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TVA

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

November 27, 2012

10 CFR 50.54(f)

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

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: Tennessee Valley Authority (TVA) - Fleet Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the Flooding Walkdown Results of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident

References:

1. NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated March 12, 2012 (ML12053A340)

2. NRC Letter, Endorsement of Nuclear Energy Institute (NEI) 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features," dated May 31, 2012 (ML12144A142)

3. TVA Letter, Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding the Flooding Aspects for Recommendation 2.3 of the Near-Term Task Force (NTTF) Review of Insights from the Fukushima Dai-ichi Accident, dated June 11, 2012 (ML 12164A674)

On March 12, 2012, the NRC issued Reference 1 to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 4 of Reference 1 contains specific Requested Actions, Requested Information, and Required Responses associated with Recommendation 2.3: Flooding.

The Nuclear Energy Institute (NEI) subsequently developed guidance for the performance of flooding walkdowns, and the NRC endorsed this guidance on May 31, 2012 (Reference 2). On June 11, 2012, TVA provided a required response to item 1 in Enclosure 3 of Reference 1 (Reference 3), informing the NRC that it intended to perform the flooding walkdown in accordance with the NEI guidance.

TVA has completed the flooding walkdown in accordance with the NEI-12-07 walkdown guidelines. The purpose of this letter is to provide TVA's required response to Recommendation 2.3, item 2 in Enclosure 4 of Reference 1. Enclosure 1 to this letter provides a fleet wide assessment of the Browns Ferry, Sequoyah, and Watts Bar Nuclear Plants. Enclosure 2, 3, and 4 provide the plant specific results for Browns Ferry, Sequoyah, and Watts Bar. There were no areas that were unable to be inspected due to inaccessibility at the Browns Ferry Unit 1, Sequoyah, or Watts Bar Nuclear Plants. The main steam tunnel flood walls were unable to be inspected due to inaccessibility at Browns Ferry Nuclear Plant, Units 2 and 3.

Enclosure 5 to this letter contains a list of regulatory commitments. If you have questions regarding this matter, please contact Kevin Casey at (423) 751-8523.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 27th day of November 2012.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures

cc: See Page 3

Enclosures:

1. Fukushima Near Term Task Force Recommendation 2.3: Flooding Response Report - Fleet Assessment
2. Browns Ferry Nuclear Plant Fukushima Near-Term Task Force Recommendation 2.3: Flooding Response Report
3. Sequoyah Nuclear Plant Fukushima Near-Term Task Force Recommendation 2.3: Flooding Response Report
4. Watts Bar Nuclear Plant Fukushima Near-Term Task Force Recommendation 2.3: Flooding Response Report
5. Commitments

cc (Enclosures):

NRC Regional Administrator - Region II
NRR Director - NRC Headquarters
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
NRR Project Manager - Browns Ferry Nuclear Plant
NRC Senior Resident Inspector - Sequoyah Nuclear Plant
NRR Project Manager - Sequoyah Nuclear Plant
NRC Senior Resident Inspector - Watts Bar Nuclear Plant
NRR Project Manager - Watts Bar Nuclear Plant

ENCLOSURE 1

Fukushima Near-Term Task Force Recommendation 2.3: Flooding Response Report Fleet Assessment Report

1.0 Introduction

On March 12, 2012, the Nuclear Regulatory Commission issued a letter to all power reactor licensees and holders of construction permits in active or deferred status entitled "Request For Information Pursuant to Title 10 of the Code of Federal Regulation 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights From the Fukushima Dai-Ichi Accident." For Recommendation 2.3: Flooding, the NRC requested that licensees take the following actions:

(1) Perform flood protection walkdowns using NRC-endorsed walkdown methodology,
(2) Identify and address plant specific degraded, non-conforming, or unanalyzed conditions, as well as, cliff edge effects through the corrective action program, and consider these findings in the Recommendation 2.1 hazard evaluations, as appropriate,
(3) Identify any other actions taken or planned to further enhance the site flood protection,
(4) Verify the adequacy of programs, monitoring and maintenance for protection features, and
(5) Report to the NRC the results of the walkdowns and corrective actions taken or planned.

