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Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-14-009

January 31, 2014

10 CFR 50.4

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Units 1 and 2
Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Watts Bar Nuclear Plant, Unit 1
Facility Operating License No. NPF-90
NRC Docket No. 50-390

Subject: **Response to NRC Request for Additional Information Related to Review of Potential Breaches of HESCO Modular Flood Barriers and Earthen Embankments Affecting the Updated Hydrologic Analysis Results for Sequoyah Nuclear Plants, Units 1 and 2, and Watts Bar Nuclear Plant, Unit 1**

References:

1. Letter from TVA to NRC, "Potential for Breaches of HESCO Modular Flood Barriers and Earthen Embankments Affecting the Updated Hydrologic Analysis Results for Sequoyah Nuclear Plant, Units 1 and 2, and Watts Bar Nuclear Plant, Unit 1," dated January 18, 2013 (ADAMS Accession No. ML13025A262)
2. Electronic Mail from NRC to TVA, "SQN 1 & 2 and WBN-1 - RAIs on TVA's Letter Dated January 18, 2013 (ADAMS Accession No. ML13025A262) - HESCO Flood Barriers and Earthen Embankments," dated July 23, 2013

By letter dated January 18, 2013 (Reference 1), Tennessee Valley Authority (TVA) submitted an analysis of the flooding levels for Sequoyah Nuclear Plant (SQN), Units 1 and 2, and Watts Bar Nuclear Plant (WBN), Unit 1, assuming potential breaches of the HESCO modular flood barriers and earthen embankments at Fort Loudon, Cherokee, Tellico, and Watts Bar Dams. The Reference 1 submittal also provided a summary of the flood level analysis for SQN, Units 1 and 2, and WBN, Unit 1. The flood level analysis assumes the HESCO modular flood barriers are not installed, and includes postulated failures of the earthen embankments if overtopped at Fort Loudon, Cherokee, Tellico, and Watts Bar Dams. The analysis supports TVA's decision to install the HESCO modular flood barriers in 2009.

On July 23, 2013, the NRC transmitted a request for additional information (RAI) by electronic mail (email) (Reference 2). The RAI forwarded four questions from the NRC's Mechanical and Civil Engineering Branch regarding the Reference 1 submittal. Enclosure 1 to this letter provides TVA's response to the RAI.

There are no new regulatory commitments included in this submittal. Please address any questions regarding this submittal to Edward D. Schrull at (423) 751-3850.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosure:

Response to NRC Mechanical and Civil Engineering Branch (EMCB) Request for Additional Information (RAI)

cc (Enclosure):

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Sequoyah Nuclear Plant
NRC Senior Resident Inspector - Watts Bar Nuclear Plant, Unit 1

ENCLOSURE

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2, AND
WATTS BAR NUCLEAR PLANT, UNIT 1

RESPONSE TO NRC MECHANICAL AND CIVIL ENGINEERING BRANCH (EMCB) REQUEST FOR ADDITIONAL INFORMATION (RAI)

Reference: Letter from TVA to NRC, "Potential for Breaches of HESCO Modular Flood Barriers and Earthen Embankments Affecting the Updated Hydrologic Analysis Results for Sequoyah Nuclear Plant, Units 1 and 2, and Watts Bar Nuclear Plant, Unit 1," dated January 18, 2013 (ADAMS Accession No. ML13025A262)

NRC RAI EMCB-RAI-1

With regards to the Computational Fluid Dynamics (CFD) Model for the Fort Loudoun and Tellico reservoirs, the Reference notes that the CFD model was developed to determine the likely movement that an uncontrolled barge would have during a Probable Maximum Flood (PMF) event. However, the Reference concludes, in the CFD model analysis section, that it is possible that the HESCO barriers could be approached by a simulated barge trajectory, but that the results should be considered indeterminate based on particle tracking results.

