Safety Evaluation Report

NUREG-0053
Suppl. No. 5

U. S. Nuclear
Regulatory Commission

related to operation of

Office of Nuclear
Reactor Regulation

North Anna Power Station Units 1 and 2

Docket No. 50-338
and 50-339

Virginia Electric and Power Company

December 1976

Supplement No. 5

Available from
National Technical Information Service
Springfield, Virginia 22161
Price: Printed Copy $3.50 ; Microfiche $3.00

NUREG-0053, Supp. 5
December 29, 1976

SUPPLEMENT NO. 5
TO THE
SAFETY EVALUATION REPORT
BY THE
OFFICE OF NUCLEAR REACTOR REGULATION
U.S. NUCLEAR REGULATORY COMMISSION
IN THE MATTER OF
VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION - UNITS 1 AND 2
DOCKET NOS. 50-338 AND 50-339

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1.0 INTRODUCTION AND GENERAL DISCUSSION

1.1 Introduction

On June 4, 1976, the Nuclear Regulatory Commission (Commission) issued its Safety Evaluation Report regarding the application for licenses to operate the North Anna Power Station, Units 1 and 2 (North Anna facility). The application was filed by the Virginia Electric and Power Company (applicant). Supplement No. 1 to the Safety Evaluation Report was issued on June 30, 1976; Supplement No. 2 was issued on August 2, 1976; Supplement No. 3 was issued on September 15, 1976; and Supplement No. 4 was issued on December 8, 1976. Supplement Nos. 1, 2, 3 and 4 to the Safety Evaluation Report documented the resolution of several outstanding items, and summarized the status of the remaining outstanding issues.

The purpose of this supplement is to update our Safety Evaluation Report (and Supplement Nos. 1, 2, 3 and 4) by providing (1) our evaluation of the Stafford fault zone, (2) our evaluation of additional information regarding preoperational testing of the emergency core cooling system, and (3) information regarding the current status of matters that are still under review.

Each section of this supplement is numbered the same as the section of the Safety Evaluation Report, and is supplementary to and not in lieu of the discussion in the Safety Evaluation Report, except where specifically so noted. Appendix A is a continuation of the chronology of our principal actions related to the processing of the application, and Appendix B is a continuation of the bibliography.

A summary of the remaining outstanding issues is presented in Section 22.0 of this supplement.

2.0 SITE CHARACTERISTICS

2.5 Geology and Seismology

2.5.1 Introduction

We stated in Supplement No. 2 of the Safety Evaluation Report that in April 1976, the U.S. Geological Survey published two open file reports: "Detailed Investigations of a Coastal Plain-Piedmont Fault Contact in Northeastern Virginia," by Mixon and Newell and "Preliminary Investigation of Faults and Folds along the Inner Edge of the Coastal Plain in Northeastern Virginia," by Mixon and Newell. The geologic structures described in these reports consist of four en-echelon northeast trending structures which collectively compose the Stafford fault zone. We also stated that the Nuclear Regulatory Commission (NRC) had not taken a position on the age of last movement of the Stafford fault zone.

The northern projection of the Stafford fault zone passes approximately five kilometers west of the proposed Douglas Point Nuclear Generating Station site (Docket Nos. 50-448 and 50-449). If projected southwest along Neuschel's lineament, it passes about seven kilometers (4.35 miles) east of the North Anna site. In addition, the above cited investigations obtained data which support an interpretation of more recent tectonic deformation than had previously been recognized in this region.

Mixon and Newell (1976) located the Stafford fault zone based on considerations of the geologic significance of the Fall Line, the boundary between the Piedmont Plateau and the Costal Plain (Thornbury, 1965). Specifically, the fault zone was located by observations of linear zones of steeper than average dips of contacts shown by structure contours on the base of the Cretaceous (136-65 million years before present) Potomac Group rocks and the base of the younger Paleocene (65-53 million years before present) Aquia Formation. Further resolution of existence and location of this zone has been accomplished through geologic field work, including the excavation of trenches across elements of the zone.

Following the identification of the Stafford fault zone, the Potomac Electric Power Company (PEPCO) through its geotechnical consultant, Dames and Moore, conducted investigations to further define the structure and determine its significance to the proposed Douglas Point Nuclear Generating Station site since the Stafford fault zone is within 5.63 kilometers (3.5 miles) of the proposed Douglas Point site. These investigations, including geologic field work, trenching, and borings, have added substantial new information about the zone. The results of those investigations were presented in a report which was submitted to the Potomac Electric Power Company entitled "Geologic Investigation of the Stafford Fault Zone," by Dames and Moore.