The NRC issued a letter on May 31, 2012 endorsing Nuclear Energy Institute (NEI) 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features". To conduct the walkdowns, TVA issued a corresponding document CTP-FWD-100 "Flood Protection Walkdowns NEI 12-07" to implement the endorsed industry guidance at its Browns Ferry, Sequoyah, and Watts Bar Nuclear plants.

The walkdown teams evaluated Watts Bar (WBN), Sequoyah (SQN), and Browns Ferry (BFN) in series. As the walkdown effort identified issues at WBN and subsequently at SQN and at BFN, TVA assessed the emerging deficiencies and observations for common themes and issues. TVA initiated a Fleet Flood Mode Operation Improvement Strategy to raise the performance of TVA's nuclear units with regard to flood mode operations. The early focus on the Fleet Strategy is on WBN and SQN which, as discussed in Enclosures 3 and 4, have significantly less warning time for design basis flood events than does BFN.

The fleet strategy is currently being developed and executed by a joint team from WBN, SQN, and TVA's Nuclear Power Group. The team consists of personnel experienced in plant operations, engineering, and licensing. Staff members from BFN are expected to be added in the near term.

2.0 Fleet Level Issues

As the team identified common themes and issues, corresponding corrective actions were identified and entered into the Corrective Action Program (CAP). Development of the Fleet Strategy is being tracked in the CAP. The Fleet Strategy is currently in draft and is expected to be issued as a Revision 0 Document by December 3, 2012. To date, the following issues are being tracked at a fleet level:

1) <u>Gaps Between Licensing Basis Documents and Implementing Documents</u>

The WBN and SQN Updated Final Safety Analysis Reports (UFSARs) have inconsistent strategy descriptions with regard to the amount of time required and/or available to prepare the plant for flood mode operation.

For example, section 2.4.14.9.4 of the WBN, Unit 1, UFSAR states:

> "...a minimum of 27 hours has been allowed for preparation of the plant for operations in the flood mode, three hours more than the 24 hours needed."

Section 2.4.14.9.4 of the WBN Unit 1, USFAR also describes the 27 hours allowed for the shutdown at the plant consists of a minimum of 10 hours of Stage 1 preparation and an additional 17 hours for Stage II preparation that is not concurrent with Stage I Activity.

The WBN UFSAR Section 2.4.14.4.3, Plant Preparation Time, states:

> "The steps needed to prepare the plant for flood mode operation can be accomplished within 24 hours of notification that a flood above plant grade is expected. An additional 3 hours are available for contingency margin. Site grading and building design prevent any flooding before the end of the 27 hour preflood period."

The SQN UFSAR Section 2.4A.8 Basis For Flood Protection Plan in Rainfall Events, states:

> "A minimum of 27 hours has been allowed for preparation of the plant for operation in the flood mode. An additional 4 hours for communication and forecasting computations are provided to translate rain on the ground to river elevations at the plant. Hence the warning plan must provide 31 hours from arrival of rain on the ground until critical elevation 703 could be reached. The 27 hours allowed for shutdown at the plant are utilized for a minimum of 10 hours of Stage 1 preparation and an additional 17 hours for Stage II preparation. This 27 hour allocation includes a 3-hour margin."

The SQN UFSAR Section 2.4.A.4.3, Plant Preparation Time, states:

> "All steps needed to prepare the plant for flood mode can be accomplished within 24 hours of receipt of the initial warning that a flood above plant grade is possible. An additional 3 hours are available for contingency margin before wave runup from the rising flood might enter the buildings."

During the review of the results of the walkdown activities, it was identified that the consideration of the three hours for contingency was not consistently reflected in the associated plant implementing procedures. As a result, the basis for demonstrating that the implementing procedures could be executed in the appropriate time frame was unclear. TVA has entered this issue into the CAP.

2) Flood Mode Operation Equipment Not Consistently Maintained In Manner That Ensures Reliable Operation During Flood Events

As discussed in Enclosures 2, 3 and 4, instances were identified at each plant in which equipment deficiencies existed. TVA concluded that, based on the number of issues identified across the fleet through these walkdowns, flood mode equipment reliability needed to be elevated for fleet-wide attention.

