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

September 27, 2013

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

Subject: **Response to NRC Request for Additional Information Related to the Application to Revise the Updated Final Safety Analysis Report Regarding Changes to the Hydrologic Analysis for Sequoyah Nuclear Plants, Units 1 and 2**

References:

1. Letter from TVA to NRC, "Application to Revise Sequoyah Nuclear Plant Units 1 and 2 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, (SQN-TS-12-02)," dated August 10, 2012 (ML122260684)
2. Electronic Mail from S. Lingam (NRC) to C. D. Mackaman (TVA), "Sequoyah Nuclear Plant, Units 1 and 2 - Request for Additional Information Related to License Amendment Request to Updated Final Safety Analysis Report Changes Associated with Hydrological Analysis (TAC Nos. ME9238 and ME9239)," dated August 26, 2013

By letter dated August 10, 2012 (Reference 1), Tennessee Valley Authority (TVA) submitted an application to revise the Sequoyah Nuclear Plant (SQN), Units 1 and 2, Updated Final Safety Analysis Report to reflect the results from a new hydrologic analysis. The proposed changes included updated input information, and updates to the methodology that include the use of U. S. Army Corps of Engineers Hydrologic Modeling System and River Analysis System software.

On August 26, 2013, the NRC transmitted a request for additional information (RAI) by electronic mail (email) (Reference 2). The staff identified three RAIs resulting from the review of the license amendment request submitted in Reference 1. The RAIs originated from the Mechanical and Civil Engineering Branch (EMCB).

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The response to the RAIs is due by September 30, 2013. The enclosure to this letter provides TVA's response.

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.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 27th day of September 2013.

Respectfully,

J.W. Shea
Vice President, Nuclear Licensing

Enclosure:

Response to NRC Request for Additional Information Related to the Application to Revise the Updated Final Safety Analysis Report Regarding Changes to the Hydrologic Analysis for Sequoyah Nuclear Plants, Units 1 and 2

Enclosure
cc (Enclosure w/o attachment):

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Sequoyah Nuclear Plant

ENCLOSURE

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2

Section 2.4.2, Floods
EMCB RAI 2.4.2-1

As stated in Reference 1, the probable maximum flood at the plant site has increased due to the revised update of the hydrologic analysis for SQN Units 1 and 2. However, the coincident wind wave activity that was predicted to be 4.2 feet (ft) (through to crest) for the original analysis has remained the same under the revised conditions.

Please confirm and provide a technical justification that documents that the coincident wind wave values predicted to be 4.2 ft are still applicable for the revised hydrologic analysis, or provide revised coincident wind wave values.

TVA Response

TVA maintained the wind activity of 4.2 feet (trough to crest) that was calculated from the original hydrology analysis (circa 1979) based on a probable maximum flood elevation of 722.6 feet. Prior to the License Amendment Request submittal (Reference 1), the fetch lengths were evaluated using current topography data and the fetch lengths for the critical structures were found to be similar (within 0.04 mile) to those used in the original analysis. Therefore, the previously determined wind activity was not updated.

An additional study was recently completed on the wind data and fetch lengths to confirm the decision to maintain the original wind activity. The study of the wind wave data supported a lower overwater wind speed of approximately 32 miles per hour (mph) using data from January 2000 to December 2012. This value is lower than the current licensing basis value of 45 mph overwater wind speed which was maintained. The evaluation of fetch lengths was completed for each critical structure versus the original more general approach. This evaluation resulted in fetch lengths that slightly exceeded the 1.7 mile effective fetch length by 0.16 mile. However, when the updated fetch lengths are combined with the reduced overwater wind speeds, the result is a smaller wind wave activity. This evaluation confirmed the 4.2 feet (trough to crest) wave activity is conservative.

The table below provides a summary of the recent study of fetch distances for the critical structures.

