Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37379

December 5, 2000

10 CFR 50.54 (f)

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - UNITS 1 AND 2 - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION ON THE INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) (TAC NOS. M83674 and M83675)

Reference: NRC Letter to TVA dated August 2, 2000, "Sequoyah Nuclear Plant, Units 1 and 2 - Request For Additional Information On Individual Plant Examination Of External Events (TAC No. M83674 and M83675)"

The purpose of this letter is to provide our response to NRC's request for additional information relative to the above reference. On October 2, 2000, we provided our response to the "Fire Events" questions. The enclosure to this letter specifically addresses the questions related to "Seismic Events."

A011

If you have any questions about this change, please telephone me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

Pedro Salas
Licensing and Industry Affairs Manager

Subscribed and sworn to before me
on this 5th day of December

Notary Public

My Commission Expires Oct. 9, 2002

Enclosure
cc: See page 3

cc (Enclosure):

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ENCLOSURE

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNITS 1 AND 2

SEQUOYAH NUCLEAR PLANT (SQN) - UNITS 1 AND 2- RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION ON THE INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) (TAC NOS. M83674 and M83675)

RESPONSE TO SUPPLEMENTAL REQUEST FOR ADDITIONAL INFORMATION SEQUOYAH NUCLEAR PLANT (SQN) IPEEE SUBMITTAL

Seismic Question 1

In the SQN IPEEE, the review level earthquake (RLE) was characterized in a manner inconsistent with the intent of NUREG-1407. The intent of NUREG-1407 is that the RLE control motion for SQN (which is predominantly a rock site) should be specified at rock outcrop as the NUREG/CR-0098 median 5% damped spectral shape for rock, anchored to a PGA of 0.30g at rock outcrop. The SQN IPEEE appropriately specified the RLE spectral shape as the NUREG/CR-0098 median rock spectrum at rock outcrop, but inappropriately specified the RLE PGA of 0.30g as occurring at the soil surface. Since this split approach of specifying the control motion has resulted in a rock outcrop peak ground acceleration (PGA) of about 0.19g, rather that 0.30g, the RLE seismic demands may have been considerably underestimated. The correct RLE demands may potentially be a factor of 1.58 (i.e., the ratio of 0.30 to 0.19) times those determined in the SQN IPEEE. [Stated differently, actual component capacities may be only about 0.63 (i.e., the ratio of 0.19 to 0.30) times the capacities computed in the SQN IPEEE.] Hence, components having computed high confidence of low probability of failure (HCLPF) capacities as high as 0.47g in the SQN IPEEE may have actual HCLPF capacities less than 0.30g.

In addition to the residual heat removal heat exchangers and essential raw cooling water 480V motor control centers that were found in the SQN IPEEE to have HCLPF capacities less that 0.3g, Table 3.1.4-1 of the SQN IPEEE submittal identified 14 items having HCLPF capacities less that 0.40g, and 43 additional items that were not screened out. These findings were based on the RLE demands as discussed above. If appropriate RLE seismic demands were applied, it is expected that additional components would not be screened out, the unscreened components would be assessed as having lower capacities, and several additional components would be identified as not meeting the RLE. For example, the following seven components were found from Table 3.1.4-1 of the SQN IPEEE submittal to have (or potentially have) a HCLPF capacity only slightly greater than the RLE.

480V Shutdown Boards (HCLPF = 0.33g)
6.9kV Shutdown Boards (HCLPF = 0.33g)
480V Shutdown Transformer (HCLPF = 0.32g)
125V DC Vital Battery Chargers (HCLPF = 0.32g)
Main Control Room Air Handling Units (HCLPF = 0.31g)
Ice Condensers (HCLPF = 0.31g)
Auxiliary Building Roof Diaphragm (HCLPF > 0.30g)

For at least these essential safe shutdown components, it is expected that HCLPF capacities would be much lower than 0.30g if correct RLE demands were applied.