Please provide additional information regarding the particle seed location and the use of other post-processing results that lead you to reach this conclusion. Regarding the seed location, the response should describe if alternate seed locations were considered in the reservoir. Regarding other visualization/post-processing methods, please state if inverse particle tracking methods were considered for use. For example, inverse particle tracking techniques could be used to determine where the particles (i.e., barge surrogates) would need to originate (i.e., moored and released) in order to have them approach the HESCO barriers during the PMF event.

TVA Response - EMCB-RAI-1

As previously described in the Reference 1 submittal, a CFD model was used to predict the movement of large objects such as barges and other waterborne debris during a PMF event. The CFD model includes sections of the Tennessee and Little Tennessee Rivers near Fort Loudon and Tellico Dams. The model includes the channel and downstream portion of the Tennessee River past the confluence of the Little Tennessee River. The Tellico Reservoir has no commercial harbors or facilities, so no commercial river traffic is expected on the Little Tennessee River or through the Fort Loudon/Tellico Channel between the two reservoirs. As characterized in communication with representatives of the U. S. Army Corps of Engineers, actual barge traffic typically associated with small residential dock builders and rip-rapping, moves on the Little Tennessee River/Tellico Lake only on rare occasions.

Six release (seed) locations were simulated in the CFD Model. Four locations are on the Tennessee River (river mile (RM) 608.3, a first class harbor location between RM 608 and 609, a first class harbor location between RM 606 and 607, and a first class landing location at approximately RM 603). Two locations are on the Little Tennessee River (Little Tennessee River mile (LTRM) 3.5 and a first class harbor designated FCL_LTN located at approximately LTRM 3.0). In each case, 400,000 independent inertial particles, each representing a barge (or flotsam/jetsam), were released in order to determine the impact probabilities.

Results of the initial CFD model analysis, provided in Reference 1, concluded that HESCO barrier impact by uncontrolled barge traffic in the Fort Loudoun/Tellico Dam area would be possible, but stated that the results should be considered “indeterminate” due to modifications that were required in order to perform the flow simulation. The flow outlet at the Tellico Dam was enlarged slightly to provide more flow area which had a significant effect on the computed barge trajectories in the vicinity of the Tellico dam. So even though the trajectories were impacting a location defined to be a HESCO Concertainer wall, the small section of boundary is actually pulling water out of the domain. Therefore the projection that barges would impact the HESCOs was suspect.

Additional barge impact simulations, with enhanced modeling, have been performed since the Reference 1 submittal. Barge modeling is discussed in the response to EMCB-RAI-3. Since the random release location results provide another visualization aspect, the inverse particle tracking method was not considered for use.

Barges of various sizes and configurations from a grid covering the entire solution domain were released as well as the same six locations described in the Reference 1 analysis with the following results:

Release Location	**# of barge releases during a PMF**	**Barge Impacts (%)**
RM 608.3	397,000	0.0
FCH_TN1	302,000	0.0
FCH_TN2	377,000	0.0
FCL_TN	375,000	0.0
LTRM 3.5	202,000	0.18
FCL_LTN	298,000	0.35

As shown in the above table, there are two release locations from which barges could impact the HESCO Concertainers. The probability of HESCO Concertainer impact from either of these two release locations (both on the Little Tennessee River) was less than 0.5%.