We have completed our review of the available data related to the Stafford fault zone, including the Potomac Electric Power Company investigation. The U.S. Geological Survey, acting as our advisors, reviewed the Dames and Moore report and submitted comments to the NRC by letters to W. P. Gammill from J. F. Devine on July 15, 1976, and October 18, 1976. Our review has included several meetings and field trips with U.S. Geological Survey scientists and the Potomac Electric Power Company and its consultant, Dames and Moore, and has considered the review comments provided by the U. S. Geological Survey.

We feel that our present knowledge of the Stafford fault zone does not warrant any change in previously approved design bases for the North Anna facility. The new information does not indicate the existence of geologic structures that would tend to localize earthquakes or cause surface displacement at the North Anna site. A description of the fault zone and a discussion of the new information and the bases for our conclusion follow.

2.5.2 The Stafford Fault Zone

The Stafford fault zone is approximately 56 kilometers in known length. It consists of four en-echelon northeast trending structures: three northwest dipping, high angle reverse faults (Fall Hill, Hazel Run, and Dumfries fault zones) and a complex of southeast dipping monoclines known as the Brooke Structure. Displacements of the Cretaceous units along the faults range from 15 to 43 meters at the base of the Cretaceous, with displacements of younger stratigraphic units decreasing to less than one meter at the base of the Upland Gravels Unit. The youngest units observed in the area (e.g., Colluvium and Pleistocene terrace deposits overlaying the Dumfries fault) are not offset.

Geologic characteristics of the elements of the fault zone can be given in somewhat more detail as a result of investigations accomplished by the U.S. Geological Survey and Dames and Moore.

2.5.2.1 The Dumfries Fault

The Dumfries fault is the most northern and western element of the Stafford fault zone. It is expressed as a 45 meter downstep over 0.4 kilometers in structural contours on the crystalline basement. The fault trends generally north-northeast and coincides with the Fall Line for a known distance of 35 kilometers (from northeast Prince William County, Virginia, to Potomac Creek in the south central Stafford County). Observations made during trenching of this fault by the U.S. Geological Survey indicate that the main fault exposed in the trench strikes North 59 East and dips 68 West. Vertical separation of the Piedmont Metamorphic and the Cretaceous Potomac Group units along the fault is about 35 meters. Horizontal separation is at least eight meters based on reconstruction of structure contours. In the same trench, many subsidiary reverse

faults and rotational normal faults (slumps) in the Cretaceous Potomac Group unit indicate that some of the fault movement was penecontemporaneous with deposition of the Cretaceous units. Post-Paleocene movement has occurred, however, as evidenced by the absence of the Paleocene (65-53 million years before present) Aquia Formation beneath the Miocene Calvert Formation west of the fault.

The Potomac Electric Power Company investigated two other locations along the strike of the Dumfries fault northeast of the U.S. Geological Survey trench. At one of these locations, a line of twelve borings and a seismic refraction line were located across a Pleistocene terrace along Quantico Creek. Three units were identified: Pleistocene terrace deposits, Cretaceous Potomac Group sedimentary rock and Piedmont Metamorphic rock. The Potomac Electric Power Company states that the terrace deposits are not offset at this location over the projected trace of the fault. Based on the elevation of its upper surface and a similarity of the soil profile developed on the terrace deposits to soil dated by Oaks and others (1974), the Potomac Electric Power Company concluded that the terrace deposits at this locale are Sangamon (40,000 to one million years before present) age or older. Further to the south trenching across a location where borings indicate a fault offset of 43 meters at the Piedmont metamorphic/Potomac Group horizon revealed faulted Potomac Group units. These were overlain by an unfaulted soil which has been interpreted to be colluvium (Dames and Moore, 1976). Analysis of the soil profile suggests that the colluvium is Early Pleistocene in age (one-0.5 million years before present).

Investigations of the Dumfries fault have yielded information which indicates only that nothing younger than Miocene (26-seven million years before present) units are faulted. The youngest formation inferred to be offset by the Dumfries fault is the Early and Middle Miocene Calvert formation.

2.5.2.2 The Fall Hill Fault

The Fall Hill fault deforms Cretaceous and Lower Tertiary rocks, Mixon and Newell (1976). Displacement of the contact between Cretaceous and Piedmont metamorphic rocks ranges between 30 to 50 meters. The Paleocene (65-53 million years before present) Aquia Formation is offset about half that amount. The mapped fault extends from the Rappahanock River to Stafford, Virginia, a distance of about 13 kilometers. Two exposures of this fault have been located and mapped by U.S. Geological Survey geologists and both indicate a westerly dipping reverse fault which juxtaposes Piedmont metamorphic rocks against the Cretaceous Potomac Group units. At one of these exposures along Fall Hill Road, the base of an Upland Gravels unit appears to be offset approximately 12 centimeters by the fault.