a) Please discuss the importance of these components in achieving safe shutdown for seismically-induced transient and small LOCA events involving loss of offsite power. Indicate and discuss what alternate paths for successful shutdown may exist that do not rely on these components. Please also discuss and identify safe shutdown components and human actions that would be affected by failure of the auxiliary building roof diaphragm.

b) For all components that are relied upon for safe shutdown in two success paths, please develop the appropriate RLE seismic demands for SQN in accordance with the intent of NUREG-1407 as clarified above. Please perform a screening assessment of the components based on the new seismic demands, and then evaluate the corrected component HCLPF capacities for all components that do not screen out. Please report results of the reevaluation, including component and plant HCLPF assessments, and any overall conclusions of the seismic IPEEE that may have changed as a result of this reanalysis.

Response

On March 29, 1996, TVA responded to NRC's "Request for Additional Information - Individual Plant Examination of External Events - Sequoyah Nuclear Plant Units 1 and 2 (TAC Nos. M8364 and M8365)" dated December 1, 1995, which included the issue of control motion. As a part of this response, TVA provided (1) technical justification to support the definition of control motion used in the IPEEE submittal, and (2) noted that the approach taken on control motion was developed and/or peer reviewed by individuals that also had key roles in the development of the Electric Power Research Institute (EPRI) Seismic Margins Assessment methodology. Our response concluded that:

> "The SQN IPEEE program complies with the intent of NUREG-1407 and EPRI NP-6041 in that the plant has been subjected to increased seismic demand resulting from the exceedance of the design basis Housner spectrum by the NUREG/CR-0098 spectral shape and from the use of updated structural models and analytical techniques. As noted in section 2 (page 2-10) of EPRI NP-6041, 'weakest-link elements are only found if one or more elements do not pass the review procedure at the selected SME level.' The RHR Heat Exchanger was identified as a low ruggedness item and modified. The increased seismic demand used in the IPEEE program is sufficient to result in the identification of vulnerable items. Increasing the seismic demand to higher levels would not change the ranking of items in Table 3.1.4-1 and Section 8.1 of the IPEEE Final Report."

The 1996 response demonstrated that the SQN IPEEE Program constitutes a seismic margins assessment of the plant, rather than a reanalysis at the SSE ground motion level.

In the response below TVA has reevaluated the IPEEE submittal results on the basis requested in the RAI, i.e., for an RLE defined as a NUREG/CR-0098 spectral shape anchored to a PGA of 0.30g at rock. The approach taken is to (1) first establish an appropriate RLE multiplication factor for converting the existing IPEEE submittal results to this revised seismic demand level, (2) reevaluate the components listed in Table 3.1.4-1 and Section 8.1 of the IPEEE submittal for the revised demand, (3) demonstrate that the component capacities established in the existing IPEEE submittal and the reevaluated capacities in this response have significant margin relative to the licensing basis, and (4) establish a revised plant capacity based on this demand level. This approach eliminated the need to identify alternate success paths for successful shutdown that do not rely on the seven listed components, as requested in item (a) of the RAI, based on adequate seismic margin being demonstrated. The importance of these components in achieving safe shutdown for seismically induced transients and small break LOCA events involving loss of offsite power is discussed in section 3.1.2 of the IPEEE submittal.

1. ***Appropriate Scale Factor for Assessing HCLPFs Using RLE anchored to 0.30g at Rock -***

   This RAI states that HCLPF values for a 0.30g RLE may be 1.58 times those reported in the SQN IPEEE submittal. The factor of 1.58 is based on the nominal ratio of PGAs for RLEs anchored to 0.30g and 0.19g, respectively. However, due to conservatism in the computation of seismic demand, a factor of 1.33 is more appropriate, as explained below.

   Section 3.1.3.4 of the IPEEE submittal and SQN IPEEE Calculation SCG-5M-0001, "IPEEE Methods and Time History Generation," describe the use of probabilistic methods to generate instructure response spectra (IRS). The probabilistic approach is widely used in probabilistic safety assessment (PSA) studies and is discussed in EPRI NP-6041 as an alternative approach for generation of IRS in seismic margin assessments. The fundamental aspects of the probabilistic approach are outlined below.