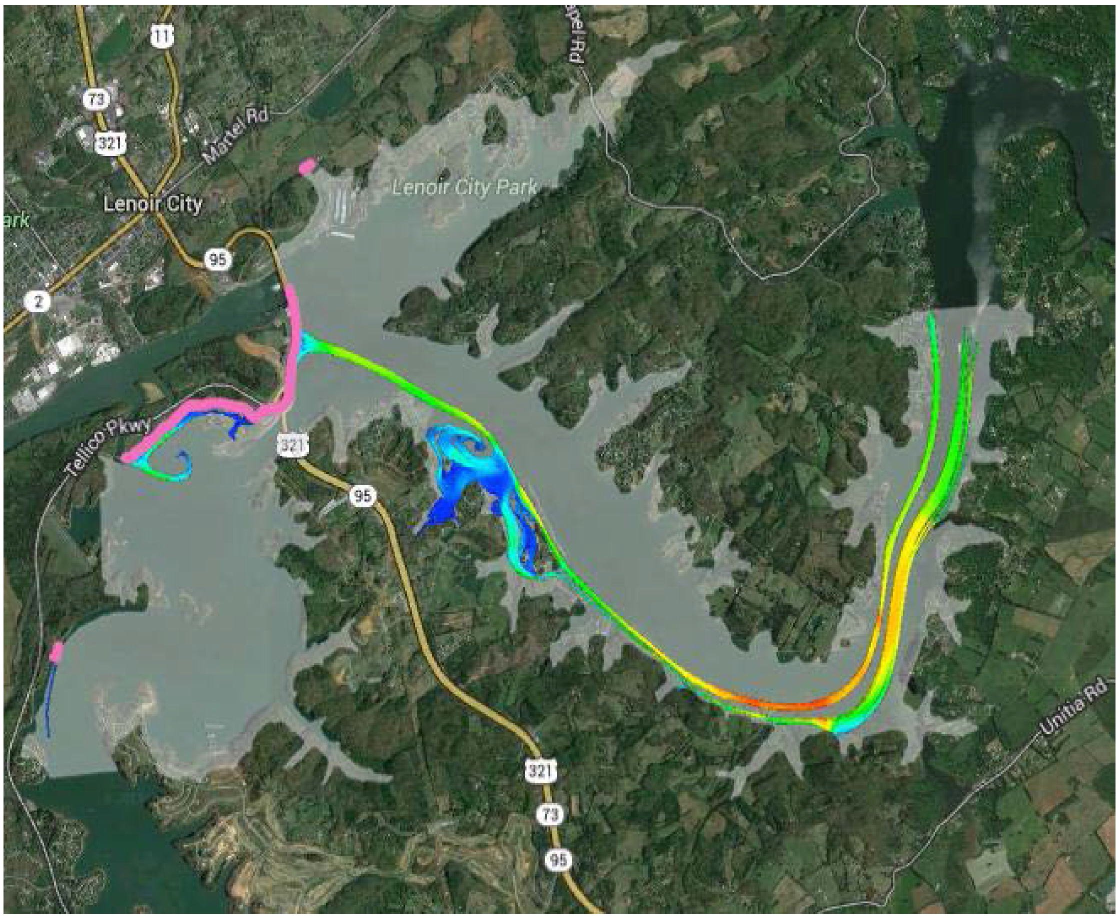
The barge impact study assumed a full (100%) PMF. The 95th percentile confidence probability of a full PMF is on the order of 1E-6 per year per Attachment 1. Therefore, the probability of a full PMF and a barge (of any size) strike during any given high water event is less than 0.5E-2 X 1E-6 = 5E-9.

In addition to the release simulations from the six previously described release points, simulations that released barges from random points covering the entire Fort Loudoun/Tellico area were also conducted. 350,000 barges were released in the configurations described in the table below. For these cases, a Cartesian grid was overlaid over the water surface and 50 meter by 50 meter cells were used as the release locations. Ten inertial particles were randomly distributed within each cell. These particles were released with the local fluid velocity. The probability of the HESCO Concertainers being impacted by the barges in these simulations was less than 1% as shown in the below table:

# of barge releases	**1,000 Ton Impacts (%)**	**15,000 Ton Impacts (%) *High Density***	**15,000 Ton Impacts (%) *Large Diameter***
350,000	0.71	0.92	0.41