Detailed examination of this exposure shows the Piedmont metamorphic rock to be almost completely weathered to clay. The degree of sharpness of the contact of the angular corner of the upthrown block against the gravels would indicate that

fault movement took place when this unit was a solid metamorphic rock prior to the saprolitization which has since changed it into a weak clay. At this location the Upland Gravels consist of poorly sorted quartz pebbles and granite and schist pebbles and cobbles. The latter have been extensively weathered to material best characterized as rottenstone. Since pebbles so completely weathered could not be transported and deposited without total destruction, it is clear the gravels must have great antiquity. That is, they were most likely deposited in a hard, unweathered form and have been extensively weathered in place since their deposition. The age of these gravels is described in greater detail later. The quality of this exposure does not allow one to observe a clear fault break in the gravel and an alternative explanation such as deposition across or against the fault offset could be offered. Minor faulting of the Upland Gravels at this location can not be discounted however.

The Potomac Electric Power Company's consultant (Dames and Moore) excavated four trenches, eight test pits and drilled four borings along the Fall Hill fault. These investigations revealed a high angle, northwest dipping reverse fault which varies in width from one to three meters. Most deformation observed occurred in the Cretaceous Potomac Group units. In one of the trenches, the Paleocene Aquia Formation overlies some of the fault splays and is not offset by the fault, however, at other locations along the Stafford fault zone the Aquia is clearly faulted. In all exposures, the base of the Upland Gravel deposits is undeformed with the possible exception of an apparent 2.5 centimeters offset in the base of Upland Gravels overlying a fault plane. This feature which was observed in the trench about 3.2 kilometers north of Fall Hill Road disappeared as the trench wall was excavated further, causing us to conclude that the offset was most likely an erosional or depositional feature.

The investigations of this fault, as discussed above, indicate that the dominant amount of fault movement took place during post Cretaceous - pre-Miocene time with lesser amounts of offset of the younger units. The youngest inferred movement along this element of the Stafford fault zone is the 12 centimeters of apparent offset in the base of the Upland Gravels as described earlier.

2.5.2.3 The Hazel Run Fault

The Hazel Run fault is described by Mixon and Newell (1976) as extending, "from Fredericksburg, Virginia about eight kilometers southeastward at least as far as the Coastal Plain - Piedmont boundary."

Two exposures of this fault near Hazel Run and U.S. Highway 1 showed the Piedmont metamorphic rock juxtaposed against Cretaceous Potomac Group units. The Potomac Electric Power Company also investigated an area along strike about 1.5 kilometers southwest of these outcrops. A series of nine borings was drilled and stratigraphic correlations were made based on available lithologic information obtained by rotary wash methods and resistivity and gamma log comparisons. These correlations indicate a 20 meter offset in the metamorphic Potomac Group contact at this location. The younger Miocene Calvert Formation is, however, not offset.

Another observation that can be made, based on these borings at this locale, is that a minimum of about 37 meters of combined Potomac Group and Aquia Formation material was eroded from the upthrown fault block. Essentially a peneplaned surface existed prior to deposition of the Calvert Formation which, within the resolution of the correlation techniques utilized, is about the same thickness on both sides of the fault. The significance of this observation is that a considerable amount of time must have been required to erode this amount of material and little, if any, fault movement has taken place since that time.

The only evidence for geologically younger fault movement along the Hazel Run fault is noted in the Preliminary Safety Analysis Report for Douglas Point (PEPCO, 1973, p. 2.5-15) where a 46 centimeter apparent offset in the base of the Upland Gravels is discussed. The apparent offset strikes North 50 East to North 70 East and dips steeply to the north, similar to the known trend and attitude of the Hazel Run fault. The offset was found in a borrow pit behind the Sports Center Marina on U.S. Highway 1 about 500 meters from the site of the Potomac Electric Power Company's investigation on the Hazel Run fault described above. The apparent offset was described as dying out within the Upland Gravels. During the present investigation a search was made for this exposure, but since its original discovery the borrow pit has been expanded. At present the contact between the Calvert formation and the Upland Gravels is clearly exposed and is not offset anywhere in the exposure. In an adjacent borrow pit, cut and fill erosional-depositional features were observed by the NRC staff geologists, which, depending on the degree of exposure available for observations, might be interpreted as faulting. However, since there does not seem to be any way to study the original exposure, offset of the Upland Gravels along a possible splay of the Hazel Run fault at this location cannot be ruled out.

2.5.2.4 The Brooke Structure

Mixon and Newell (1976) described the Brooke structure as a zone of flexuring and faulting, about seven kilometers southeast of the Dumfries structure. It is further described as a southeast dipping monocline which deforms Cretaceous and Tertiary strata. Structure contours along an 18 kilometer segment of the structure show that down-to-the-coast displacement of the base of the Aquia is 30 meters over a horizontal distance of about 1.6 kilometers. This is anomalous, as the normal dip of the base of the Aquia is three to six meters per kilometer.