   - Input in each direction of motion is represented by an ensemble of 30 artificial time histories.
   - Each ensemble, and its associated 30 artificial time histories, is different from the other two ensembles.
   - Response spectra were produced for each of the time histories in each ensemble.

- For each direction of motion (i.e., for each ensemble) the 30 response spectra were compared to the target NUREG/CR-0098 median spectral shape anchored to 0.19g.
- As described in Section 3.1.3.4, time history scale factors were adjusted for each ensemble such that the 30 response spectra provided an 84^{th} percentile fit to the target NUREG/CR-0098 median spectral shape anchored to 0.19g.

Additional studies found in SQN IPEEE Calculation SCG-5M-0004, "Top of Soil Response Spectra at the Auxiliary Control Building Location" showed that further time history scaling was needed to provide 84^{th} percentile nonexceedance probability (NEP) responses at top of soil in the vicinity of the Auxiliary Control Building (ACB). The final scaling of the three ensembles yielded 84^{th} percentile NEP values of PGA for Components 1, 2, and 3 (i.e., Directions 1, 2, and 3) of approximately 0.22g, 0.235g, and 0.23g, respectively, rather than the target anchor value of 0.19g.

This conservatism in the PGA level in the ensemble time histories is qualitatively illustrated in Figure 3.1.3-12 (copy attached) of the IPEEE submittal. Therefore, the most appropriate factor for converting the HCLPF values presented in the IPEEE submittal to comparable values for an RLE anchored to 0.30g at rock would be the average PGA for the three components; or a conversion factor of 1.33.

2. ***HCLPFs Using RLE anchored to 0.30g at Rock -***

As requested in the RAI, Table 3.1.4-1 of the IPEEE submittal was reevaluated and nominal HCLPF values were computed for seismic demand based on control motion represented by an RLE anchored to 0.30g at rock outcrop. With one exception, these revised HCLPF values were computed using the RLE conversion factor described above. In other words, TVA did not recompute HCLPFs based on the specifics of each component; rather, the use of the conversion factor of 1.33 is sufficient for demonstration purposes because the PGA level does not vary significantly among the three directions of motion.

The exception is that the HCLPF value for the ACB Roof Diaphragm was reevaluated, as described below, based on the HCLPF established for the corresponding roof diaphragm for the Watts Bar (WBN) ACB during the WBN IPEEE Program.

ACB Roof Diaphragm -

Sequoyah IPEEE Calculation SCG-5M-0046, submitted in the 1996 RAI response, concluded that the HCLPF for the Roof

Diaphragm was > 0.30g based on modeling the roof slab as a finite length beam 223 feet by 83 feet on an elastic foundation, supported along its long axis by the A5 and A11 walls on the North and South sides. The SQN calculation based its failure mode on a shear friction approach that ignored the contribution of the concrete in calculation of a beam shear capacity. However, this failure mode was reevaluated when the WBN IPEEE Program was performed and determined to be excessively conservative. For the WBN evaluation the shear capacity of the slab was based on American Concrete Institute (ACI) 349 Section 11.8, "Special Provisions for Deep Flexural Members."

The HCLPF for the WBN ACB Roof Diaphragm was determined to be approximately 0.75g, and even that value was noted as being conservative. WBN is a focused-scope plant for which the RLE was defined at rock as a NUREG/CR-0098 spectral shape anchored to a PGA of 0.30g. Note that the NRC recently issued its Safety Evaluation, "Watts Bar Nuclear Plant, Unit 1 - Review of Individual Plant Examination of External Events (IPEEE) Submittal (TAC No. M83693)," on May 19, 2000. The SQN and WBN ACBs are based on the same design and are essentially the same with the exception of building elevations and rotation of building axis by 90 degrees. The slab and wall thicknesses and reinforcement are equivalent. Therefore, the ruggedness displayed by the WBN ACB Roof Diaphragm is also indicative of a similar ruggedness for the SQN ACB Roof Diaphragm. Consequently, the SQN ACB Roof Diaphragm is no longer considered a low capacity item for the SQN IPEEE Program.