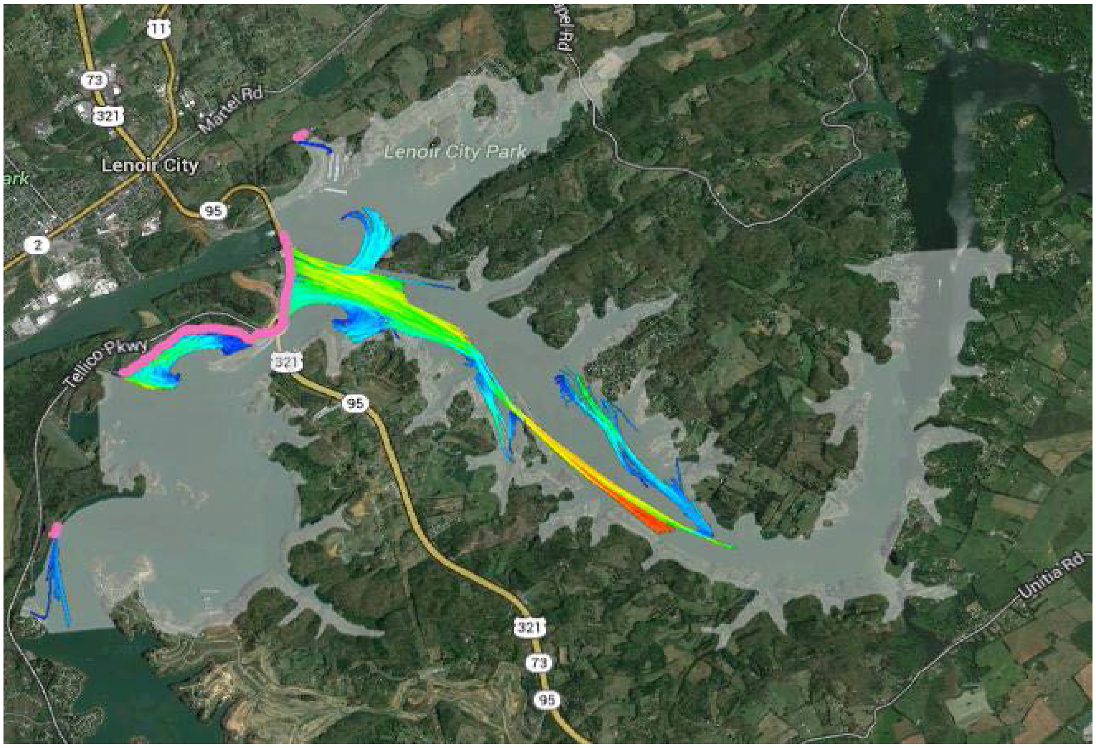
The following figures are a product of the random location simulations and provide a representation of barge origination locations that result in HESCO Concertainer impact in the enhanced simulation.

For the 1,000 ton barges, some releases near the inlet of the domain result in impacts on the HESCO Concertainers. These releases are close to the FCH_TN2 release point from which the analyses indicate no impacts would occur. The primary difference is the stream velocity associated with the simulated release. The release for the specified location (FCH_TN2) is associated with a zero velocity, while the random release location is associated with the local stream velocity.



1,000 Ton Barges - Random Release HESCO Concertainer Impacts
(Solid pink represents the HESCO Concertainers, other colors represent varying river velocities)

For the 15,000 ton barges (high density model), most of the trajectories that result in impacts on HESCO Concertainers originate in the middle of the river or are very close to the HESCO Concertainers themselves.



15,000 Ton Barges (High Density) HESCO Concertainer Impacts
(Solid pink represents the HESCO Concertainers, other colors represent varying river velocities)

Similarly, for the 15,000 ton barges (large diameter model), all of the barge trajectories that impact the HESCO Concertainers either originate midstream or are very close to the HESCO Concertainers themselves.

15,000 Ton Barges (Large Diameter) HESCO Concertainer Impacts
(Solid pink represents the HESCO Concertainers, other colors represent varying river velocities)

During a high water event, river traffic is controlled such that barges would be tied up at the identified First Class Landing harbor locations. Using the probability evaluation from above and a less than 1% probability of impact, the probability of a barge impact during a full PMF from an uncontrolled barge located anywhere in the Ft. Loudoun/Tellico area is on the order of 1E-8.