Abrupt folding on the southeast side marks the up-dip limit of Eocene (53-37 million years before present) Nanjemoy Formation and its Marlboro Clay member. On the east side of the structure, the Miocene (26-seven million years before present) Calvert Formation overlies the Nanjemoy Formation, but on the west side the Nanjemoy is absent and the Calvert directly overlies the Paleocene Aquia Formation. This stratigraphic relationship supports Middle Tertiary (37-26 million years before present) deformation.

Mixon and Newell (1976) also report that a 60 meter offset of Potomac Group unit's contact with the crystalline basement rocks is indicated by data from wells on the Quantico Marine base along the projection of Brooke structure. The Potomac Electric Power Company has investigated the Brooke structure by reconnoitering areas along it, by detailed mapping at certain locations, by drilling a line of borings across it, and by conducting a seismic refraction survey. These investigations confirmed the existence of the Brooke structure as defined by Mixon and Newell (1976); however, no site where post-Aquia deposits extended completely across the structure was found. A geologic section across the structure constructed from boring data showed a relatively flat erosion surface at the top of the Aquia formation. To east and west, but not continuous across the entire structure, is a post-Aquia clay (probably post Nanjemoy-preCalvert, 37-seven million years before present, U.S. Geological Survey review letter, July 1976). Although not conclusive, the stratigraphic relationships of the base of this unit to the east and west of the Brooke structure indicate that this unit is essentially horizontal across the structure at the same location where the base of the Aquia formation is folded or offset by faulting approximately 15 meters.

North of Aquia Creek, and trending toward the northwestern boundary of the Brooke structure, is an arcuate fault called the Tank Creek fault. It was mapped during the Douglas Point site investigations. It trends northeast and has at least three meters of vertical displacement within the Potomac Group units. An adjacent and intersection fault plane shows relative reverse and left lateral movement. The fault does not appear to offset the Aquia-Potomac contact along its southward projection nor a layer of colluvium overlying it. The colluvium at this location may be as young as Holocene (less than 10,000 years old, U.S. Geological Survey review letter, July 15, 1976).

2.5.2.5 Discussion

Post Triassic (225-190 zone million years before present) offsets on faults in the Eastern United States, although previously recognized by numerous geologists (Darton, 1950; White, 1952; York and Oliver, 1976), have not been generally acknowledged by the geologic community. With the current geologic interest in neotectonics, these post Triassic offsets have been acknowledged and are the subject of ongoing investigations. A reasonable assessment of the historical geologic development of the Stafford fault zone can be made based on the information that has been gathered to date. The zone has experienced post Cretaceous offset.

Based on knowledge of the stratigraphic relationships along the Stafford fault zone, the dominant amount of offset, approximately 30 meters, took place between Cretaceous 136-65 million years before present) and Paleocene (65-53 million years before present). Lesser amounts of offset of geologically younger formations have taken place with apparent offset of the youngest formation, the Upland Gravels, from 12 to 46 centimeters at two localities. The age of the youngest apparent offset is dependent on the age assigned to Upland Gravels.

At this time a definitive age for this unit is not known. Our current knowledge does, however, allow us to make a reasonable estimate of its age.

Studies by the Potomac Electric Power Company of comparative observations of weathering in the Upland Gravels with similar gravels in the Delmarva Peninsula indicate that the Upland Gravels are at least as old as Miocene (25-11 million years before present). Other sources (Darton, 1950; Glaser, 1971; Mixon and others, 1972) indicate that the Upland Gravels range in age from late Miocene to early Pleistocene (11-one million years before present). Based on information on soil development on a sand facies of the Upland Gravels, the Potomac Electric Power Company further suggests that the soils are early or pre-Pleistocene in age (greater than approximately one million years before present). Although the age of the Upland Gravels is not definitive, it is reasonable, based on our current knowledge, to accept that this unit is greater than 500,000 years old.

Based on our review of the geologic information presently available on the Stafford fault zone, we feel that the geologic evidence does not support an interpretation of a single movement on the Stafford fault zone in the last 35,000 years or multiple movements during the last 500,000 years. Reasonable geologic analysis indicates that movement on this zone has decreased through geologic time. A maximum known offset of 43 meters has occurred since the Cretaceous (136-65 million years before present).

The evidence for youngest movement indicates a possible maximum of one half meter of offset locally in the last million years or more. We address these points and the bases for our comments further in the conclusion of this evaluation.