The recomputed values for components with HCLPFs less than 0.30g are listed in Table 1. The reevaluation shows no change in the relative ranking of components as to capacity.

3. ***Component Capacities Relative to the Housner Licensing Basis Spectrum -***

The licensing basis for the Safe Shutdown Earthquake (SSE) for SQN is defined by a Housner spectral shape anchored at rock to a PGA of 0.18g horizontally and 0.12g vertically. Figure 1 shows the Housner spectrum for horizontal motion plotted against NUREG/CR-0098 spectral shapes anchored to 0.19g (as was used for the IPEEE submittal) and 0.30g (as requested in this RAI), all for 5-percent damping. This figure demonstrates the conservatism of the component capacities computed in the IPEEE submittal and in Table 1 relative to the licensing basis Housner spectrum. The tabulation below, taken from Figure 1, shows the exceedance factors (i.e., margin) of the NUREG/CR-0098 spectral shape anchored to 0.19g at rock, as used in the IPEEE submittal, relative to the Housner spectrum, especially in the critical

frequency range for assessing seismic damage potential of 2-10 Hz.

Exceedance Factors for RLE Anchored to 0.19g
Relative to the Licensing Basis Housner Spectrum

Frequency (Hz)	RLE at 0.19g Exceedance Factor
2	1.55
3	1.48
4	1.40
6	1.48
8	1.82
10	1.90
11	1.92
15	1.70
20	1.44
25	1.28
33	1.28[1]

1. Factor based on average PGA of 0.23g in each direction of motion for the ensemble of artificial time histories used to generate probabilistic instructure response spectra.

This tabulation shows that HCLPFs computed for components having fundamental frequencies in the 2-10 Hz range and for an RLE anchored at 0.19g (as in the IPEEE submittal) would have a minimum margin relative to the licensing basis of 40-percent, based on the exceedance factor of 1.4 at 4 Hz. The tabulation demonstrates conclusively that HCLPFs reported in the SQN IPEEE submittal have significant margin relative to the licensing basis Housner Spectrum.

4. *Conclusions -*

The reevaluation to establish HCLPF values for components, for seismic demand based on an RLE defined by a NUREG/CR-0098 spectral shape anchored to 0.30g at rock, is presented in Table 1 and shows no change in the relative ranking of components as to capacity. The revised HCLPF values were computed using the RLE conversion factor of 1.33 described above. In other words, TVA did not recompute HCLPFs based on the specifics of each component; rather, the use of this factor is sufficient for demonstration purposes because the PGA level does not vary significantly among the three directions of motion.

This reevaluation also shows that the ACB Roof Diaphragm is seismically rugged and is, therefore, no longer considered a low capacity item. As noted in Table 1, the limiting recomputed component HCLPF values range from 0.23g to 0.29g. Therefore, for an RLE anchored to 0.30g at rock, the plant HCLPF would be 0.23g and would be limited by the Main Control Room AHUs and the Ice Condenser System.

In conclusion, this response shows that the IPEEE Program demonstrates significant margin relative to the licensing basis of the plant.

TABLE 1
SQN IPEEE Program
Comparison of Limiting HCLPFs

Equipment Description	System/Function	Failure Mode	HCLPF Value per Original SQN IPEEE Submittal	HCLPF Value for RLE Anchored to 0.3g at Rock Outcrop
RHR Heat Exchangers	Decay Heat Removal	Anchor Weld	0.27g[1]	NA[1]
Auxiliary Bldg. Roof Diaphragm	Structural Pressure Boundary	Shear Capacity at Column Line Y	> 0.30g[2]	Not computed[2]
Main Control Room AHUs	Ventilation/HVAC	Anchorage	0.31g	0.23g
Ice Condenser	Post-LOCA Containment Cooling	Capacity of lattice frames, lower support structure, and top deck structure	0.31g	0.23g
125V Vital Battery Chargers	125V Vital Power	Function from Test	0.32g	0.24g
480V Shutdown Transformers	6.9kV Vital Electricity	Anchorage	0.32g	0.24g
480V Shutdown Boards	480V Vital Electricity	Structural Integrity	0.33g	0.25g
6.9kV Shutdown Boards	6.9kV Vital Electricity	Function from Test	0.33g	0.25g
Regenerative Heat Exchangers	Chemical & Volume Control	Support Column	0.36g	0.27g
480V Diesel Auxiliary Boards	480V Vital Electricity	Function from Test	0.37g	0.28g
480V Reactor MOV Boards	480V Vital Electricity	Function from Test	0.37g	0.28g
480V Control & Auxiliary Bldg. Vent Boards	480V Vital Electricity	Function from Test	0.37g	0.28g
480V Reactor Vent Boards	480V Vital Electricity	Function from Test	0.37g	0.28g
RHR Pumps	Residual Heat Removal	Anchor Weld	0.39g	0.29g

