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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

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ATOMIC SAFETY AND LICENSING BOARD

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Before Administrative Judges:

Morton B. Margulies, Chairman  
Gustave A. Linenberger, Jr.  
Dr. Oscar H. Paris

OFFICE OF SECRETARY  
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BRANCH

**SERVED AUG 29 1986**

In the Matter of  
GEORGIA POWER COMPANY, et al.  
(Vogtle Electric Generating Plant,  
Units 1 and 2)

Docket Nos. 50-424-0L  
50-425-0L

(ASLBP No. 84-499-01-0L)

August 27, 1986

PARTIAL INITIAL DECISION

Appearances

Bruce W. Churchill, and David R. Lewis, Esqs., Shaw, Pittman, Potts & Trowbridge, Washington, D.C., and James E. Joiner, Charles W. Whitney, Kevin C. Greene, and Hugh M. Davenport, Esqs., Troutman, Sanders, Lockerman & Ashmore, Atlanta, Georgia, for the Applicants.

Douglas C. Teper, Raymond Tingle, and Daniel Feig, Atlanta, Georgia, for the Intervenor, Georgians Against Nuclear Power.

Bernard M. Bordenick, and Lee Dewey, Esqs., Bethesda, Maryland, for the Nuclear Regulatory Commission Staff.

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## INTRODUCTION

### A. Scope of Decision

The proceeding involves an application for an operating license for the nuclear Vogtle Electric Generating Plant, Units 1 and 2 (VEGP), located in Burke County, Georgia. The application was filed by Georgia Power Company as agent and representative for the co-owners, Georgia Power Company, Municipal Electric Authority of Georgia, Oglethorpe Power Corporation and City of Dalton, Georgia (Applicants). Intervenor Georgians Against Nuclear Energy (GANE) contests the application. In this partial initial decision, the Board considers two of three Intervenor contentions involving environmental and technical issues litigated at a hearing held in March 1986, in which Nuclear Regulatory Staff (Staff) also participated as a party.

The three contentions heard, as originally numbered, consist of Contention 7 (alleging that Applicants have failed to assure that the ground water below VEGP will not be contaminated by a spill of radioactive water); Contention 10.1 (alleging that Applicants have failed to assure that certain polymer materials, to be employed in components of the VEGP that perform safety related functions, are environmentally qualified); and Contention 10.5 (alleging that Applicants have failed to assure that certain models of solenoid valves that are to be used to perform safety related functions in the VEGP are environmentally qualified). The Board has deferred ruling on Contention 10.5 because of the issuance, on August 25, 1986, of BOARD NOTIFICATION REGARDING ASCO SOLENOID VALVES FOR VOGTLE UNITS 1 AND 2

(BOARD NOTIFICATION NO. 86-18). We have decided Contentions 7 and 10.1 in Applicants' favor. Staff had supported Applicants on the contentions.

The Board found that: as to Contention 7, Applicants have provided adequate assurance that public ground water supplies will not be contaminated by an accidental spill of radioactive water at VEGP, and as to Contention 10.1, Applicants have provided adequate assurance that certain polymer materials, to be employed in components of the VEGP that perform safety related functions, are environmentally qualified.

The Board concluded that, as to the contentions addressed in this partial initial decision, there is reasonable assurance that, if an operating license is granted to Applicants, the activities authorized will not be inimical to the common defense and security, can be conducted without endangering the health or safety of the public, and will be conducted in compliance with applicable NRC regulations.

#### B. Development of the Proceeding

Applicants filed an application to operate VEGP on June 22, 1983. The facility contains two pressurized water nuclear reactors and is located in Burke County, Georgia, 26 air miles south southeast of Augusta and 15 air miles east northeast of Waynesboro. Each unit is designed to operate at a net electrical output of approximately 1160 megawatts.

The Nuclear Regulatory Commission (NRC) published a Federal Register Notice of Opportunity for Hearing on December 28, 1983.

48 Fed. Reg. 57,183 (1983). Petitions for leave to intervene and requests for hearing were subsequently filed by GANE, Campaign for a Prosperous Georgia (CPG), Coastal Citizens for a Clean Environment and the Consumers' Utility Counsel of Georgia. On January 31, 1984, this Board was established to rule on the petitions to intervene and to preside over the proceeding in the event a hearing were ordered. 49 Fed. Reg. 4,570 (1984).

The Consumers' Utility Counsel withdrew its petition for leave to intervene on February 20, 1984, and in a Memorandum and Order dated March 9, 1984, we ruled that Coastal Citizens for a Clean Environment had not demonstrated the necessary interest to establish standing to intervene.

On May 30, 1984, the Board conducted a prehearing conference to consider some two dozen proposed contentions submitted by GANE and CPG, many of which were identical. Thereafter, by Memorandum and Order, of September 5, 1984, the Board admitted for adjudication nine separate contentions on environmental and technical issues, which GANE and CPG adopted as Joint Intervenors. Contentions on emergency planning were permitted to be refiled after the emergency plans were submitted. This caused consideration of emergency planning issues to be delayed and considered separately from the other matters.

The contentions admitted by the September 5 Order, with their original numerical designations, were: Contention 7 (alleging a lack of assurance that a spill of radioactive water onsite would not result in contamination of the aquifers underlying the site); Contention 8

(alleging a failure to enforce a quality assurance program in the construction of the facility that provides adequately for the safe functioning of diverse structures, systems and components); Contention 10.1 (alleging that Applicants have failed to assure that certain polymer materials, to be employed in components of the VEGP that perform safety related functions, are environmentally qualified); Contention 10.3 (alleging a lack of assurance that the environmental qualification of single conductor cables is representative of multiconductor performance); Contention 10.5 (alleging that Applicants have failed to assure that certain models of solenoid valves that are used to perform safety related functions in the VEGP are environmentally qualified); Contention 10.7 (questioning whether the VEGP hydrogen recombiners have transducers or sensors that need to be qualified and whether the recombiners have been qualified as a unit); Contention 11 (alleging that Applicants have failed to consider vibration induced fatigue cracking and bubble collapse induced water hammer in the VEGP steam generators); Contention 12 (alleging that Applicant had not properly assessed the amount of salt and chlorine gas release from the cooling towers and the extent of consequent adverse agriculture and environmental damage); and Contention 14 (alleging that there is no reasonable assurance that the emergency diesel generators manufactured by Transamerica Delaval, Inc., to be used at VEGP, will be adequate).

Following discovery, Applicants then moved for summary disposition of each of the admitted contentions in which they were supported by Staff. Intervenors responded only to the motions concerning

Contentions 7 and 8. The Board granted summary disposition on all of the motions except those involving Contentions 7, 10.1 and 10.5<sup>1</sup>

The Board granted in part, and denied in part, Applicants' motion for summary disposition of Contention 7 and denied the motion as to Contention 10.1. The matters to be litigated in each of the contentions were identified in the Memoranda and Orders ruling on the motions for summary disposition.<sup>2</sup>

Hearing on the contentions commenced on March 11, 1986 at Waynesboro, Georgia and continued through March 14, 1986. Applicants, GANE, CPG and Staff appeared, GANE and CPG without counsel.<sup>3</sup> CPG took the time allotted for making an opening statement to comment adversely on the Commission's hearing process and then immediately withdrew from the proceeding. (In this decision where the term Intervenor is used, it pertains to the time when GANE and CPG were both participating in the proceeding. The singular is used to identify

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<sup>1</sup> The unpublished Memoranda and Orders granting the motions are dated as follows: Contention 8, October 3, 1985, reconsideration denied, December 3, 1985; Contention 10.3, August 21, 1985; Contention 10.7, November 5, 1985; Contention 11, September 3, 1985; Contention 12, December 24, 1985; and Contention 14, November 25, 1985.

<sup>2</sup> The unpublished Memoranda and Orders ruling on the motions are dated as follows: Contention 7, November 18, 1985, reconsideration denied, January 8, 1986 and Contention 10.1, January 23, 1986, partial reconsideration granted, February 14, 1986.

<sup>3</sup> Counsel for Intervenor withdrew from the proceeding on January 28, 1986.

GANE.) Applicants and Staff presented witnesses to testify on each of the contentions and cross-examined GANE's witnesses. GANE presented a witness and cross-examined on Contention 7 but not on 10.1. Attached as an appendix is a list of the witnesses that testified at the hearing on Contentions 7 and 10.1.

At the conclusion of the hearing the Board directed that the parties file proposed findings of fact and conclusions of law in accordance with the schedule set forth in 10 CFR 2.754. Filings were made by Applicants and Staff as directed. The witness who had testified on behalf of GANE on Contention 7 submitted timely proposed findings in the name of GANE for the contention, but he was not an authorized representative of the organization. The Board permitted GANE to adopt his filings, which the organization did on May 30, 1986. It is permissible not to require the same precision in the filings of a layman than is demanded of a lawyer. No prejudice was shown to have resulted from this course and the timely proposed findings were considered as if they were filed by GANE in the first instance.