2.5.3 Seismicity of the Stafford Fault Zone

The Stafford fault zone lies in a region where, because of early colonization, we have good historical records extending back at least 200 years. Worldwide seismograph network stations have been operating in Blacksburg, Virginia; Georgetown University, District of Columbia; and at State College, Pennsylvania since the early 1960's. In addition, the Virginia Polytechnic Institute operates stations at several localities in Virginia, including one at Corbin, approximately 11 kilometers southeast of the Stafford fault zone. Various investigations utilizing different subsets of data from the above sources have implied or stated directly that there is a relatively low level of seismic activity in the Stafford fault zone. These include:

(1) A regional study of seismicity in the southeastern United States (Bollinger, 1973): In this study, the Stafford fault zone is found to lie in a relatively aseismic area bounded by the more active Southern Appalachian Seismic Zone to the west and the Central Virginia Seismic Zone to the south.

(2) The seismotectonic map of the eastern U.S. (Hadley and Devine, 1974): Their plot of earthquake epicenters and seismic frequency contours show results similar to Bollinger, (1973).

(3) A catalog of southeastern U.S. earthquakes from 1754 through 1974 (Bollinger, 1975b): This catalog is the most recent and comprehensive listing of felt and instrumentally detected earthquakes for the region. These epicenters were plotted on a map of the Stafford fault zone. Only one earthquake was found to correlate spatially. This is the 1789 earthquake whose record consists of a Richmond newspaper reporting a small shock felt in Fredericksburg (Hopper and Bollinger, 1971). No other event in this catalog falls on or within 20 kilometers of the fault zone.

(4) A summary of five years of recording at Corbin, Virginia (G. A. Bollinger, letter to NRC, 1976) indicates that all events that were recorded and could have occurred within 45 kilometers of the station were tabulated. These events include one felt earthquake (Magnitude 3.5 and Intensity IV, 30 kilometers southeast of the fault zone), three smaller aftershocks and seven microearthquakes (Magnitude plus one to minus one range) whose locations could not be determined. The letter points out that this is an extremely low frequency of earthquake occurrence even when compared to another area in Virginia (Richmond).

(5) A review of Stafford fault zone studies conducted by U.S. Geological Survey (letter to W. P. Gammill from J. F. Devine, October 18, 1976) concludes that there is no demonstrable relationship between historical seismicity and the fault zone as known.

Summarizing the above, we find no correlation between historical seismicity or instrumentally determined macroseismicity and the Stafford fault zone as presently defined. In addition, a preliminary report of microearthquakes in this area indicates a low level of microearthquake activity.

2.5.4 Regional Geologic Considerations

Regional geologic considerations indicate that the Stafford fault zone aligns with a lineament formed by the northeast trending segments of the Potomac, Susquehanna, and Delaware estuaries. According to Mixon and Newell (1976), this is a possible suggestion of deformation in latest Tertiary or Quaternary time. Parallel to the Stafford fault zone, and located about 24 kilometers to the east, is the Brandywine fault zone. Similarities between this fault zone and the Stafford fault zone suggest that the two structures may be tectonically related.

Jacobeen (1972), reporting studies conducted by the Washington Gas Light Company, described the Brandywine fault zone as being composed of two en-echelon east dipping, high angle reverse faults. The southernmost one be called the Danville fault. This fault exhibits more than 76 meters of offset at both the top of the crystalline basement and the top of the lower Cretaceous Arundel formation. The northernmost fault was termed the Cheltenham fault and shows about 30 meters of throw of the top of the Arundel formation.

The results of the investigations performed by Washington Gas Light Company, and later by the Potomac Electric Power Company (PEPCO, 1973), indicated that most of the activity occurred during the Cretaceous with continued or sporadic activity taking place into Middle Tertiary in the form of monoclinal flexuring.

Lineaments coincident with the trend of the subsurface Brandywine fault zone suggest that the faults may extend to the surface. However, based on borehole correlations, there appears to be a lack of fault displacement of the Paleocene Aquia formation and the Miocene strata where they overlie the fault.

It is likely that both the Brandywine and Stafford fault zones experienced movements during the same tectonic events. Mixon and Newell (1976) suggest that the two fault systems apparently define a 25 kilometer-wide block of Coastal Plain sediments which has been depressed relative to blocks on either side. Most of the deformation along both systems appears to have occurred during the Cretaceous and again in post-Middle Eocene to pre-Middle Miocene time. Some Late Tertiary movement is suggested along the Brandywine fault zone by slight flexuring across anticlinal structure near Danville, Maryland (PEPCO, 1973, and Jacobeen, 1972). Likewise, Late Tertiary or Early Pleistocene movement along the Stafford fault zone can be inferred by possible offsets of the base of the Upland Gravels (Dames and Moore, 1976, and U.S. Geographical Survey review letter, July 15, 1976).

The presence of linears, sharp turns in the Potomac and Rappahanock Rivers, and the Richmond Triassic bassin along a southern projection of the Brandywine fault zone may reflect a geologic relationship between these structures. Additionally, Triassic rocks have been encountered in deep borings along the trend. The data are suggestive of a major structure extending from at least Prince Georges County, Maryland to the Richmond Triassic Basin. A similar relationship can be inferred by the alignment of the Stafford fault zone, Neuschel's lineament, and the Farmville Triassic Basin.