	Effective Fetch (mile)	Over water wind speed (mph)	Wave Run-up (ft)	Wind Setup (ft)	Total Wind Wave Height added (ft)	Maximum Water Surface Elevation (ft)
Diesel Generator - Northeast	0.00	0.00	0.00	0.00	0.00	722.00
ERCW Pumping Station - Southwest	0.72	29.63	1.93	0.05	1.98	723.98
ERCW Pumping Station - Northeast	1.86	32.32	3.37	0.13	3.49	725.49
Shield Building- Southwest	1.13	30.71	2.53	0.08	2.60	724.60
Shield Building - Northeast	1.76	32.06	3.13	0.12	3.25	725.25

EMCB RAI 2.4.2-2

Reference 1 proposes to change the inputs for defining the antecedent precipitation index (API) using 11 years of historical rainfall records (1997-2007). The SQN Units 1 and 2 Updated Safety Analysis Report (UFSAR) Subsection 2.4.3.1 describes the current analysis for precipitation losses.

a) What is the range, in terms of years, of the historical data analyzed to determine the median API described in the current UFSAR analysis? If the proposed range of the historical data for the LAR is less than the data in the UFSAR, please provide a justification for using this new proposed range that demonstrates that the range selected for the proposed LAR is representative and relates precipitation excess to the rainfall, week of the year, geographic location and API.

b) Please explain and justify the selection of the year 2007 as the upper range of the revised historical rainfall records, otherwise, justify why the latest rainfall records were not used.

TVA Response

The median starting API value for this analysis was determined using the available on-line USGS stream flow data from 1997 to 2007. Variable median API values, ranging from 0.78 to 1.29, were used for this analysis as compared to a fixed median API value of 1.0 for the previous analysis. The variable median API values from 1997 to 2007 result in an area weighted value of 1.08 which is slightly more conservative than the previous fixed median starting API of 1.0.

The probable maximum flood analysis for SQN, Units 1 and 2 was originally completed in the mid-1970s with information that had been collected for TVA's flood control purposes. The rainfall-runoff relationships for the original analysis resulted in an approximate 11% precipitation loss during the main storm; the reevaluation of the data performed in the 2008-2009 timeframe verified that the precipitation loss still remains at approximately 11%. Slight differences in the antecedent storm were realized but when evaluating throughout the entire storm, the losses were consistent with the original analysis results. Additional history of the use of the API method is described below.

TVA met with the United States Weather Bureau (USWB) on May 30 and June 1, 1950 to discuss the USWB method of developing rainfall-runoff relationships. This method was described in an unpublished paper entitled "Predicting the Runoff from Storm Rainfall," by M.A. Kohler and R.K. Linsley. It was later published in September 1951 as a research paper. In 1951, a USWB natural flow river stage forecasting unit was opened in Knoxville, TN to; 1) provide predicted natural flows on uncontrolled streams to determine reservoir inflows necessary in the integrated operation of the TVA reservoir system, 2) supply TVA with predicted natural stream flows and stages for significant points on the Tennessee River and tributaries, for existing (pre-regulated) conditions, so that the controlled flood stages would be lower than the elevations obtained naturally (unregulated), and 3) prepare flood stage forecasts for those points on uncontrolled streams in the Tennessee Valley which are vulnerable to flood damage and in need of flood warning. A fundamental requirement needed to accomplish these assignments was to estimate surface runoff from storm rainfall. The USWB river stage forecasting unit developed the rainfall-surface runoff relationships in the 1950s as part of this task. The relationships were based on the antecedent precipitation index. The data used to develop the relationships was from the time period of 1937 to 1955.

Since that early development by USWB, TVA has continued to use this method to accomplish their federally mandated, integrated operation of the TVA reservoir system which includes flood control responsibilities. The information that was retrieved from the original hydrology analysis for SQN and other TVA nuclear plants indicated that only minor adjustments have been made to the API since TVA adopted the method with the original relationships remaining the same.

The verification of the API was completed by comparison with two other industry standard rainfall runoff relationships, the Soil Conservation Service (SCS) curve method and the Initial/Constant (IC) loss method. When compared to both these methods, the API method produces more conservative total runoff volumes. The API method accounts for a fixed volume available in the watershed for surface and infiltration losses, and transitions to 100% runoff for any increment of rainfall occurring above that volume. Because the antecedent precipitation for the Tennessee Valley is a large event as set forth in the hydrometeorological report (Reference 2), a 1:1 runoff-to-rainfall relationship occurs at the end of the antecedent storm and early in the main storm.