NRC RAI EMCB-RAI-2

The Reference notes that no bathymetry data was available for the Fort Loudoun/Tellico channel, between the two reservoirs when developing the model, and therefore the channel bottom was estimated to be 10 meters (m) below the pool level. Due to the high importance of this location in relation to the case model studies performed as part of the analysis, please provide additional technical information that documents the basis for selecting 10m as a bathymetry estimate between the channels. The response should clarify if a sensitivity study was performed as means of verifying the estimate and provide reasonable assurance that the bathymetry assigned to the model is conservative and appropriate for use.

TVA Response - EMCB-RAI-2

Where bathymetry data was absent, engineering judgment and knowledge of the surrounding topography was the basis for selecting 10 meters as the bathymetry estimate for the Fort Loudoun/Tellico channel bottom as described in the section explaining the adjustment of topology features. A sensitivity study was not performed to verify the estimate.

An additional barge impact study, with enhanced modeling, was performed since the Reference 1 submittal. In the new study, an estimated depth of 10 meters was also used for the demonstration of the mechanism used to raise or lower features in the topology where data was absent. However, actual bathymetry data taken from the silt ranges was used for the Little Tennessee River and the Fort Loudoun/Tellico channel modeling. The silt ranges approximate the Little Tennessee River bottom, including the channel connecting the two rivers, to range between 10 to 24 meters below pool level.

NRC EMCB-RAI-3

The Reference notes that the barges were modeled using a sphere whose wetted area equals that of a 195 foot(ft) barge with a width of 35ft and draft of 6ft. Furthermore, the Reference notes that the density of the sphere matches the laden weight of a barge weighing 1000 tons. The simulations use 1000-ton large objects to represent the barges. The 195 ft by 35 ft dimensions are typical for a single barge. However, commercial barges are frequently transported in groups and this has been acknowledged by TVA. Please clarify if the barges, once stationed at the docks, are also tied together. If a group of barges were not considered for the model, please provide additional information that documents why this approach was acceptable.

TVA Response - EMCB-RAI-3

Commercial barges transported on the Tennessee River are moved in groups and also tied together in transit and when stationed at the docks. The initial modeling simulated the movement of an individual barge (flotsam/jetsam), i.e., it assumed a 1000 ton barge broke away from the group and thus was able to float down the river.

The additional barge impact simulations discussed in EMCB-RAI-1 model two classes of barges. The first class is an isolated barge, using a sphere whose wetted area equals that of a 195 foot barge with a width of 35 feet. Sphere density was chosen to match the laden weight of the barge at 1000 tons. The second class is a flotilla of barges (fifteen 1,000 ton barges connected together) modeled in two different ways: 1) high density and 2) large diameter. In the high density group, the density of the sphere used for single barge simulation was increased by a factor of 15. The large diameter class models a 3-barge by 5-barge configuration and is used with the adjusted density of the sphere to account for the total weight of a barge train.

NRC EMCB-RAI-4

In Figure 19 of the Reference, it is not clear what the caption or the image is trying to convey. The caption states that 17% of the modeled sphere beaches [sic]. If this is assumed, then 83% of the modeled sphere would then continue in the flow path. However, a typical barge that is flowing uncontrolled would flow as a unit. Please clarify the perceived discrepancy in this analysis.

TVA Response - EMCB-RAI-4

In all CFD simulations in the Reference 1 submittal, 400,000 particles (simulated barges) were released from locations along the Tennessee or Little Tennessee rivers. The locations were "First-Class landings" where barges would tie off during large flooding events.