The Board reached its decision in this proceeding upon consideration of the entire record pertaining to Contentions 7 and 10.1. All proposed findings of fact and conclusions of law submitted by the parties on the two contentions, that are not directly or inferentially considered in this initial decision, were rejected as unsupported in fact or law or as unnecessary to the rendering of the decision. The Board's findings of fact are supported by reliable, probative and substantial evidence of record that was presented by competent



witnesses. The Board has concluded as to the matters considered in this partial initial decision that should operating licenses be issued to Applicants for VEGP, it will not be inimical to the common defense and security or to the health and safety of the public.

At the time the oral hearing concluded on March 14, 1986, there remained, of the eight contentions admitted for litigation on the issue of emergency planning, six that were unresolved. Two had previously been disposed of by motions for summary disposition.<sup>4</sup> This posed the possibility of a further hearing on emergency planning issues. Motions then were filed for summary disposition of the remaining contentions, which the Board granted, the last on July 17, 1986.<sup>5</sup> All of the motions for summary disposition of the emergency planning contentions were unopposed. As a result of the disposition of all of the emergency planning contentions, there was nothing left for the Board to adjudicate in the proceeding beyond the issues raised in the oral hearing. By notice to the parties of August 5, 1986, we advised: (1) that we considered the entire record closed and (2) an initial decision would be issued, not a partial initial decision as was envisioned as of the close

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<sup>4</sup> The unpublished Memoranda and Orders ruling on the motions are dated as follows: Contention EP-6, February 3, 1986 and Contention EP-7, August 12, 1985, reconsideration denied, October 1, 1985, refiled motion granted, March 6, 1986.

<sup>5</sup> The unpublished Memoranda and Orders ruling on the motions are dated as follows: EP-1/EP-1(a)/EP-2(b), May 12, 1986; EP-2/EP-2(a), May 15, 1986; EP-2/EP-2(c), May 22, 1986; EP-2/EP-2(h), May 5, 1986; and EP-5, July 17, 1986.

of the oral hearing. The issuance on August 25, 1986 of BOARD NOTIFICATION REGARDING ASCO SOLENOID VALVES FOR VOGTLE UNITS 1 AND 2 (BOARD NOTIFICATION NO. 86-18), however, caused the Board to defer ruling on Contention 10.5 and to issue this partial initial decision. The Board Notification advised that Staff had forwarded a request for additional information to Applicants on their main steamline break (MSLB) analysis, which relates to the environmental qualification of certain ASCO solenoid valves considered in Contention 10.5. The Staff's request in part questioned the applicability of the methodology used for the qualification of ASCO valves exposed to superheat conditions following an MSLB outside of containment. The Board retains jurisdiction of Contention 10.5, the only contested issue yet to be decided in the proceeding.

## II. Findings of Fact

### A. Ground Water Contamination - Contention 7

#### Background

1. As admitted by our Memorandum and Order dated September 5, 1984, Contention 7 states as follows:

Applicant has not adequately addressed the value of the ground water below the plant site and fails to provide adequate assurance that the ground water will not be contaminated as required by 10 C.F.R. 51.20(a), (b), and (c), 10 C.F.R. 50.34(a)(1), and 10 C.F.R. 100.10(c)(3).

LBP-84-35, 20 NRC 887, 898 (1984). The gravamen of Contention 7 is that an accidental spill of radioactive water on the Plant Vogtle site could result in radioactive contamination of the water-table and possibly the deeper aquifers under the site.

2. On July 15, 1985 the Applicants filed "Applicants' Motion for Summary Disposition of Joint Intervenors' Contention 7 (Groundwater)". The motion was granted in part and denied in part by our Memorandum and Order (Ruling on Motion for Summary Disposition of Contention 7 re: Groundwater Contamination), issued November 12, 1985 (November 12 Order). Those issues satisfied by Applicants in the motion to strike were the following: whether data on ground water should be analyzed statistically; whether settlement of the VEGP has deformed the marl and thus affected its ability to function as an aquiclude; whether radioactive water in the auxiliary building (resulting from an accidental spill) could leak through the walls and into ground water; whether there is significant uncertainty with regard to the geology and

hydrology under the marl; whether hazardous chemical wastes are covered by the contention; whether ground water contamination experience at the Savannah River Plant (SRP) can be extrapolated to VEGP; and whether exploratory wells could provide a pathway for radioactive contaminants to reach ground water.

3. There were five issues of material fact remaining to be litigated, as found by the November 12 Order. Those issues were:

- (1) Adequacy of the Geological/Hydrological Exploration of the Vogtle site;
- (2) Uncertainty in Data on Marl Thickness and Permeability;
- (3) Data on Marl Continuity;
- (4) Direction of Ground Water Flow; and
- (5) Ground Water Travel Time.

4. Each of the parties prefiled testimony on this Contention and sponsored witnesses who testified with respect to it at the hearing. Applicants prefiled testimony by Thomas W. Crosby, Clifford R. Farrell, and Lewis R. West (hereinafter Crosby, et al., ff. Tr. 253) and testimony of Dr. Stavros S. Papadopoulos on Contention 7 (hereinafter Papadopoulos, ff. Tr. 253). We have examined the qualifications statements of these witnesses and find that they are well qualified geologists and/or hydrogeologists. Joint Intervenors prefiled testimony by William F. Lawless (hereinafter Lawless, ff. Tr. 720) and an attachment to the Lawless testimony characterized as an analysis of the Board's November 12 Order and dated December 15, 1985 (hereinafter Lawless Attachment, ff. Tr. 720). No qualifications statement was

appended to the filing by Mr. Lawless, but we are able to assess his qualifications from the cross-examination of the witness at the hearing. Tr. 721-28. Mr. Lawless, who is currently an Assistant Professor of Mathematics at Paine College, formerly worked for the Department of Energy's Savannah River Plant (SRP) where he had some experience reviewing reports and managing research projects dealing, at least in part, with ground water hydrogeology. He has had no training in geology or hydrology, however; his formal training has been in mathematics. We find him to have a general familiarity with the scientific method and to be conversant in the area of ground water hydrology, but his professional qualifications are in the area of mathematics, not ground water hydrology. The NRC Staff prefiled testimony of Lyman W. Heller and Raymond Gonzales (hereinafter Heller, et al., ff. Tr. 764). Their qualifications statements show that they are qualified geological and hydraulic engineers.

#### Discussion

5. To make the context of Contention 7 understandable, we shall begin with a brief description of the VEGP site geology and hydrology. In the discussions that follow, we have relied on the testimony that we found convincing.

6. Plant Vogtle is located on the Coastal Plain of Georgia. The Coastal Plain is underlaid by a sequence of sedimentary formations consisting of alternating beds of sand, clay, marl and limestone sediments atop a basement complex of older sedimentary, crystalline and metamorphic rocks. Crosby, et al., ff. Tr. 253, at 2. The Tuscaloosa

Formation overlies the older basement complex and consists of sands and gravels with scattered beds of silt and clay deposited in late Cretaceous time (about 90 million years ago). Id., at 3. The Huber and Ellenton Formations overlie the Tuscaloosa Formation and consist of dark gray sandy clays and silts and multicolored clays deposited during the Paleocene Epoch (Tertiary Period). The Lisbon Formation was deposited atop the Huber and Ellenton Formations during the Eocene Epoch (Tertiary Period). This formation is comprised of a lower calcareous sand unit, called the "unnamed sands" because it has no formal name, and an upper calcareous clay unit named the Blue Bluff marl. Finally, the Barnwell Group of sediments were deposited over the Lisbon Formation during the late Eocene Epoch and consists of sand with minor amounts of clay and limestones. The lowest stratum in the Barnwell Group, the Utley Limestone, was locally deposited on the Blue Bluff marl and is not present everywhere. The overlying sediments of the Barnwell Group are composed primarily of sands and silts which are exposed at the surface in the Plant Vogtle area. Ibid.

7. There are two major aquifers in the coastal plain region, both of which occur under the Vogtle site. The lower aquifer is called the Cretaceous aquifer and consists primarily of the sands and gravels of the Tuscaloosa Formation; it is often referred to as the Tuscaloosa aquifer. The upper aquifer is called the Tertiary aquifer and consists primarily of permeable sands and limestones of several Tertiary-age geologic formations. At the Vogtle site the Tertiary aquifer consists of the unnamed sands of the Lisbon Formation. Both of these aquifers

are confined under the Vogtle site, with the uppermost confining layer being the Blue Bluff marl of the Lisbon Formation. Id., at 4. In addition to these aquifers, ground water also exists in the Barnwell Group in shallow, discontinuous bodies and is referred to as the water-table aquifer. Id., at 4-5.

#### Issues of Material Fact

##### (1) Adequacy of Geological/Hydrological Exploration of Vogtle Site

8. In denying in part Applicants' Motion for Summary Disposition we pointed to three inadequacies in Applicants' program for exploring the geology and hydrology of the Vogtle site that the Staff had identified in the Safety Evaluation Report (June 1985) (SER) and Applicants had agreed to correct. We concurred with the Staff that further evaluation was needed. This involved further monitoring of the water-table aquifer and backfill to establish the design-basis ground water level. In addition, Staff required additional wells in the marl because of the limited monitoring that had been done over the full depth of the marl. Finally, Staff is requiring that the Tuscaloosa aquifer be monitored by reading observation wells on a monthly basis, to determine the long-term effect of withdrawing water from the aquifer. November 12 Order, at 12-13.