As discussed earlier, the discovery of Cretaceous and Cenozoic faulting in the coastal plain and Piedmont is not unique. York and Oliver (1976) have catalogued and briefly described 33 faults in the eastern United States, 18 of which are located on the Atlantic Coastal Plain and Piedmont, that displace sediments ranging in age from Cretaceous to Pleistocene. In regard to the present study, perhaps the most significant of the faults mentioned by York and Oliver, because of its apparent age and proximity to a northward projection of the Stafford fault zone, is that mapped by Darton (1950) near Rock Creek in Washington, D.C. The fault has apparent high angle reverse movement and offsets what Darton considered Pleistocene terrace gravels. Another fault that should be mentioned because it is indicative of possible post-Tertiary movement is the Belair fault near Augusta, Georgia. Although several hundred miles from the Stafford fault zone, it is near the Fall Line and has a similar orientation and sense of movement. The Belair fault is described by Prowell and others (1976), who cite evidence for movement on the fault since 2,450-1,000 years before present. Based on more recent studies, the U.S. Geological Survey has noted that errors were made in assessing the age of last movement on this fault and a recent

U.S. Geological Survey news release, dated November 18, 1976, indicates only that movement has taken place in the last 50 million years.

2.5.4.1 Neuschel's Lineament

Neuschel (1970), in an analysis of geophysical measurements and lithology in the Virginia Piedmont, has found a general northeast-southwest trend of aeromagnetic and aeroradioactivity anomalies in the region. One magnetic high has a striking rectilinear boundary in conjunction with a radioactive high. The radioactive high can be associated with granite gneiss while the magnetic high overlies hornblende gneiss. No modeling of the anomalies has been done, but Nueschel has postulated that the lineament reflects a fault boundary.

An extension of this lineament to the northeast would align with the Stafford fault zone. Subsequent aeromagnetic mapping indicates that the lineament is continuous to the Farmville Triassic Basin, to the southwest in southern Virginia (Mixon and Newell, 1976). Higgins and others (1973) have argued that this feature is a major fault zone, citing field evidence near Fredericksburg that shows the lineament to coincide with the boundary between a high grade migmatite terrane and a lower grade metasedimentary terrane. Stone and Webster (1973) conducted field investigations of Neuschel's lineament in the vicinity of the present Lake Anna and concluded that the different metamorphic suites represent a facies change rather than a large scale fault zone.

A recent report of 27 months of microearthquake monitoring in the vicinity of the North Anna site (Dames and Moore, 1976) shows seismic activity fairly well limited to a specific area within the array. This area is bounded on the southeast by Neuschel's lineament, on the northwest by a northeast trending line extending from the plant site and is confined to the shores of Lake Anna. The northeast shore of the lake and particularly its intersection with Neuschel's lineament shows the highest level of activity during this time interval. There is no evidence from the array that microearthquake activity occurs elsewhere on the lineament. The array was sensitive enough to detect a magnitude 1.4 event 46 kilometers from the North Anna site and a magnitude 0.0 event 29 kilometers from the site. Bollinger's catalog (Bollinger, 1975b) of southeastern United States Earthquakes from 1754 through 1974 shows no earthquake activity associated with Neuschel's lineament.

The rate of microearthquake activity within the confines of the North Anna array (one event every nine days) is similar to the average rate of microearthquake occurrence (one event every eight days) for similar size areas within the Central Virginia seismic zone (Bollinger, 1975a). Therefore, whatever the cause of these earthquakes of rate of activity does not appear to be regionally anomalous. Our conclusions related to microseismic activities are stated in Supplement No. 2 of the Safety Evaluation Report and remain unchanged.

2.5.5 Conclusions

The available data do not definitively demonstrate the age of most recent movement on the Stafford fault zone. The U.S. Geological Survey has indicated that a final interpretation of the regional significance of this structure may require several years of additional investigations (J. F. Devine letter to NRC, 1976). Certainly extensive additional investigations are needed before the complete geologic significance of the Stafford fault zone will emerge. But we can draw conclusions based on the totality of the information now available.

Several lines of evidence support possible Late Tertiary movement along some elements of the Stafford fault zone.

(1) The alignment of the Stafford fault zone with the lineament formed by the northeast trending segments of the Potomac, Susquehanna, and Delaware estuaries, is suggestive of at least some deformation in Latest Tertiary or Quaternary time (Mixon and Newell 1976);

(2) Small reverse faults offsetting terrace deposits believed to be Pleistocene in age near Rock Creek in Washington, D.C. (Darton, 1950);

(3) The 12 centimeter apparent offset of the base of the Upland Gravels along Fall Hill Road west of Fredericksburg, coincident with the Fall Hill fault; and

(4) The 46 centimeter apparent offset of the base of the Upland Gravels near the Marina on U.S. Highway 1 (PEPCO, 1973, Preliminary Safety Analysis Report, page 2.5-15).