Notes:

1. The RHR Heat Exchanger was modified as a result of the IPEEE Walkdowns. HCLPF shown is based on capacity prior to modification. The modified Heat Exchanger is not considered a low capacity item.

2. The roof diaphragm is not considered a low capacity component, based on the findings of the Watts Bar IPEEE Program (see discussion).

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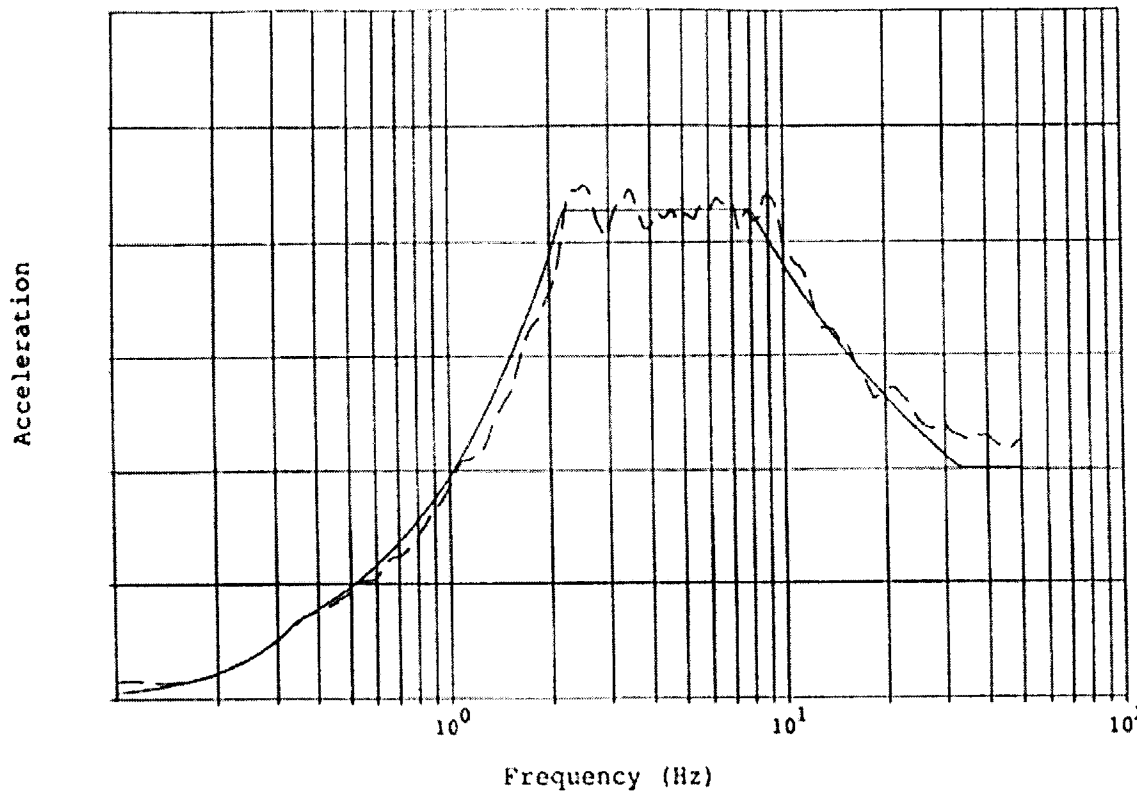