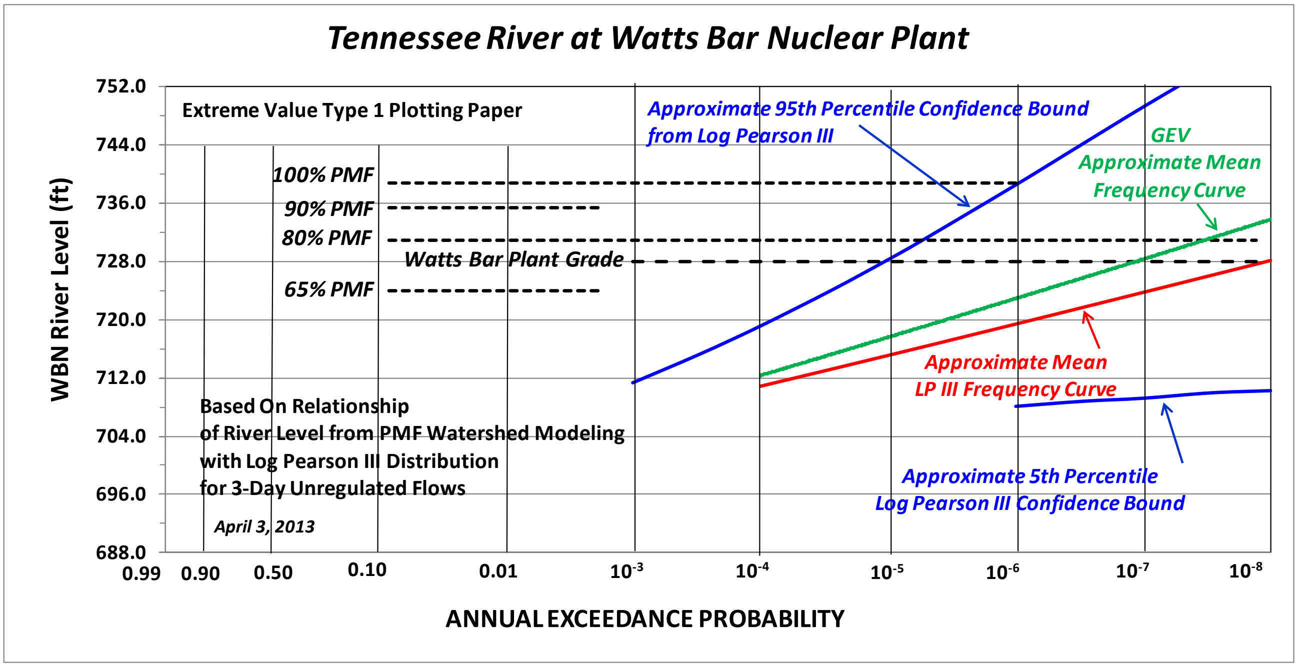
Figures 18 and 19 of Reference 1 represent the result of releasing those 400,000 particles (simulated barges). The results show that considering 400,000 (modeled spheres/particles) uncontrolled barges, none of the barges pose a threat to the HESCO barriers, with most of the barges (83% probability) impacting Fort Loudon Dam. The remaining barges (17% probability) are projected to beach on the shoreline adjacent to the first class landing at RM 603. Figure 18 (Reference 1) depicts the 83% that impact the dam and are entrained in the flow that naturally exits the dam, following the narrow streamline shown. Figure 19 (Reference 1) depicts the 17% that are projected to beach adjacent to the first class landing at RM 603.

Figures 18 and 19 in the Reference 1 submittal represent the release of 400,000 objects weighing 1,000 tons each from the first class landing near Fort Loudoun dam (approximately TRM 603) designated FCL_TN in the more recent enhanced simulations. The enhanced simulation released 375,000 particles from the same location and also concluded no impacts with the HESCO barriers would result (shown below).

Barge Trajectories (Release from FCL_TN)
(Solid pink represents the HESCO Concertainers, other colors represent varying river velocities)

Attachment 1

ATTACHMENT



Hydrologic Hazard Curve for Regulated Maximum River Level at the Watts Bar Nuclear Plant

Reference: "Development of Preliminary Hydrologic Hazard Curves for Levels on the Tennessee River at the Watts Bar and Sequoyah Nuclear Plants," MGS Engineering Consultants, Inc., April 9, 2013.