9. During the summer of 1985, a further program of geotechnical verification work was conducted at Plant Vogtle to resolve NRC Staff questions and to acquire supplementary data on site characteristics. The work consisted of conducting standard penetration tests of the backfill, core drilling and in situ permeability testing of the marl,

laboratory measurement of marl permeability, observation well installation, and laboratory measurement of the cation exchange capacity and equilibrium distribution coefficient of the backfill. Crosby, et al., ff. Tr. 253 at 7-8.

10. At the time the Motion for Summary Disposition was filed, Applicants were still conducting laboratory permeability tests on cores taken from the marl in June 1985, and data from well series 42 were still being supplemented and confirmed by data from additional wells. At the hearing the Staff witnesses testified that, based on Staff's review of Applicants' report entitled "Geotechnical Verification Work - Report of Results", the geological exploration of the Vogtle site is now adequate. That report, which was submitted to Staff by GPC on August 23, 1985, describes the exploratory work carried out by six core borings into the marl and the results of pressure tests conducted in the cored holes. Heller, et al., ff. Tr. 764, at 4. In addition, laboratory permeability tests were conducted on ten core samples from the marl, the results of which indicated that the marl permeability is about  $10^{-7}$  cm/sec. This value is consistent with the description and classification of the marl. Id., at 5.

11. To address the Staff's concern about the design-basis ground water level in the unconfined aquifer, which related to a structural rather than a ground water contamination concern, Applicants installed four new monitoring wells in the plant backfill and two new wells in the Barnwell sediments. Two of these wells have continuous water level recorders, and the remainder are being monitored on a weekly basis. Id.,



at 7. The Staff will impose a license condition for VEGP to require this monitoring throughout the life of the plant, although the frequency of monitoring will be subject to change. Id., at 8. Data thus far indicate that the water level in the unconfined aquifer has remained well below the 165 foot design-basis level. Crosby, et al., ff. Tr. 253, at 34-35.

12. In response to the SER concern regarding marl permeability, Applicants performed six continuous and controlled core borings into the marl. The wells were located in two clusters at opposite corners of the power block. Heller, et al., ff. Tr. 764, at 8. Data on pore pressure distribution within the marl obtained from these wells provide additional evidence that the marl is an aquiclude that impedes the movement of ground water from the water-table aquifer to the lower aquifers. Id., at 16

13. The monitoring of the Tuscaloosa aquifer called for in the SER is an environmental concern intended to ensure that the withdrawal of water from this aquifer will not have an adverse impact on other ground water users. Id. at 8. This monitoring will be required throughout the lifetime of the plant. Id.; Crosby, et al., ff. Tr. 253, at 35-36.

14. Laboratory permeability tests on 10 samples obtained during core drilling of the marl, which gave permeabilities ranging from  $10^{-6}$  to  $10^{-8}$ , together with in situ field tests, confirm that the marl is nearly impermeable. Heller, et al., ff. Tr. 764, at 9. Staff testified that its requirement for additional geologic and hydrologic exploration of the marl has now been satisfied. Id., at 6, 13.

15. Intervenor's witness Lawless testified that breaching the marl in order to monitor it may have resulted in the creation of flow pathways through the marl. The witness cited no data or other source of information to support this statement, however. The suggestion apparently is pure speculation. Lawless, ff. Tr. 720 at 7.

16. The Board finds that the further geological/hydrological exploration called for by the Staff in the SER, for the purposes set forth, supra, in ¶ A.8, has been adequately carried out by Applicants.

17. Prior to the 1985 explorations called for in the SER, Applicants conducted extensive investigations of the geology and hydrology at and in the vicinity of the plant. Crosby, et al., ff. Tr. 235, at 5. The investigations commenced with site exploration in 1971. A thorough literature search, stereoscopic examination of color air photographs, detailed evaluation of geologic conditions at and within five miles of the site, and geologic reconnaissance along 12 miles of the Savannah River bluff upstream and downstream were conducted. Geological field investigations included geologic mapping, drilling, and geophysical surveys. During this phase of the investigation, 474 exploratory holes were drilled for a total of 60,000 feet of hole. The drilling program included electric logging, natural gamma, density, neutron, caliper, and three dimensional velocity logs in selected drill holes. Menard pressure meter tests were performed to determine in situ engineering properties of the marl, which is the load bearing unit for plant structures. The geophysical surveys consisted of a total of 28,400 feet of shallow refraction seismic lines, 5000 feet of deep

refraction lines, and cross-hole velocity measurements in the upper 290 feet of materials. Id., at 5-6.

18. Ground water studies were also conducted during initial site exploration. These studies included in situ permeability testing, installation and monitoring of observation wells, and canvasses of off-site, non-project wells. A total of 280 wells were located and inspected on the west side of the Savannah River. These included all wells in use within seven miles of the site and an estimated sixty percent of the wells beyond to a distance of ten miles from the site. Id., at 6.

19. Investigations of the geology and hydrology at VEGP continued during site excavation and construction. These included detailed geologic mapping of the soil and rock strata exposed during the power block excavation plus coring and testing of the Blue Bluff marl. Over 100 additional exploratory holes were drilled in the vicinity of Plant Vogtle. In addition, since initial site exploration in 1971, 37 observation wells have been used to monitor water levels in the water-table aquifer, and the Tertiary aquifer has been monitored by 23 wells. Data have also been obtained from four wells open to the Cretaceous aquifer. Ibid.

20. In May and June of 1982 another major well canvass was conducted to accumulate a comprehensive hydrogeologic data base to evaluate the postulated Millett fault. A total of 886 wells encompassing an area of approximately 4400 square miles surrounding the plant were investigated. Geophysical well log data from both the State

of Georgia Geological Survey and the U.S. Geological Survey were obtained and analyzed. As part of the Millett study, 12 observation wells were installed along two lines southeast of the plant. The wells were drilled through the marl and water levels were monitored in the Tertiary and Cretaceous aquifers below the marl. Data from these and other core holes provide accurate definition of the depth of geologic units, lithology, and aquifers from the plant to nineteen miles southeast of the plant, and evidence of the lateral extent of the marl in that direction. Even more recently, in 1984, a well canvass was conducted to identify all off-site wells within two miles of the plant.<sup>6</sup> Id., at 7 and Fig. 3.

21. Witness Ferrell testified that he believes that the exploration done is adequate for characterization of ground water, and witness Papadopoulos testified that the number of wells to the north and northwest, in the direction of ground water flow, are more than adequate to establish the presence of the marl. Tr. 272-73. Witness Crosby testified that the Blue Bluff marl was also explored to the south and southeast by core holes and that examination of core holes throughout the plant site gives confidence that the marl is consistent throughout

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<sup>6</sup> On brief Intervenor speculates that the Applicants' geological/hydrological surveys "appear to have treated protection of the ground water as a secondary consideration", citing Crosby, et al., ff. Tr. 253, Figure 4, Tr. 271-73, and Tr. 280-281. Lawless PF at 10. The testimony cited, however, contradicts this speculation.

the area. Tr. 281. Dr. Papadopoulos attested that he, too, believes, based on his professional experience, that the number of wells at the site are more than adequate to establish the continuity of the marl. Tr. 274. Staff Witness Heller testified that in his opinion, the data set now available for the marl indicates the marl to be continuous and to provide an effective impediment to ground water movement from the backfill to the aquifer directly below the marl. Heller, et al., ff. Tr. 764 at 14. Finally, witness Gonzales attested that based on a review of all the information that has been made available to the Staff, he concludes that there is no need for concern that the water-table and underlying aquifer will be contaminated by normal plant operation or a design basis accident. Id., at 25.

22. The Board finds that the geological and hydrological exploration at VEGP is adequate to accurately characterize the geological formations and ground water conditions beneath the site.

(2) Uncertainty in Data on Marl Thickness and Permeability

23. As we indicated, supra, at ¶ 8, Staff had required in the SER that additional exploration over the full depth of the marl was needed because of the limited monitoring of the marl prior to 1985. Because the required work was still in progress in November 1985, this issue remained to be litigated.

24. The Blue Bluff marl is a densely consolidated, fine grained calcareous clay with subordinate lenses of dense, well indurated, well cemented limestone. Reported values of the permeability of unweathered

clays, of which the marl is a type, range from  $10^{-7}$  to  $10^{-10}$  cm/sec. Crosby, et al., ff. Tr. 253, at 12.