Items 2, 3 and 4 support compressional deformation in this region possibly into early Pleistocene. The data, however, suggest that movement on this fault zone decreased through time from Cretaceous. If there has been movement on the zone during the Quaternary, it has been small and localized. Observations supporting the conclusion that the Stafford fault is not capable include:

(1) The level of seismicity in the vicinity of the Stafford fault zone is lower than in the surrounding area which includes the Southern Appalachian and Central Virginia Seismic Zones, and no correlation between the fault zone and historic seismicity can be seen.

(2) The amount of current movement along the Stafford fault zone decreases through time. For example, between the beginning of the Cretaceous (136 million years before present) and the beginning of the Miocene (26 million years before present) approximately 40 meters of fault offset took place. Since the beginning of the Miocene, possibly 12 to 46 centimeters of local movement has occurred as suggested by offset of the Upland Gravels which overlies the Miocene Calvert Formation. The U.S. Geological Survey, Dames and Moore, and individual

researchers have done considerable geologic investigation in the region. To date, only these two instances of possible Late Tertiary or Quaternary movement have been observed on the Stafford fault zone.

(3) The 46 centimeter offset of the base of the Upland Gravels that is discussed in the Douglas Point Preliminary Safety Analysis Report may be a local feature. Although evidence of this original feature is no longer available, other apparent offsets in the same area as explained earlier, can be better explained as being caused by depositional processes.

(4) A trench excavated across the projection of the Hazel Run fault, about 1.5 kilometers south of the Hazel Run Creek exposure of the fault, showed that, at least i the area of the trench, the Calvert Formation of Early and Middle Miocene age is not disturbed. In addition, the line of borings drilled in the same area, within which geophysical logging was done, show that the base of the Calvert Formation is not offset within the resolution of a few feet. This further supports decreasing movement since the Cretaceous.

(5) The trenches excavated by Dames and Moore across the Fall Hill Fault showed the base of the Upland Gravels truncating the fault, with the exception of a possible 2.5 centimeter offset which could also be interpreted as an erosional feature.

(6) The ages of the unfaulted soils (colluvium and terrace deposits) overlying the Dumfries fault that were exposed by the Dames and Moore trenches are not definitely determined. However, the elevations at which they lie, the similarity to other soils of known antiquity in the region, and the degree of weathering, indicate that they are ancient.

(7) With regard to the Brooke Structure, an erosional surface cuts across the top of the Aquia Formation. Deposition of a clay unit prior to deposition of the Miocene Calvert Formation on this surface, which is now at the same elevation on both sides of the structure, indicates that little or no offset has taken place since that time.

No one element of the above data unambiguously determines a definitive age of most recent movement on the Stafford fault zone. Taken in total, however, the available geological and seismological information supports the conclusion that the Stafford fault zone has not experienced a single movement during the last 35,000 years or multiple movements during the 500,000 years, and, therefore, is not capable within the meaning of Appendix A to 10 CFR Part 100, "Seismic and Geologic Siting Criteria for Nuclear Power Plants." We therefore conclude that this information does not warrant any change in our previously approved seismic design bases for the North Anna Power Station, Units 1 and 2.

Additional detailed geologic mapping is presently being conducted by the U. S. Geological Survey in the site region and we are funding geologic mapping which is being performed by Professor L. Glover along the James River to the south of the site region. It is expected that these activities will continue to discover geologic structures and features not unlike those previously identified, investigated, and considered in our original seismic analysis. These previously identified geologic structures and features have been discussed in this report, the Safety Evaluation of North Anna Power Station Units 1 and 2 (construction permit stage), and the Safety Evaluation of the North Anna Power Station Units 3 and 4 (Docket Nos. 50-404 and 40-405). The staff has recently participated in preliminary field reconnaissance of these regions and will continue to closely monitor these mapping activities. To date these mapping activities have not disclosed any geologic structures that would change our previously approved seismic design bases for the North Anna Power Station, Units 1 and 2.

6.0 ENGINEERED SAFETY FEATURES

6.3 Emergency Core Cooling System

6.3.4 Tests and Inspections

We stated in Supplement No. 1 to the Safety Evaluation Report that we would review the applicant's procedures for demonstrating adequate net positive suction head for the low head safety injection pumps prior to conducting the relevant emergency core cooling system preoperational tests. We further stated that we would report the results of our evaluation in a future supplement to the Safety Evaluation Report.