Legend:

Target M+SD Spectrum ————

Generated M+SD Spec. — — — — —

Notes:

Iteration #6

Target Median Scaled to 1.0g PGA

Accelarations in g's

5% Spectral Damping

Figure 3.1.3-12: Comparison of CR-0098 Rock Target Mean + one Standard Deviation Spectra to that generated for the 30 Time Histories: Sequoyah Nuclear Power Station, Component 2

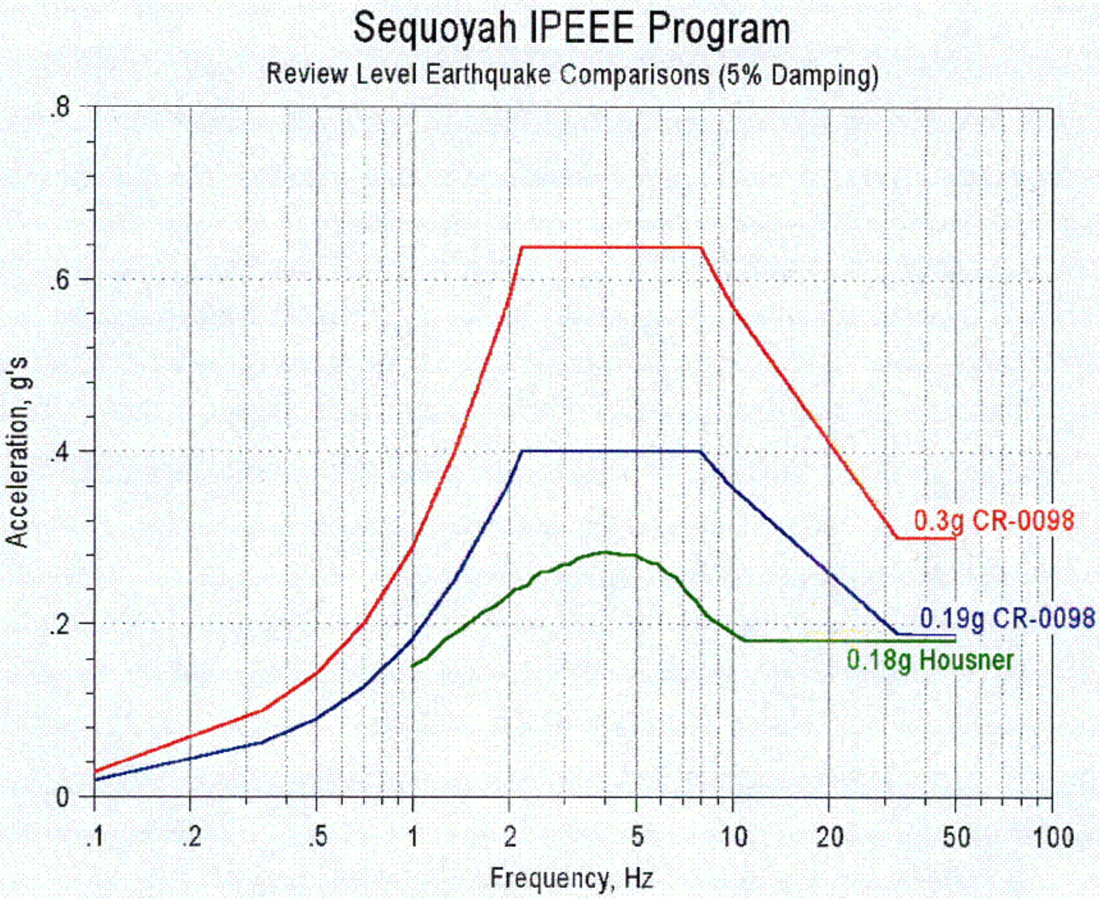

Figure 1
Comparison of NUREG/CR-0098 RLEs anchored to 0.19g and 0.30g
at Rock to the Sequoyah Licensing Basis Housner Spectrum