25. Thickness and permeability of the marl were tested in situ during the site exploration in 1971-83; 80 packer tests and permeameter tests were conducted in 22 drill holes. During the geotechnical verification work conducted in the summer of 1985 an additional 15 packer tests were performed in six new holes, and laboratory permeability measurements were taken on ten samples from these holes. Id., at 9, 13-14; Tr. 281. Marl thickness was determined by data from more than 200 exploratory holes and wells, which included approximately 25 south of the power block area (the power block area includes the entire backfilled excavation) and a large number to the north.<sup>7</sup> Id., at 8 and Fig. 4; West, Tr. 810-11; Tr. 267. The marl is 65 to 70 feet thick and extends over an area well beyond the limits of the plant site and the interfluvial ridge on which the site is located. Because of excavation, marl thickness has been reduced to generally about 60 feet under the power block. An exception occurs under the auxiliary

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<sup>7</sup> The Staff's written testimony stated that marl thickness was known from 33 exploratory holes, which Staff considered to be a more than adequate number. Heller, et al., ff. Tr. 764 at 11. Witness Heller cited Table 2B-2 of the FSAR as the source of this information. Id. But Table 2B-2 is merely a catalogue of selected marl core samples, obtained from 33 principal borings, that were placed in protective storage. FSAR, § 2B.2. FSAR Table 2B-1, however, tabulates drilling statistics of 354 borings. Id., § 2B.1. Far more than 33 of these holes were deep enough to penetrate the marl. Moreover, Witness Farrell testified that more than 200 holes penetrated the marl. Tr. 663.

building, where additional excavation to accommodate the building's foundation reduced marl thickness to 38 feet. Crosby, et al., ff. Tr. 253, at 12-13; Heller, et al., ff. Tr. 764, at 11 ; Tr. 379.

26. During site exploration, in situ permeability tests were performed at 80 intervals of varying depth in 22 exploratory holes. Constant-head inflow methods were used. In 20 of the holes, inflatable packers were used to isolate a specified test interval, and water was injected under pressure into the isolated interval. Crosby, et al., ff. Tr. 253 at 13; Papadopoulos, Tr. 451. In two holes near the intake structure, permeameter tests were conducted. Crosby, et al., ff. Tr. 253 at 13. In nearly all of the test intervals, no measurable water inflow occurred. Water inflow from test intervals into the marl was measured in only three holes. Two of these were in near-surface, weathered marl at the intake structure. Three other cases of apparent water inflow actually resulted from leakage around the packers. Id., 13-14. These results indicate a permeability of less than  $10^{-7}$  cm/sec, which would allow 1.5 to 2 inches per year of water to pass through the marl. This estimate of permeability is consistent with the total recharge, about 15 inches per year, that is available to the water-table aquifer. Were the permeability of the marl as high as  $10^{-6}$  cm/sec the flow through the marl would be about 20 inches per year and the water-table aquifer above the marl would not exist. Papadopoulos, Tr. 451.

27. In situ permeability testing was conducted again in the summer of 1985, at 15 intervals in six new holes. The entire thickness of the

marl penetrated in the holes was tested in ten-foot intervals, to ensure that all of the marl and interbedded limestone lenses were tested. In all of these in situ tests water intake was zero. Thus, results from the recent in situ tests confirmed the earlier in situ measurements. Crosby, et al., ff. Tr. 253 at 14.

28. The laboratory permeability tests on ten marl core samples collected in the summer of 1985 gave permeabilities ranging from  $8.5 \times 10^{-6}$  to  $5.0 \times 10^{-9}$  cm/sec. Ibid. There were five values in the  $10^{-6}$  range, three in the  $10^{-7}$  range, one in the  $10^{-8}$  range, and one in the  $10^{-9}$  range. Papadopoulos, Tr. 391. The harmonic mean of these permeability tests is  $4.3 \times 10^{-8}$ .<sup>8</sup> Crosby, et al., ff. Tr. 253 at 20. The harmonic mean is the appropriate statistic for estimating average rate of water movement across a layered earth system, and the Blue Bluff marl has such a layered heterogeneity. Ibid.; Papadopoulos, Tr. 587-589; also see: VEGP-FSAR, at 2.5.1-19 and Fig. 2.5.1-24. Water movement through the marl is primarily in the vertical direction, across the layers. Papadopoulos, Tr. 591. Moreover it is the vertical component of flow in the marl that is of interest. Id., Tr. 588. We conclude that it is clearly appropriate to use the harmonic mean of the permeabilities of the core samples, rather than the arithmetic mean.

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Intervenor challenges Applicants use of the harmonic mean, on the grounds that Applicants have not shown that the marl is layered or that water movement through the marl is predominantly vertical. Lawless PF, at 14. There is no basis for either allegation.



29. Applicants used the harmonic mean only as a check on the permeability of  $10^{-7}$  cm/sec (0.1 ft/yr) estimated from the in situ tests, which was adopted by Applicants as the upper bound of marl permeability. The mean of  $4.3 \times 10^{-8}$  cm/sec (0.045 ft/year) from the laboratory permeability tests indicates that the 0.1 ft/yr estimate is reasonably conservative.<sup>9</sup> Crosby, et al., ff. Tr. 253 at 20. In situ permeability tests are generally considered to be more accurate than laboratory tests on core samples, because laboratory samples are of small size and therefore may not be representative, and the samples are necessarily disturbed when extracted. Papadopoulos, Tr. 451-452; Gonzales, Tr. 769. We conclude that the evidence establishes that the permeability estimate of  $10^{-7}$  cm/sec is both reasonably accurate and reasonably conservative.

30. The Board finds that there is sufficient certainty in the data on marl thickness and permeability to resolve this issue in Applicants' favor.

(3) Data on Marl Continuity

31. The continuity of the Blue Bluff marl, i.e., the lack of voids, open joints, or fractures, has been demonstrated at VEGP by a

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<sup>9</sup> On brief, Intervenor proposed a permeability value for the marl of 0.5 ft/yr, or  $5 \times 10^{-7}$  cm/sec, and calculated ground water travel time across the 38 ft thick section of marl beneath the Auxiliary Building on this basis. Lawless PF, at 18. This permeability value was suggested de novo and totally lacks any evidentiary basis. Consequently it must be rejected.

program of drilling, coring, standard penetration testing, and undisturbed sampling that has penetrated over 10,000 feet of the marl since 1971. During coring, the most revealing evidence of voids or fractures is a loss of drilling fluid and/or a sudden or rapid advance of the core barrel. At no time during the testing program was there any unaccountable fluid loss or abnormal tool advance in the marl. Very few joints or fractures were observed, and those identified were consistently found to be tight and without voids. Crosby, et al., ff. Tr. 253 at 14-15. More than 200 holes penetrated the marl and showed it to be a tight, calcareous clay of essentially constant thickness throughout the area. Farrell, Tr. 663-664.

32. Visual inspection and detailed logging and photographing of more than 500 feet of extracted samples of marl have likewise produced no indications of voids or extensive fracture zones. Marl that was exposed during excavation in the power block was examined directly and carefully logged by qualified geologists. This included more than 900,000 square feet of the upper surface of the marl in the power block excavation, more than 20,000 square feet of vertical face in the auxiliary building excavation, and more than 20,000 square feet in the radwaste solidification building caisson excavation. These extensive and detailed mapping investigations of the marl produced an abundance of data indicating an absence of voids, solution cavities, and systematic or extensive fractures or joint sets in the marl. Crosby, et al., ff. Tr. 253 at 15-16.

33. The report from the 1985 geotechnical verification work presented geologic drill logs for the new holes drilled into the marl, which provide evidence that the marl is continuous and lacks detectable paths for water to leak into the lower aquifer. Helier, et al., ff. Tr. 764 at 16. Staff testified as to additional evidence which also demonstrated the marl to be an effective and continuous aquiclude; the evidence is found in another report, "Vogtle Energy Generating Plant - Groundwater Monitoring program July-December, 1985" that was attached to a letter, dated February 6, 1986, from J. Baily to B. J. Youngblood at the NRC. Id., at 14-15.

34. The large and consistent hydraulic head differential between the water-table aquifer and the confined aquifer immediately below the marl confirms that the marl is a barrier to significant ground water movement. Crosby, et al., ff. Tr. 253, at 16. The hydraulic head or energy potential of ground water in an aquifer is commonly expressed in units of feet above sea level and is determined by measuring the elevation of water in an observation well. Ibid. Observation wells constructed in 1971, including two open to the marl itself and one each open to the confined and water-table aquifers, showed that in the vicinity of VEGP the hydraulic head in the water-table aquifer is 45 to 55 feet greater than the hydraulic head in the aquifer immediately below the marl. Ibid. These wells were monitored for four years until construction of the plant required their closure. Id., at 17.

35. In addition, two clusters of piezometers were installed in the power block in June and July of 1985 at opposite corners of the power

block; they provide a direct measurement of hydraulic head over the full depth of the marl. The differences in hydraulic head between piezometers within a cluster show a progressive decline in head with depth which is consistent with the results obtained from the observation wells installed in 1971.<sup>10</sup> Id., at 18.

36. The Board finds the data regarding the continuity of the marl to be adequate; they show that there are no voids, fissures, or fractures that would allow radioactive material which might get into the water-table aquifer as a result of an accidental spill at VEGP to move into the confined aquifers below the marl.

(4) The Direction of Ground Water Flow

37. Three ground water maps for the Vogtle area dated November 1971, March 1980, and December 1984 showed differences in the flow fields sufficient to suggest the possibility that flow fields under VEGP may shift and change. These maps led Intervenor to challenge Applicants' claim that ground water flow from the plant would be to the northwest, toward Mathes Pond; Intervenor alleged that flow could occur to the southeast and southwest as well. November 12 Order, at 23-24.

