345 million years) in age, most probably late Devonian (Drake and Woodward, 1973). The Appalachian curvature has also been postulated to have been caused by an early Paleozoic rift structure (Rankin, 1976). Subsequent investigations have been unable to confirm or disprove the existence of the Cornwall-Kelvin fault or the rift structure.

Many faults have been mapped in the Newark Triassic basin. The most significant of these are the Hopewell and Flemington faults which cross the Delaware River a few miles of each other near Lambertville, New Jersey. The Flemington fault continues to the north and northwest through central New Jersey to the edge of the Newark basin, while the Hopewell fault extends northeast to near the south branch of the Raritan River. To the west the two faults join south of Doylestown, Pennsylvania, where they become the Chalfont fault. Several thousand feet of vertical displacement have been mapped on the faults, and several miles of right lateral movement have been measured on the Hopewell fault (Sanders, 1963).

These faults displace Triassic rocks, therefore the latest movements are interpreted to have occurred during late Triassic or early Jurassic (200 mybp to 170 mybp). The nearest approach of this fault system is more than 50 miles (80 kilometers) northwest of the site.

The Newark Triassic Basin of New Jersey and New York is a half graben bounded on the northwest side by a northeast trending, high angle fault (Sanders, 1963 and Van Houten, 1969). Ratcliffe (1971) describes this and related faults which he collectively terms the Ramapo fault system as follows: "in northern New Jersey and southeastern New York State, the border fault system is expressed by a fairly straight fault trace marked by the topographic escarpment of the Ramapo Mountains for which the fault is named. The Ramapo fault proper extends from Stoney Point, New York, on the Hudson River, southwest approximately 50 miles to Peapack, New Jersey. North of about Rockland, New York the fault becomes more diffuse into several splays and extends into the Hudson Highlands."

Aggarwal and Sykes (1978) and Yang and Aggarwal (1981) identify a zone of seismicity approximately 30 kilometers wide centered on the Ramapo fault at zero to about 10 kilometers depth, based on data from the Lamont-Doherty, Consolidated Edison, and New England seismic networks. They conclude that current seismicity in this zone is being controlled by reactivation of the northeast striking steeply southeast dipping faults that control the main structural grain in this area. The NRC staff in its findings regarding the Indian Point nuclear site concluded that, based on extensive investigations, the Ramapo fault system is not capable within the meaning of Appendix A, but it is likely that faults of the Ramapo system along with the numerous other faults in the Hudson Highlands may be localizing seismicity. The Ramapo fault system is located more than 60 miles (95 kilometers) northwest of the site.

During the past decade much evidence for post-Mesozoic (younger than 65 mybp) deformation has been found (McMaster, 1971; Jacobeen, 1972; Spoljaric, 1972; York and Oliver, 1976, Mixon and Newell, 1976; Prowell et al. 1975; and, Berendt et al, 1981). The closest known post-Mesozoic structures to the site are two minor, northeast-trending anticlines in coastal plain deposits located about 10 miles (16 kilometers) east of Trenton, New Jersey (Minard and Owens, 1966). The youngest material apparently involved in the folding is the Miocene Cohansey Formation (more than five million years old).

Spoljaric (1972) reported faulting involving the basement and the overlying Cretaceous Potomac formation along the Fall Zone in the Newark, Delaware area approximately 75 miles (120 kilometers) west-southwest of the site. The faulting has a predominant east-west trend with several minor north-south branch faults. Traces of the faults are not evident at the ground surface.

A subsequent report by Spoljaric (1973) defined basement faulting in the Red Lion area several miles southwest of Newark, Delaware. Spoljaric's paper suggests normal faulting involving only the Piedmont-like metamorphic rocks, mainly schist and gneiss, forming a northeast-trending graben with displacements of up to 30 meters. No evidence indicating displacement of the overlying Cretaceous material was found. Studies performed to investigate the Summit Nuclear Power Plant site (Docket Nos. 50-450 and 451) confirmed Spoljaric's findings in the Red Lion area and showed that the basement fault complex extended south of the area described by Spoljaric, across the Chesapeake and

Delaware Canal. We and the U.S. Geological Survey concluded in the Summit Safety Evaluation Report that this faulting pre-dated the Merchantiville Formation and is a least 65 million years old (NRC, 1975).