3) Flood Mode Implementation Procedures Not Maintained to Ensure Optimum Usage During Flood Events

As discussed in Enclosures 2, 3 and 4, issues were identified with the flood mode implementation procedures. These issues included instances of (1) little demonstrated margin between the time required to implement procedures as identified by the walkdown reasonable simulations and the time specified for flood preparation in design and licensing basis documents and (2) opportunities for added clarity and efficiency in the procedures. As a result, TVA concluded flood mode procedure construction and implementation needed to be elevated for fleet-wide attention.

4) Flood Mode Operation Tools Not Designed for Optimum Implementation

As discussed in Enclosures 2, 3 and 4, instances were identified in which the accessibility to and ease of installation of equipment required to implement flood mode operations could be improved. As a result, TVA concluded flood mode equipment implementation needed to be elevated for fleet-wide attention.

3.0 Flood Mode Operating Improvement Strategy

To address these issues, TVA's draft Flood Mode Operation Improvement Strategy includes three principle components:

1) Flood Mode Preparation Engineering Analysis and Modifications

In order to facilitate transition to flood mode operation, TVA evaluated potential changes to WBN and SQN with an emphasis on analysis and modifications associated with reducing implementation time of Stage II of the flood preparation phase. (Consideration of flood preparation plant modifications and analysis, as necessary, for BFN is expected to be assessed subsequent to preliminary work on WBN and SQN modifications)

One of the principal insights gained from the walkdown activities was the time critical nature of the installation of a number of piping spool pieces during the Stage II phase. These piping spool pieces are short length flanged pipe stubs that are 20”, 16”, and 3” diameter for WBN and 16” and 6” diameter for SQN. TVA is focusing on improving the Stage II performance time and expects to assess the merits of modifying the spool pieces as a means to accomplish this goal. Other modifications may be considered as the Flood Mode Operation Improvement Strategy is fully developed. Additionally, implementation of Stage II at SQN is limited by a requirement for minimum operation of shutdown cooling before flood mode cooling can be accomplished; analysis of this requirement is expected to provide additional margin for Stage II preparation.

2) Flood Mode Procedure Improvement Plan

In order to facilitate more efficient transition to flood mode operation, TVA evaluated potential procedure improvements at WBN and SQN with emphasis on improvements to reduce the Stage II implementation time. Flood Mode preparation is divided into two Stages (Stage I warning (10 hours) and Stage II plant preparation (17 hours)). The governing WBN procedure is AOI-7.01, "Maximum Probable Flood," and the SQN procedure is AOP-N.03, "External Flooding." Both procedures refer to additional Maintenance Instructions for the performance of specific tasks.

The reasonable simulations performed for the AOI-7.01 and AOP N.03, at WBN and SQN respectively, demonstrated that the procedures can be completed in less than 27 hours at each facility. The reasonable simulations were performed in several steps which ultimately resulted in this demonstration. However, as discussed in Section 2.0 above, the licensing basis does not have clarity as to whether the procedure is required to be completed in 24 hours or 27 hours.

TVA then performed a detailed Microsoft Project analysis of the timeline of the procedures for both sites to determine the critical path during Stage II procedure actions to identify where efficiencies could be gained in procedure enhancements. The procedure analysis was iterative in that when time was gained for one critical path task, the critical path was re-examined to determine the next most limiting critical path.

As a result, evaluations are underway at WBN and SQN to assess:

- Improvements to the flood mode procedures to reduce the time required to reliably implement Stage II preparation actions and establish margin to the 17 hour duration describe in the licensing basis
- The need for staff initial and continuing training in flood mode preparation actions
- Improved labelling of flood mode equipment to facilitate performance of the procedures

In addition, a joint review between WBN, SQN, and TVA corporate nuclear offices is planned to evaluate procedural differences between the sites for several key flood mode transition actions.

3) Flood Mode Equipment Reliability Plan

As part of the TVA Fleet Flood Mode Operation Improvement Strategy, TVA is establishing a Fleet-wide Flood Mode Equipment Reliability (ER) Improvement Plan. The following initiatives are being considered for inclusion in the plan:

- Equipment Identification and Classification:

  This initiative is intended to validate that Flood Mitigation Equipment has been classified to reflect the correct level of importance of the equipment. This measure affects the treatment of maintenance priority for deficient and corrective maintenance and the application of preventive maintenance for the equipment.