38. Because the marl will prevent significant vertical movement of contaminants through it, any migration of contaminants from an

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<sup>10</sup> Although Intervenor stated that this issue was addressed in § II.B of its proposed findings, it was not. Lawless PF, at 2.

accidental spill at VEGP would be predominantly lateral in the direction of the decreasing head in the water-table aquifer. Crosby, et al., ff. Tr. 253, at 21.

39. The November 1971 map shows ground water conditions prior to construction of the plant, with the highest ground water level of 162 feet south of the plant, and another high ground water level of 161 feet northeast of the plant. Both of these elevations are higher than the ground water level of 160 feet that is directly underneath the plant. These two ground water levels indicate a ridge in the ground water surface extending from northeast of the plant to south of the plant. If the plant were located astride the ridge, contaminants from a spill at the plant might flow in both directions. Staff testified that because the plant is located northwest of the ridge and ground water can only flow down-gradient, it is not possible for ground water to move from a level of 160 feet beneath the plant to a higher elevation along the ridge located south of the plant. Heller, et al., ff. Tr. 764, at 17.

40. The November 1971 map also shows that ground water levels west of the plant are even higher at an elevation of 165 feet; therefore there could be no flow in a westerly direction. Flow in a northerly direction is also impossible, because ground water would have to move from an elevation of 160 feet beneath the plant down to an elevation of 155 feet, and then back up to an elevation of 160 feet. Staff believes that the only direction ground water can flow from the plant is in a northwesterly direction. Id., at 18.

41. The March 1960 map suggests that the flow fields around the plant are directed back toward the plant, but this circumstance resulted from the effects of a temporary construction-related activity. The excavation of the power block extended well below the ground water level. To prevent sloughing of the excavation side slopes and to ensure dry, firm working conditions, the construction area was dewatered; the 1980 map reflects the effects of this dewatering program. The dewatering program was terminated once construction was completed.

Ibid.

42. The post-construction December 1984 map is similar to the pre-construction November 1971 map in that it suggests a ground water ridge extending from south of the plant to northeast of the plant. This result indicates that dewatering was a temporary condition and suggests that water table has returned to approximately the 1971 configuration. Id., at 19; Crosby, et al., ff. Tr. 253, at 22. Applicants' witnesses acknowledged, however, that changes in the water table due to construction preclude, at this time, a precise definition of its future configuration. Consequently, a flow path to the northeast cannot be unequivocally eliminated as a possibility. Id., at 31. But in any case, the ground water ridge running south to northeast will prevent ground water flow in a southerly direction. Id., at 23; Heller, et al., ff. Tr. 764 at 19; Farrell and Papadopoulos, Tr. 673-77; Gonzales, Tr. 774. Ground water records taken for a period of three years prior to

the start of construction indicated a persistent divide south of the site.<sup>11</sup> Papadopoulos, Tr. 675.

43. Ground water levels north and west of the plant are also lower than at the plant, but the gradients in those directions are flatter than the gradient toward the northwest. Heller, et al., ff. Tr. 764, at 19. Since ground water flow follows the path of least resistance, flow will be toward the northwest. Ibid. Ground water moving northwestward from beneath the power block would eventually reach Mathes Pond. Crosby, et al., ff. Tr. 253, at 23; Crosby, Tr. 401; Papadopoulos, Tr. 486. If radionuclides from a spill at the plant moved in ground water to Mathes Pond, their concentrations would be further diluted to below MPC levels for continuous routine releases as ground water slowly discharged into Mathes Pond and, subsequently, to the stream below Mathes Pond. Crosby, et al., ff. Tr. 253, at 23, 30-31.

44. If, on the other hand, flow is northeasterly rather than toward Mathes Pond, contaminants reaching the water table aquifer from the backfill would travel toward the Savannah River. Id., at 31. The discharge point would be on the bluff of the river at the head of a

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<sup>11</sup> On brief Intervenor argues that contaminants can move upgradient because of a hydraulic head and concentration gradient resulting from a spill. Lawless PF, at 19-20. Nothing in the record supports this claim, however. Intervenor also refers to Fig. 16 of Applicants' testimony which showed that in 1985 the ground water divide had shifted closer to the power block. Id., at 20. This shift is believed to be the temporary result of localized recharge cause by the addition of water to the area during placement of the backfill. Crosby, et al., ff. Tr. 253 at 22.

small tributary to the river. After discharging to the tributary, concentration of the spill would be diluted in the stream to below MPC levels. Id., at 32.

45. The Mathes Pond drainage has cut down to the marl, as have the other streams bordering the interfluvial ridge on which the plant is located, thus interrupting continuity between water-table aquifers. Ibid. Ground water in the water table aquifers on both sides of the streams and the pond discharges into the streams and the pond and does not cross them. Id., at 10, 23. Since the interfluvial ridge on which the plant is located is bordered by the streams and pond, the water-table aquifer beneath VEGP is hydraulically isolated. Ibid. Consequently a spill at the site flowing in any direction could not impair any domestic or other wells located beyond the streams that border the interfluvial ridge. Id., at 23. There is only one well on the interfluvial ridge that draws water from the water-table aquifer beneath VEGP; it is located approximately 1.7 miles south of the plant, however, and an accidental spill would not move in that direction. Ibid. The determination that flow is northwestward is based on 13 years of records, from 1971 to 1984, and those records suggest that the divide can be expected to exist for the life of the plant. Gonzales, Tr. 7/4.

46. The Board finds that the evidence shows that radioactivity from an accidental spill that gets into the water-table aquifer can be expected to move either northwestward and eventually enter Mathes Pond or northeastward and eventually enter the Savannah River. In either case, the contaminants would pose no threat to domestic or commercial



ground water supplies. Thus the issue of direction of ground water flow is satisfactorily resolved.

(5) Ground Water Travel Time

47. In its November 12 Order the Board acknowledged Intervenors' concern because Applicants and Staff had used a one-dimensional model to calculate ground water travel time, assuming the travel pathway to be the linear distance between point of spill and point of discharge, whereas at the Department of Energy's SRP across the river from VEGP a more realistic three-dimensional model has been recently developed for estimating ground water travel times. The Board noted that at VEGP the hydraulic gradient becomes very steep as Mathes Pond and the Savannah River are approached from the plant, and it wanted to know whether a three-dimensional model that could account for changes in flow velocity as the water table gradient changed would be superior to the one-dimensional model that had been used by Applicants and Staff.

48. The time required for ground water to migrate through the backfill toward Mathes Pond is determined by the permeability and porosity of the material and by the hydraulic gradient. The

relationship between these parameters in determining ground water seepage is expressed by Darcy's Law:

$$v = \frac{Ki}{n_e}$$

where  $V$  = seepage velocity (L/T),  
 $K$  = coefficient of hydraulic conductivity (permeability) (L/T),  
 $i$  = hydraulic gradient (ratio), and  
 $n_e$  = effective porosity (ratio).

Crosby, et al., ff. Tr. 253 at 18-19.

49. Applicants' witness Papadopulos addressed the foregoing question. Papadopulos, ff. Tr. 253. Papadopulos compared results calculated with a three-dimensional model with results calculated with the one dimensional model and showed that the one-dimensional model gave a smaller travel time because the linear pathway is shorter than the three-dimensional pathway. Id., at 2-4 and Figs. 1 and 2. Staff took a different approach, arguing that since travel time and sorption would reduce radionuclide concentration within the homogeneous backfill to below 10 CRF Part 20 limits by the time the contaminants left the backfill, the varying gradients between the site and Mathes Pond could be ignored.<sup>12</sup> Heller, et al., ff. Tr. 764, at 20-24.

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<sup>12</sup> Intervenor claims that Applicants assert "that the one-dimensional approach is ... more conservative because the flow path is longer" (emphasis added), goes on to argue that it would be more correct "to assert that flow path is shorter in a one versus a  
 (Footnote Continued)

50. The Board finds that the concern with regard to use of the one-dimensional model has been resolved by the foregoing testimony, which shows the one-dimensional model to be more conservative than the three-dimensional model. Therefore we shall proceed now with our evaluation of the estimates and testimony based on the one-dimensional model.

51. The backfill in the power block at VEGP is sand and silty sand compacted to an average of 97% of its maximum density. The permeability assigned to the backfill by Applicants was the maximum value measured in situ, 1220 ft/yr. Total porosity measurements of compacted backfill samples ranged from 31.6 to 37.6%, with an average of 34%. For sand and silty sand total and effective porosity are essentially the same. The hydraulic gradient in the backfill along the Mathes Pond flow path is  $3.5 \times 10^{-3}$ , but for conservatism it was rounded off to  $4.0 \times 10^{-3}$ . Crosby, et al., ff. Tr. 253 at 25-26. With these parameter values, Applicants estimated seepage velocity in the backfill, using Darcy's equation, to be 14.4 ft/yr. Using a flow path length of 550 feet, the ground water travel time in the backfill was estimated by Applicants to be 38.2 years. Id., at 26. Taking into account retardation due to

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(Footnote Continued)

three-dimensional model" (emphasis added), and concludes "it does not then follow that the one dimensional model is more conservative". Ibid. Intervenor appears to have mis-read the testimony of Dr. Papadopoulos, who testified "Since the linear distance  $l$  is shorter than the three-dimensional pathway  $d$ , the travel time calculated by the one-dimensional approach is smaller." Papadopoulos ff. Tr. 253, at 4.

radionuclide sorption, Applicants concluded that this travel time is sufficient to reduce the concentration of Sr-90 and Cs-137 spilled by rupture of the recycle holdup tank to below the maximum permissible concentration (MPC) limits of 10 CFR Part 20. Tritium, on the other hand, is not retarded; it would migrate with ground water travelling through the backfill and would exceed MPC limits. These three radionuclides are considered important because of their long half-lives. Id., at 27-29.