The ability of the API method to fit historical stream flow data was not reviewed directly but was compared against historical data used to develop the watershed unit hydrographs. This comparison demonstrated a good fit between historical and calculated data. The unit hydrographs were originally developed using historical flood data for a period ranging from the 1940's to the 1970's. For the hydrology analysis that supports this license amendment request, the original unit hydrographs were validated with the highest of two or more floods from a new range of data between the years of 1997 to 2007. This data range was chosen because high resolution, radar-based, hourly precipitation data was available for this period. The data was cut off in 2007 because the unit hydrograph validations were started in 2008 and completed in 2009, therefore the 2007 data was the latest available data.

In summary, although this analysis used only 11 years of data to determine the median starting API, this data compared well to previous work that was based on extensive data and was deemed appropriate for use.

Section 2.4.3, Probable Maximum Floods (PMF) on Streams and Rivers

EMCB RAI 2.4.3-1

Please provide additional information that clarifies the differences between the runoff model used in the previous analysis to determine the Tennessee River flood hydrograph (45 unit areas) to the proposed analysis (40 units), as described in Reference 1. The response should also include an expanded justification for the acceptability of the differences between the models.

TVA Response

The runoff model used in the previous analysis segmented the Clinch River watershed into six subbasins, with subbasin number 32 further broken into five smaller subbasins. This detailed refinement was completed for a proposed Clinch River Breeder Reactor in the late 1970s to early 1980s. Synthetic unit hydrographs were developed for this watershed area because detailed stream flow gage data was not available for these refined eleven unit hydrograph areas. For the analysis used to support this LAR, the additional refinement required of the Clinch River Breeder Reactor was not necessary and use of a single unit hydrograph developed and validated using observed flood data was judged to be a better runoff model.

An original single unit hydrograph was found within historic documents. The floods used in the original single unit hydrograph development were those of March 1967, December 1969 through January 1970, and March 1973. The flood inflows were obtained from reverse reservoir routing. The composite unit hydrograph was computed from the three floods using methodology proposed by Newton and Vineyard (Reference 3).

The original unit hydrograph was validated following the methodology described in ANSI/ANS-2.8-1992. With regard to verifying runoff models, ANSI/ANS-2.8, 1992 states the following:

> "Deterministic simulation models including unit hydrographs should be verified or calibrated by comparing results of the simulation with the highest two or more floods for which suitable precipitation are available."

The analysis that supports this license amendment request submittal has validated the original single unit hydrograph through use of observed flood data. The two floods selected for validation were the March 1973 and May 2003 events. The TVA Simulated Open Channel Hydraulics (SOCH) program was used for this validation together with Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS). The unit hydrograph was used with effective rainfall inputs to obtain inflow hydrographs for the two floods using HEC-HMS and used as inputs to the SOCH model. Using these inputs into the SOCH model, reasonably replicated the observed discharges for the two flood events.

In the analysis used to support this LAR, an additional change to the runoff model was an inclusion of a refinement at Hiwassee River. Hiwassee River was broken up into two separate subbasins, number 44a and number 44b, instead of a single subbasin. The original subbasin number 44 area for the lower Hiwassee River was 1,082.6 square miles (sq. mi.). Review of the available gage data showed a gage at Hiwassee River mile 18.9 which could be used in the revised analysis. Splitting the basin into number 44A

(686.6 sq.mi.) and number 44B (396 sq.mi.) allowed the direct validation of the UH for the larger sub-basin number 44A against gage data. This reduced the area draining to the Chickamauga Reservoir requiring validation using reverse routing and thus was a more accurate approach.

References

1. Letter from TVA to NRC, "Application to Revise Sequoyah Nuclear Plant Units 1 and 2 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, (SQN-TS-12-02)," dated August 10, 2012 (ML122260684)

2. NWS, Probable Maximum and TVA Precipitation Over the Tennessee River Basin Above Chattanooga, Hydrometeorological Report 41, US Department of Commerce, NOAA, Weather Bureau, June 1965.

3. Newton, D.R. and J.W. Vineyard, Computer-Determined Unit Hydrograph from Floods, Journal of the Hydraulics Division, ASCE, Vol. 93, No. Hy5, September 1967.