The applicant has proposed two sets of tests to demonstrate the functional performance of the low head safety injection pump suction line under conditions representative of those obtained during the recirculation phase after a postulated loss-of-coolant accident. The first series of tests which are discussed in Amendment 57 to the Final Safety Analysis Report will test flow from the containment sump using a single low head safety injection pump. These tests will be performed as part of the preoperational tests prior to loading fuel in the core. Results from these tests are expected to show that the available net positive suction head for the pumps will be adequate and that there are no incipient vortex problems at the suction pipe inlet under the proposed test conditions.

As a further confirmation of the sump design, the applicant in a letter dated November 6, 1976 has agreed to conduct scale model tests simulating a portion of the containment floor, sump, and the six suction lines that draw water from the sump during the recirculation phase after a postulated loss-of-coolant accident. These tests will specifically examine potential vortex formation when various combinations of suction lines are used. The scale model tests will be completed by June 1977.

Satisfactory completion of the limited in situ sump tests will provide reasonable assurance that the sump design is adequate. The timely completion of the scale model tests will provide additional confirmation of the design. Therefore, we conclude that the proposed tests are acceptable for fulfilling that portion of Regulatory Guide 1.79 dealing with the sump testing for verifying vortex control and acceptable pressure drops across screening and suction lines and valves and consider this matter resolved.

22.0 CONCLUSIONS

In Section 22.0 of Supplement No. 4 to the Safety Evaluation Report we stated that several items were still outstanding, and that satisfactory resolution of these items would be required before operating licenses for North Anna Power Station, Units 1 and 2 could be issued. Two of these have been resolved, as reported in this supplement. The outstanding items which must be resolved and their present status are summarized below. Resolution of each item will be discussed in a future supplement to the Safety Evaluation Report.

(1) The design of the system of well points for groundwater control has recently been submitted. We have reviewed this design and have requested additional information we have determined necessary for the completion of our review (Section 2.6 of Supplement No. 2 to the Safety Evaluation Report).

(2) The applicant must provide additional information regarding the dynamic analyses of the effects of a postulated loss-of-coolant accident on fuel elements (Safety Evaluation Report Section 4.2.4).

(3) The applicant has provided additional information on the seismic and environmental qualification of seismic Category I instrumentation and electrical equipment. Our evaluation of this information has not been completed (Safety Evaluation Report Section 3.10 and Section 3.10 of Supplement No. 3).

(4) The applicant has provided additional information on overpressurization of the reactor coolant system when in a water-solid condition. Our evaluation of this information has not been completed (Section 5.2.8 of Supplement No. 2 to the Safety Evaluation Report).

(5) The applicant has provided a reanalysis of the stress distribution in the spent fuel pool. Our evaluation of this information has not been completed (Section 3.8.2 of Supplement No. 3 to the Safety Evaluation Report).

Subject to satisfactory resolution of the outstanding matters described above, the conclusions as stated in Section 22 of the North Anna Power Station, Units 1 and 2 Safety Evaluation Report remain unchanged.

APPENDIX A

CONTINUATION OF CHRONOLOGY OF RADIOLOGICAL REVIEW

November 24, 1976	Virginia Electric Power Company's letter containing the final report on the Structural Analysis of the Spent Fuel Pool.
November 30, 1976	Virginia Electric Power Company's letter concerning Reactor Coolant System overpressurization events.
December 3, 1976	Virginia Electric Power Company's letter concerning testing, by either scale model or testing in Unit 2, would be conducted to demonstrate the absence of adverse vortexing in the containment sump for the operation of the lower head safety injection pumps during the recirculation phase of the emergency core cooling system.
December 8, 1976	Issuance of Supplement No. 4 to the Safety Evaluation Report.
December 10, 1976	Virginia Electric Power Company's letter transmitting an evaluation of a degraded grid voltage condition on North Anna 1, "Class IE Electrical Distribution System Evaluation for Degraded Voltage Conditions, North Anna Power Station, Unit No. 1."
December 14, 1976	Virginia Electric Power Company's letter transmitting a Westinghouse Electric Corporation Report entitled, "Westinghouse (W) CID Process Control System for a Nuclear Power Plant - System, Temperature and Seismic Test Report."
December 14, 1976	Virginia Electric Power Company's letter transmitting additional information concerning responses to Comments 2.19, 2.20 and 2.21.
December 14, 1976	Division of Project Management letter to Advisory Committee on Reactor Safeguards transmitting Staff Report - Assessment of the Stafford Fault Zone.

December 15, 1976	Division of Project Management letter transmitting copies of Supplement No. 4 to the North Anna Power Station, Units 1 and 2 Safety Evaluation Report to Virginia Electric and Power Company.
December 15, 1976	Order issued by the Atomic Safety and Licensing Board adopting two contentions of intervenor, Mrs. Arnold. The Board also requested that Virginia Electric and Power Company's evidence on its commitment to good quality control and safe operation be offered by board level management.

APPENDIX B

CONTINUATION OF BIBLIOGRAPHY

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