52. The Staff performed its own calculations with Darcy's Law, using somewhat more conservative parameter values. Staff assumed a permeability of 2260 ft/yr and an effective porosity of 25% but used the same hydraulic gradient and length of flow path as Applicants. The resultant ground water velocity through the backfill is 36.6 ft/yr and the travel time would be 15 years. SER, at 2-35. Staff assumed a rupture of the waste evaporator concentrate holdup tank and considered Co-60, Sr-90, Cs-134, and Cs-137. Ibid. Staff also assumed that once outside the backfill, radionuclides would travel rapidly through the Utley Limestone to a spring located at Mathes Pond. It conservatively ignored travel time through the Utley Limestone in calculating travel time to the spring. Id., at 2-34 and Fig. 2.9. Considering, then, a travel time of 15 years and the effects of sorption by soil and rock, Staff came to the conclusion that by the time the four radionuclides left the backfill, each would have a concentration that is a small

fraction of the MPC limits set by 10 CFR Part 20 and Part 100.<sup>13</sup> Id., at 2-36; Heller, et al., ff. Tr. 764, at 20-24.

53. As was mentioned, supra, tritium is not retarded and would travel with the ground water; given the postulated accidents, tritium concentration in ground water would exceed the MPC limits. Crosby, et al., ff. Tr. 253, at 29; Farrell, Tr. 306. If tritium migrated with ground water from the backfill and through the Utley Limestone to Mathes Pond, it would be further diluted in the pond and subsequently in the stream running from the pond to the Savannah River, so that its concentration would be below 10 CFR Part 20 limits before it flowed off-site. Crosby, et al., ff. Tr. 253, at 29-30. If, on the other hand, tritium migrated from the backfill and through the Utley Limestone to the Savannah River, it would be diluted by stream water as it moved in the tributary toward the river. By the time it entered the river,

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<sup>13</sup> Intervenor argues that Sr-90 is not retarded by sorption to the extent assumed by Applicants and Staff, citing the Final Environmental Impact Statement, L-Reactor Operation, Savannah River Plant (May 1984) (L-Reactor EIS), the Technical Summary of Groundwater Quality Protection Program at Savannah River Plant (December 1983) (Technical Summary), and a report concerning the Edwin I. Hatch Nuclear Plant. Lawless PF at 19. None of these documents is in evidence in this proceeding. Aside from that legal technicality, the two pages cited in the Technical Summary display maps, only, neither of which contains any reference to Sr-90, and the paragraph which discussed Sr-90 on the page cited in the L-Reactor EIS opens with the statement, "Strontium, unlike tritium, does not move at the same rate as ground water;...". The Hatch report was not available to us. Evidence in this proceeding indicates that Sr-90 is retarded by sorption as assumed by Applicants and Staff; therefore Intervenor's claim to the contrary must be rejected.

the concentration would be about half the MPC value, and after entering the river it would be diluted to a negligible concentration almost immediately. Id., at 32-33. If tritium migrated downward through the 38 feet of marl under the auxiliary building, the estimated travel time for it to reach the confined aquifer below would be 123 years, because of the low ground water velocity in the marl. Id., at 20. When it finally reached the aquifer below the marl, the tritium [which has a half-life of 12.26 years] would have decayed to acceptably low concentrations. Farrell, Tr 306.

54. We need not reach the question of whether the Staff's or Applicant's estimate of ground water travel time is the more acceptable, since the results from both show that radionuclide concentrations from the postulated accidents would be within MPC limits before migrating off-site. We find that ground water travel time is sufficiently low to assure that any radionuclides that might be released by a design basis accident into the water table aquifer under VEGP would be reduced to acceptably low concentrations, as a result of sorption, dilution, and radioactive decay, or a combination of these factors, before migrating off-site in ground water.

#### Settlement of the VEGP

55. Although not raised as an issue of material fact to be resolved at hearing, the Board permitted inquiry into a collateral issue regarding the impact that settlement of the VEGP would have on the grouted wells under the buildings in the power block. There are three grouted bore holes beneath the auxiliary building, eleven beneath unit 1

containment, three beneath unit 2 containment, and seven under the turbine building. West, Tr. 789-91. The issue is whether settlement might push the ground columns downward, causing slippage of the grout columns within the marl and thus opening a pathway for travel of contaminants. Tr. 713; Lawless ff. 720, at 6.

56. Lawless testified that the well grout columns are likely to be less compressible vertically than the more elastic marl and plant settlement would punch these well grout columns downward at a rate that might be different from the marl. Lawless Attachment, ff. Tr. 720, at 8. Applicants testified that the marl is actually more rigid than the grout columns. Crosby, Tr. 792. Moreover, slippage of the grout columns is very unlikely because the large surface area of grout in contact with the marl provides more than enough frictional area to prevent any movement. Crosby, Tr. 792-93. In addition, the unnamed sands under the marl are dense enough to resist punching of the grout columns into the lower sands. Crosby, Tr. 793; Papadopoulos, Tr. 805. Moreover, the plasticity of the marl would cause the marl to tend to deform and close any opening that occurred. Papadopoulos, Tr. 804-05; Crosby, Tr. 798.

57. Net settlement during the entire excavation, construction, and backfilling process has been about one inch. Crosby, Tr. 794. Net settlement is the difference between heave, which occurred before placement of the backfill, and gross settlement after placement of the backfill. At VEGP the heave was about three inches and the weight of

the plant plus the backfill caused a total settlement of about four inches. Crosby, Tr. 815-16; Heller, Tr. 776-77.

58. The Board finds the evidence shows that the grout columns under the building at VEGP will not move at a different rate than the marl, should there be additional settlement.<sup>14</sup> Therefore they pose no risk to the integrity of the marl beneath the power block.

#### Conclusions

59. Based on the evidence of record, the Board finds that Applicants have adequately explored the geology and hydrology at VEGP and in its vicinity. The thickness, permeability, and continuity of the Blue Bluff marl have been established and will protect the underlying aquifers from contamination should an accidental spill or a design basis accident occur at the plant. Further, the possible directions of ground water movement away from the plant and ground water travel time have been determined, and the results assure that a postulated spill would pose no threat to domestic or commercial water supplies. We also find

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<sup>14</sup> Additional settlement at VEGP is not expected to be significant, because backfilling is now 95% complete. Crosby, Tr. 794. Intervenor claims that the possibility of uneven settlement was raised in testimony. Lawless PF, at 28. Intervenor's citation, however, was to the opening statement read into the record by Mr. Tim Johnson when he withdrew his organization, Campaign for a Prosperous Georgia, from this proceeding. See: Tr. 229-240. Mr. Johnson's statement is not testimony. Moreover, the issue of continuing settlement at VEGP has already been resolved in this proceeding by our November 12 Order, where we found from the undisputed Affidavit of Walter R. Ferris (Sept. 7, 1985) that settlement at VEGP was essentially complete.



that settlement of structures overlying grouted wells could not result in the opening of flow paths for contaminants through the marl. Thus, we conclude that the issues regarding contamination of the water table and protection of the underlying aquifers by an accidental spill or a design basis accident are resolved. There is reasonable assurance that ground water used as public water supplies will not be contaminated by an accidental spill, including that resulting from a design basis accident, at VEGP. Contention 7 is without merit.

B. Environmental Qualification - Contention 10.1

Background

1. This contention asserts that VEGP safety-related equipment containing certain polymer materials identified in a report by Sandia National Laboratories (Sandia), and cited by Intervenor, has not been properly qualified because of possible dose rate effects dealt with in the report. (Dose rate effects refers to a phenomenon whereby radiation degradation of some materials may depend upon the rate of radiation exposure even though the total integrated dose remains the same.) In this contention Intervenor rely upon one Sandia report (NUREG/CR-2157, discussed below) for the proposition that dose rate effects can distort conclusions regarding the acceptability of polymer materials destined for use in the VEGP. That report gave results of tests on mechanical properties of these polymers, whereas their applications in VEGP also involve the integrity of electrical properties of some of the polymers. Subsequent Sandia work included testing of electrical properties.