- Equipment Assessment:

  This initiative is intended to ensure that existing material condition issues for the affected equipment have been identified and correctly prioritized in the Work Control process for correction. Furthermore, this phase would verify that the correct priority for the related deficient and corrective maintenance is assigned to ensure proper placement in the cycle plans.

- Long Term Equipment Reliability:

  In concert with the changes in ER Classification, this initiative is intended to ensure that the affected equipment is appropriately incorporated into TVA's existing Long Term Equipment Reliability processes. This would include verifying the correct application of Preventative Maintenance (PM) templates, incorporation of any significant issues or improvements in the Long Term Asset Management database and Plant Health process, and incorporation into the site Long Term Major Maintenance Plans, as appropriate.

- Infrastructure:

  This initiative is intended to determine if any changes to fleet infrastructure, including organization and resources, is required to ensure that the flood mode operation Equipment Reliability initiative are implemented and maintained in a manner consistent with the importance of the equipment.

ENCLOSURE 2

Fukushima Near-Term Task Force Recommendation 2.3: Flooding Response Report
Browns Ferry Nuclear Plant Report

1.0 INTRODUCTION

On March 12, 2012, the Nuclear Regulatory Commission issued a letter to all power reactor licensees and holders of construction permits in active or deferred status entitled "Request For Information Pursuant to Title 10 of the Code of Federal Regulation 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of the Near-Term Task Force Review of Insights From the Fukushima Dai-Ichi Accident." For Recommendation 2.3: Flooding, the NRC requested that licensees take the following actions:

(1) Perform flood protection walkdowns using and NRC-endorsed walkdown methodology,
(2) Identify and address plant specific degraded, non-conforming, or unanalyzed conditions, as well as, cliff edge effects through the corrective action program, and consider these findings in the Recommendation 2.1 hazard evaluations, as appropriate,
(3) Identify any other actions taken or planned to further enhance the site flood protection,
(4) Verify the adequacy of programs, monitoring and maintenance for protection features, and
(5) Report to the NRC the results of the walkdowns and corrective actions taken or planned.

The NRC issued a letter on May 31, 2012 endorsing Nuclear Energy Institute (NEI) 12-07, "Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features". To conduct the walkdowns, TVA issued a corresponding document CTP-FWD-100 "Flood Protection Walkdowns NEI 12-07" to implement the endorsed industry guidance. A walkdown team was established with personnel knowledgeable in hydrology, Browns Ferry Nuclear Plant (BFN) design criteria, and operational procedures. The team was trained for walkdowns using the industry standard training module on the INPO NANTEL website. The team was also trained on TVA procedure CTP-FWD-100 and NEI 12-07 and site-specific requirements for performance of walkdowns.

As described in Section 2.0 and 3.0, BFN is designed to remain watertight against floods that exceed plant grade. The flood walkdowns reviewed procedures, tools and components required to maintain the plant safely during a design basis flood. The walkdowns included components and tools associated with flood response procedures, penetrations, and observations of the site drainage paths. Reasonable simulations were performed to evaluate flood response procedures.

As a result of the walkdowns and simulations, items were entered into the corrective action program to address potential deficiencies in flood response operating or maintenance instructions and flood protection features. The report did not identify any degraded non-conforming conditions with regard to flood protection features not previously identified.

2.0 DESIGN BASIS FLOOD HAZARDS

2a - Describe the design basis flood hazard level(s) for all flood-causing mechanisms, including groundwater ingress.

The BFN design basis flood hazards for all flood-causing mechanisms, including groundwater ingress, are described in BFN Units 1, 2, and 3 Updated Final Safety Analysis Report (UFSAR) Subsection 2.4.2.2.3 and Appendix 2.4.A.