A LANDSAT (formerly called ERTS) linear is described in the Preliminary Safety Analysis Report for the Atlantic Generating Station (AGS) as extending from Port Republic Great Bay, New Jersey, approximately due west towards Buena, New Jersey. The lineament coincides to some extent with an eliptical east-west gravity high (Bonini, 1965), and a magnetic anomaly shown on a magnetic map in the AGS Preliminary Safety Analysis Report (Figure 2.5.1-13). The area of the LANDSAT lineament was investigated by the Public Services Electric and Gas Company (PSE&G) during investigations for the Atlantic Generating Station site by means of well-log analysis and field reconaissances. Data presented in U.S. Geological Survey Professional Paper 796 (Brown et al., 1972) which included geologic cross sections, a structure contour map of basement, and structure contours and isopachs of identifiable Coastal Plain strata from the lower Cretaceous (Jurassic) through the Cenozoic, do not indicate a disruption of these strata in the vicinity of the linear. The gravity and magnetic anomalies likely represent either lithologic variation in the basement rocks or structure that does not significantly affect the Cretaceous and younger strata above it (NRC, 1977).

During geological and geophysical investigations for the Atlantic Generating Station (AGS) extensive offshore seismic reflection profiling was done. These lines extended northward from the AGS site to the offshore vicinity of the Oyster Creek site. There was no evidence for faulting in strata ranging from upper Miocene to Recent (10 mybp to Present).

Although there is no indication of faulting in the vicinity of the site, it is possible that faults similar to some of those described above may be present in the basement rock in the area. However, if they do exist they are not capable within the intent of Appendix A, 10 CFR Part 100.

Two NRC-funded geological and seismological research projects, the results of which are relevant to all sites located on the Atlantic Coastal Plain, have been under way for the past several years. These programs are: (1) the New England Seismotectonic Study by Weston Observatory of Boston College, and (2) Studies Related to the Charleston, South Carolina Earthquake of 1886 by the U.S. Geological Survey (USGS).

A small part of the New England study is the investigation of the Northern Fall Line Zone of Central and Northern New Jersey (Thompson, 1979). In this study Thompson has identified narrow linear zones of seismic activity which he believes may represent fracture and fault zones. Some of these alignments coincide with topographic linears and others with geophysical (aeromagnetics and air gravity) anomalies. Several are characterized by both Some suggestion of faulting in the basement rocks has been found along three of the linears. The most direct evidence for faulting was found in borings in basement rock along a north, trending linear in northern Delaware, however, it is not one of the five seismic linears. The meaning of these data is not clear, but the staff concludes that they do not represent a hazard to the site because: (1) the seismic linears may not be real because too few earthquakes are involved and there is likely a large band of error in epicentral locations; (2) the closest of these postulated linears is 30 miles (48 kilometers) west of the site; (3) all lines of evidence (LANDSAT imagery, aeromagnetic, air gravity, and geologic evidence for faults) do not consistently apply to all linears; and (4) no evidence has been found for faults that cut Coastal Plain strata younger than Miocene.

In his summary of the FY 1979 New England Seismotectonic Study Activities P. Barosh, program coordinator, sees a spatial relationship between ongoing subsidence, seismicity, structural embayments (irregulatities in the outcrop of the contact between the Cretaceous of the Coastal Plain and Paleozoic metamorphic rocks of the Piedmont), grabens, such as the Triassic-Jurassic basins, and high angle faults along the Atlantic Coast. He interprets this observation to suggest that continental rifting which began in the Mesozoic Era is continuing today, and that this could be the source of eastern seismicity (Barosh, 1981). This hypothesis, which requires that eastern U.S. is in a tensional stress regime, is in conflict with other current theories concerning the origin of seismicity in the eastern United States. These other theories (Behrendt et al, 1981 and Seeber and Armbruster 1980) are based on the existence of a compressional stress regime in eastern U.S.

A wealth of new information has been obtained from the investigations in the Charleston, South Carolina region, but the generating mechanism for the continuing seismicity in the epicentral area of the 1886 earthquake is still not known. As a result of this new information numerous hypotheses have been developed about the origin of Charleston seismicity. These hypotheses can be grouped into three main categories (1) reactivation of a major thrust fault that underlies the entire Appalachian Mountains, Piedmont and Coastal Plain at depths of 6 to 15 kilometers; (2) reactivation of high angle basement faults; and (3) stress amplification near the boundaries of mafic plutons (NRC 1981).

It has been the position of the staff, supported by our advisor the USGS, that Charleston seismicity is related to structure at Charleston and should not be assumed to migrate anywhere else in the Coastal Plain. Several of the hypotheses allow for the migration of this seismicity to other parts of the Piedmont and Coastal Plain. The staff reviewed all of the available information from the Charleston study during the operating license review of the V. C. Summer nuclear site. Based on the weight of that information and advice from the USGS (Appendix E to the Summer SER, memorandum to R. E. Jackson from J. F. Devine, 30 December, 1980) we reaffirmed our earlier conclusion that the Charleston seismicity, including the 1886, Modified Mercelli Intensity X Earthquake, is related to geologic structure in the Charleston area and should not be assumed to occur anywhere but in that area (NRC, 1981).

6 CONCLUSION

We conclude that data that has become available since the original site review confirms the staff's conclusions made at that time, that there are no geologic hazards that would affect the safety of the Oyster Creek site.

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