Applicants' motion for summary disposition considered dose rate effects on mechanical properties of the polymers, as raised by intervenors in the contention, as well as the electrical properties of some of the polymers as appropriate to their VEGP applications. The motion generated no Intervenor response. The motion satisfactorily resolved the contention issues on dose rate effects on mechanical properties, and adequately explained Applicants' review of investigations of dose rate impacts on electrical properties, with the exception of certain mechanical and electrical issues that the Board found to have been inadequately addressed. Because of those issues, we denied the summary disposition motion (n. 2, supra). The issues were identified as follows:

- (1). Whether cross-linked polyolefin is the only polymer in question whose electrical properties were evaluated subsequent to radiation exposure.
- (2). What significance is to be derived from Duke Power Company's ten year cable surveillance program.
- (3). The scope and results of the mechanical stress tests on prototype VEGP cables.
- (4). The nature of Staff's requirement for an operational surveillance program, the status of Staff's approval of Applicants' submittal of a proposed surveillance program, and Staff's requirement for its implementation.
- (5). The Staff's reliance upon a future operational surveillance program rather than upon the prior environmental testing results described by Applicants.

Intervenor GANE offered no witnesses, conducted no cross-examination, and submitted no proposed findings on the contention. Applicants presented the following witnesses as a panel: Joel Kitchens, Mark L.

Mayer, Patrick R. Nau, Harold J. Quasny, and George Bockhold (hereinafter the testimony of Kitchens, et al., ff. Tr. 561) and the testimony of Bockhold and Quasny (Bockhold and Quasny, ff. Tr. 561). The Staff presented Armando Masciantonio (whose prefiled testimony is in evidence) as a witness (Masciantonio, ff. Tr. 576). The professional qualifications of these witnesses were found to be acceptable for giving expert testimony on the issues.

#### Discussion

2. The Staff described the reason for the environmental qualification of nuclear power plant equipment and identified the NRC's regulatory requirements for same. The purpose of environmental qualification at a nuclear power plant is to demonstrate that equipment used to perform a necessary safety function is capable of maintaining functional operability under all service conditions postulated to occur during its installed life. The qualification program must also demonstrate that the equipment in question is capable of the specific length of operating time required following an accident. Environmental qualification is normally achieved by subjecting a representative piece of equipment to a test program that simulates the expected environmental and service conditions the equipment will see during its installed life, followed by exposure to a simulation of design basis accident environment during or after which the equipment is required to operate. Exposure to the radiation generated by the normal operation of a nuclear plant represents an environmental condition that plant components and equipment must be qualified to endure. The higher radiation doses

associated with a design basis accident are not of concern with respect to dose rate effects, since accident radiation effects can be readily simulated. The regulatory requirements for environmental qualification are stated in General Design Criterion 1 and 4 of Appendix A and in Sections III, XI and XVII of Appendix B to 10 CFR Part 50. Specific requirements for environmental qualification of electric equipment important to safety are stated in 10 CFR 50.49. Masciantonio, ff. Tr. 550, at 5-7.

3. In June 1981, Sandia published a report, NUREG/CR-2157, entitled "Occurrence and Implications of Radiation Dose-Rate Effects for Material Aging Studies." The work reported therein dealt with laboratory studies of the mechanical properties of ethylene propylene rubber (EPR) and cross-linked polyolefin (XLPO), to be used in VEGP as electric cable insulation materials, and the mechanical properties of chlorosulfonated polyethylene (Hypalon) and chloroprene (Neoprene), to be used in VEGP as electric cable jacketing materials. These materials were stripped from cable samples and irradiated in air and nitrogen at radiation dose rates ranging from approximately 0.001 to 1.0 megarads per hour. Degradation of tensile properties (elongation and tensile strength) was measured; radiation dose-rate effects were found in all materials tested in air. Kitchens, et al., ff. Tr. 561, at 4-6, 8-9; Masciantonio, ff. Tr. 576, at 2-4.

4. The dose-rate effects on mechanical properties observed in these four polymers, however, are minor. Moreover, the differences in the rate of degradation caused by the various dose-rates decrease as the

total integrated dose decreases, and they are not discernible at the maximum total integrated doses these polymers could incur over 40 years of normal plant operation at VEGP. In the case of EPR and Hypalon, the reduction of tensile properties is virtually the same for all dose rates up to a total integrated dose of 20 megarads. In the case of Neoprene, the reduction is virtually the same for all dose rates up to a total integrated dose of 10 megarads. At VEGP, no safety-related equipment containing XLPO, EPR, Hypalon, or Neoprene, will receive a total integrated dose for 40 years of normal operation greater than 10 megarads, and most such equipment will receive less than two megarads. Thus for EPR, Neoprene, and Hypalon, the dose-rate effects reported in NUREG/CR-2157 are insignificant irrespective of polymer application. Kitchens, et al., ff. Tr. 561, at 9-10.

5. Of the four polymers tested by Sandia and reported in NUREG/CR-2157, only the sample designated as XLPO exhibited dose-rate effects that were discernible at total doses below 10 megarads. Id. at 10; Masciantonio, ff. Tr. 576, at 4. The term "XLPO", however, does not refer to a specific polymer, but instead refers to a group of cross-linked polymers that are based on aliphatic alkene monomers. Kitchens, et al., ff. Tr. 561, at 7. Cross-linked polyethylene (XLPE) is the polymer most often referred to generically as XLPO. Applicants learned from Sandia, however, that the polymer that was designated as XLPO in the Sandia study (NUREG/CR-2157) was a co-polymer of ethylene and vinyl acetate (EVA). Id. at 8.

6. Applicants stated that EVA is not used at VEGP in any safety-related equipment subject to a harsh environment. Nor can the results for EVA be used to predict similar effects in other cross-linked polyolefins. A later study by Sandia, released after Applicants' summary disposition motion was filed, evaluated dose-rate effects in XLPE. NUREG/CR-4358, "Applications of Density Profiling to Equipment Qualification Issues" (September 1985). Sandia evaluated the degradation of tensile properties of XLPE insulation at various dose-rates. The results demonstrate that dose-rate effects on tensile properties of XLPE are insignificant below 20 megarads total integrated dose. Id. at 10.

7. Applicants had assumed, for the purpose of their summary disposition motion, that the dose-rate effects reported in NUREG/CR-2157 for XLPO (which was EVA) were applicable to XLPE. The only safety-related application of XLPE, or of any other type of XLPO, subject to a harsh radiation environment at VEGP is cable insulation. To demonstrate that the dose-rate effects observed in XLPO did not compromise safety-related cable, Applicants described the results of another Sandia study demonstrating that degradation of the mechanical properties of XLPO insulation does not prevent the cable from performing its required electrical function. This particular Sandia study is reported in NUREG/CR-2932, "Equipment Qualification Research Test of Electric Cable With Factory Splices and Insulation Rework Test No. 2" (September 1982). For the results reported in NUREG/CR-2932, the XLPO materials that were tested consisted of XLPE. Electrical cable

insulated with these materials was exposed to radiation at a relatively low dose rate (0.062 megarads/hr) for a total integrated normal operational dose of 50 megarads/hr. Then, after elevated temperature aging, the cable was exposed to an accident dose of 150 megarads at a rate of 0.77 megarads/hr. Despite severe degradation of mechanical properties, the cable was able to perform its electrical function at all times. This series of tests was conducted according to industry standards (IEEE 323-1974 and IEEE 383-1974) and NRC guidelines (NUREG-0588). Sandia concluded that the methodology employed by the nuclear industry to qualify electrical equipment (which includes accelerated aging) is adequate. Id. at 11-12. We concur.

Issue (1)

8. Applicants testified that they are not aware of studies that evaluated dose-rate effects in the electrical properties of polymers other than XLPE after radiation exposure. The electrical properties of XLPE and EPR after radiation exposure have been evaluated in two additional Sandia studies, but these studies did not assess dose-rate effects. Id. at 12-13. However, Applicants and Staff noted that during environmental qualification testing, all safety-related cables undergo an insulation test after LOCA simulation. Id. at 13; Masciantonio, ff. Tr. 576, at 4. Thus, we find that the electrical properties (in this case insulating capability) of all polymers in question used as insulation are tested and we conclude that Issue A has been resolved to our satisfaction.

Issue (2)

9. In support of their prior summary disposition motion, Applicants noted that additional information regarding dose-rate effects may be obtained from a Duke Power Company study. Duke Power established an informal cable life evaluation program at its Oconee Nuclear Generating Unit 1, which became commercially operational in 1973. For this program, representative specimens of control, instrumentation and power cable were placed in selected locations within the reactor building so that they would be subjected to a normal in-containment environment. The cables were for the most part insulated with EPR and had Neoprene jackets. In addition, some samples were insulated with XLPE and covered with Neoprene jackets. For all cable samples, the average radiation exposure rate was 0.65 rads/hr during operation and 0.12 rads/hr when the unit was shut down. The actual exposure level that each sample received is considered to have varied considerably over the length of the cable dependent upon the exact location of the cable within the reactor building. These dose rates are quite low in comparison to rates used in the Sandia investigations, but are representative of the dose rates expected to occur at VEGP. Samples of these cables were removed after 5 years and again after 10 years of exposure. Physical and electrical tests were conducted to determine the degree of degradation of the cable components. In all cases, the cables were in good condition with no more deterioration observed than would be expected over a similar period in a non-nuclear environment. Kitchens, et al., ff. Tr. 561, at 13-14.



10. Applicants testified that the significance of the Duke Power Company's cable surveillance program is that a 10-year exposure to the low dose-rate radiation actually encountered in operating nuclear power plants has not done detectable harm to cables of the same general type that are to be used at VEGP. Furthermore, the results demonstrate that there will be plenty of time to benefit from operating experience gained from other plants and to take any necessary corrective action if significant dose-rate effects are identified. Id. at 14-15. This testimony establishes to our satisfaction that the Duke Power Company experience, although not ruling out dose-rate effects in VEGP, adds confidence that such effects will not rapidly occur. Thus Issue (2), we conclude, has been put to rest.

Issue (3)

11. Environmental qualification tests of cable types to be used at VEGP include a mechanical durability (or stress) test, applied to the cable samples following their exposure to the simulated normal and accident environmental conditions. All VEGP safety-related cables are given such tests, which comply with Section 2.4 of IEEE-383-1974. In pertinent part, the IEEE requirement states:

Upon completion of the LOCA simulation, the specimens should be straightened and recoiled around a metal mandrel with a diameter approximately 40 times the overall cable diameter and immersed in tap water at room temperature. While still immersed, these specimens should again pass a voltage withstand test for 5 minutes at a potential of 80 V/mil ac or 240 V/mil dc.

All specimens used to qualify each type of VEGP safety-related cables passed this test. Kitchens, et al., ff. Tr. 561, at 15-16. This

testimony explains the nature of the stress tests and reports the successful results therefrom. Hence we find that Issue (3) has been resolved to our satisfaction.

Issue (4)

12. In order to detect any unanticipated degradation, Applicants stated that prior to fuel loading at Unit 1 they will implement a maintenance and surveillance program to be employed over the lifetime of the plant. Bockhold and Quasny, ff. Tr. 561, at 2. Such a program derives from Regulatory Guide 1.33, Rev. 2 and its endorsement, in turn, of the more detailed guidance of the American Nuclear Society/American National Standards Institute standard ANS-3.2/ANSI N18.7-1976. This standard defines the scope and content of a maintenance/surveillance program for safety-related equipment that is acceptable to the Staff. Regulatory Guide 1.33 is acceptable to the Staff as a means of meeting the requirements of 10 CFR 50.49. Additional guidance is found in NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment." Masciantonio, ff. Tr. 576, at 5-6. The Applicants have submitted their proposed maintenance and surveillance program, which has been found to be satisfactory by the Staff. Applicants' witnesses Bockhold and Quasny stated that this program is described in Applicants' FSAR response to Staff question Q271.1 (September 6, 1983) and in Section 4.2 of "Environmental Qualification of Safety-Related Equipment Located in a Harsh Environment" (September 1985). In addition, their testimony also

summarizes the important features of that program. Bockhold and Quasny, ff. Tr. 561, at 2-7. The Staff stated that it will formally document its approval of the maintenance program in the Safety Evaluation Report prior to licensing the VEGP. Masciantonio, Tr. 579.

The Board has reviewed the Bockhold and Quasny testimony cited above and finds that, if implemented as planned, such a maintenance program will provide a means whereby unanticipated radiation degradation of polymer materials can be detected and remedied prior to compromising operational safety. The nature and intent of the Staff's requirement and the Applicants' response, along with the Staff's stated approval of that response cause us to find that Issue D has been dispositively addressed.

#### Issue (5)

13. Issue (5) notes that the Staff relies upon a future operational maintenance and surveillance program rather than upon the prior testing results described by Applicants. The matter was not explicitly addressed by Staff or Applicants. The Staff did state that its review of Applicants' testimony did not generate any exceptions or disagreements with that testimony. Masciantonio, Tr. 580. The Applicants' commitment to implementing a Staff approved maintenance and surveillance effort directed toward these polymers (approved by Staff and us, as discussed under Issue (4) above) provides assurance that safety related equipment will perform its intended function if needed. Thus, the silence of both parties on this difference in their approaches does not appear to us to be of material significance since each approach

provides the assurance required. We find that Issue (5) has been implicitly resolved.

### Conclusions

14. The full testimony of Applicants and Staff on Contention 10.1 is uncontroverted. We find that testimony to be correct and persuasive. The evidence addressed Intervenors' original challenge, limited in NUREG/CR-2157 to mechanical properties, and included the adequacy of the environmental testing of those polymers whose electrical properties are also of import to VEGP. Moreover, each of the litigable issues identified (II.1, above) has been addressed to the Board's satisfaction as discussed above. We find from the evidence that polymer materials destined for use in safety-related VEGP applications have acceptably passed an adequate environmental qualification program. Additional assurance as to the adequacy of these polymers will derive from an operational surveillance program to be implemented by Applicants. Accordingly, the Board concludes that Contention 10.1 is without merit and that Applicants have prevailed.

### III. Conclusions of Law

The Board has considered all of the evidence submitted by the parties in this proceeding on Contentions 7 and 10.1. Based upon a review of the record and the foregoing Findings of Fact on the two contentions, the Board concludes that:

1. As to the contentions addressed herein, there is reasonable assurance that, if operating licenses are subsequently granted to

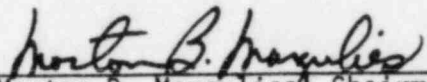
Applicants, the activities authorized thereby will not be inimical to the common defense and security, can be conducted without endangering the health or safety of the public, and that such activities will be conducted in compliance with applicable NRC regulations.

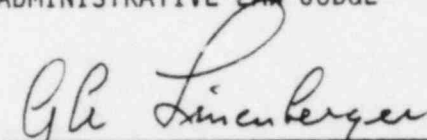
#### IV. Appeal

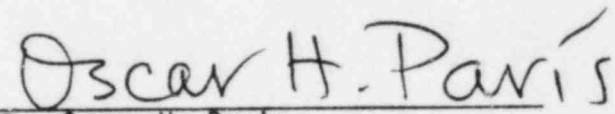
Although this decision does not authorize the issuance of licenses or resolve all contentions, i.e. Contention 10.5, it does resolve a major segment of the case and is therefore appealable at this time. Any party may take an appeal from this decision by filing a Notice of Appeal within ten (10) days after service of this decision. Each appellant must file a brief supporting its position on appeal within thirty (30) days after filing its Notice of Appeal (forty (40) days if the Staff is the appellant). Within thirty (30) days after the period has expired for the filing and service of the briefs of all appellants (forty (40) days in the case of the Staff), a party who is not an appellant may file a brief in support of or in opposition to the appeal of any other party.

A responding party shall file a single, responsive brief regardless of the number of appellants' briefs filed (See 10 CFR 2.762(c)).

THE ATOMIC SAFETY AND  
LICENSING BOARD

  
Morton B. Margulies, Chairman  
ADMINISTRATIVE LAW JUDGE

  
Gustave A. Linenberger, Jr.  
ADMINISTRATIVE JUDGE

  
Dr. Oscar H. Paris  
ADMINISTRATIVE JUDGE

Dated at Bethesda, Maryland  
this 27th day of August 1986.

V. APPENDIX: LIST OF WITNESSES

LIST OF WITNESSES

<u>Name</u>	<u>Position</u>	<u>Tr. Location</u>
<u>For Applicants:</u>		
George Bockhold, Jr.	General Manager, Plant Vogel Nuclear Power Operations, Georgia Power Company, Waynesboro, Georgia	561
Thomas W. Crosby	Engineering Geologist, Bechtel Civil and Minerals, Inc. San Francisco, California	253
Clifford R. Farrell	Engineering Geologist, Bechtel Civil and Minerals, Inc., San Francisco, California	253
Joel Kitchens	Assistant to the Chief Electrical Engineer, Bechtel Power Corporation, San Francisco, California	561
Mark L. Mayer	Nuclear Engineer, Bechtel Power Corporation, San Francisco, California	561
Patrick R. Nau	Coatings Engineer, Bechtel National, Inc., San Francisco, California	561
Stavros S. Papadopoulos	Ground Water Hydrologist, President of S. S. Papadopoulos & Associates, Rockville, Maryland	253
Harold J. Quasny	Equipment Qualification Supervisor, Bechtel Power Corporation, Norwalk, California	561
Lewis R. West	Hydrogeologist, Bechtel Civil and Minerals, Inc., San Francisco, California	253



LIST OF WITNESSES

<u>Name</u>	<u>Position</u>	<u>Tr. Location</u>
<u>For NRC Staff:</u>		
Raymond Gonzales	Hydraulic Engineer, Engineering Branch, Division of Pressurized Water Reactor Licensing, Office of Nuclear Reactor Regulation, United States Nuclear Regulatory Commission	764
Lyman W. Heller	Senior Task Manager, Engineering Issues Branch, Division of Safety Review and Oversight, Office of Nuclear Reactor Regulation, United States Nuclear Regulatory Commission	764
Armando Masciantonio	Mechanical Engineer, PWR-A Engineering Branch, Division of Licensing, Office of Nuclear Reactor Regulation, United States Nuclear Regulatory Commission	576
<u>For Intervenor GANE:</u>		
William F. Lawless	Assistant Professor of Mathematics, Paine College, Atlanta, Georgia	720