The current licensing basis for maximum possible flood at BFN is calculated to reach elevation 572.5 ft. This is the flood which defines the upper limit of potential flooding at the plant. A maximum flood elevation of elevation 578 ft. at the plantsite results from a combination of the maximum possible flood and wind wave runup on a vertical wall. The plant could possibly be flooded by the Tennessee River, by a small stream northwest of the plant, and by intense local storms which overtax the site drainage system. Each situation has been examined and is discussed separately in BFN Units 1, 2, and 3 UFSAR Appendix 2.4.A. Determination of the peak flooding levels resulting from the limiting seismically-induced dam failure combination is not required by the BFN Units 1, 2, and 3 licensing basis. Other possible flood-causing mechanisms have been evaluated in the BFN Units 1, 2, and 3 UFSAR and found to not be credible, including probable maximum surge and seiche flooding, probable maximum tsunami flooding, and ice effects.

Consistent with the description of revisions to the flood hazard design and licensing basis discussed in Enclosures 3 and 4 for SQN and WBN respectively, the design basis flood hazards described in BFN UFSAR Section 2.4 and Appendix 2.4.A are in the process of being revised and implemented in accordance with 10CFR50.59 to adopt a revised hydrologic analysis for the BFN Units 1, 2, and 3 site, consistent with the latest approved calculations. The changes in the updated hydrologic analysis include updated input information, and updates to methodology which includes use of the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System (HEC-HMS) and River Analysis System (HEC-RAS) software. However, the most recent calculated PMF and wind wave runup elevations remain lower than the elevations of 572.5 ft and 578 ft in the current BFN UFSAR, so the design and licensing basis elevations will not be revised. Therefore, the flooding evaluation report is based on the current PMF and wind wave runup elevations of 572.5 ft and 578 ft, respectively.

Probable Maximum Precipitation (PMP)

As described in BFN Units 1, 2, and 3 UFSAR Appendix 2.4.A, PMP for the watersheds above Wheeler and Guntersville Reservoirs has been defined for TVA by the Hydrometeorological Branch of the National Weather Service. Three basic storm situations have the potential to produce a maximum flood at BFN. These are (1) storms producing maximum rainfall on the 21,400-square-mile watershed above Chattanooga, (2) storms centered and producing maximum rains in the basin to the west of the n Divide and above Chattanooga, hereafter called the 7,980-square-mile storm, and (3) storms producing maximum rainfall on the 16,170-square-mile watershed above Wheeler Dam and below the major tributary dams.

Estimates of PMP for the watershed above Chattanooga are fully defined in Hydrometeorological Report No. 41, “Probable Maximum and TVA Precipitation Over the Tennessee River Basin Above Chattanooga,” published in June 1965. PMP depths for the

21,400-square-mile watershed above Chattanooga are tabulated below. This storm would occur in March. Two possible isohyetal patterns producing these depths are presented in Hydrometeorological Report No. 41. The pattern critical to this study is the “downstream pattern.”

PMP depths for the 7,980-square-mile storm contained in the tabulation below would also occur in March. The isohyetal pattern for this storm is not orographically fixed and can be moved parallel to the long axis northeast and southwest along the valley. Depths for the full watershed above Wheeler Reservoir in these patterns were obtained by extrapolation of the isohyetal pattern in accordance with recommendations made by National Weather Service personnel and are somewhat less than the tabulated values.

PMP depths for the 16,170-square-mile watershed above Wheeler Dam but below the major tributaries are contained in an open file report entitled “Probable Maximum and TVA Precipitation Estimates for the Browns Ferry Project," issued March 1969 with minor revision by letter dated July 2, 1969. PMP depths for the 16,170-square-mile watershed are also tabulated below. The isohyetal pattern and depths are for a storm centered within 35 miles of Nickajack Dam.

A 72-hour storm three days antecedent to the main storm was assumed to occur in all PMP situations with storm depths equivalent to 40 percent of the main storm outlined in Hydrometeorological Report No. 41.

Basin Depth, Inches

Storm	72-Hour		Main Storm	
Square Mile	Antecedent Storm	6-hour	24-hour	72 hour
21,400	6.7	5.03	11.18	16.78
7,980	8.1	7.02	14.04	20.36
16,170	7.2	5.7	12.2	18.1

Precipitation excess resulting from the PMP storm was computed using multivariable relationships developed and used in the day-to-day operation of the TVA system. These relationships, developed from a study of flood records, relate the amount of precipitation excess expected from a given storm rainfall to the week of the year, an antecedent precipitation index (API), and geographical location. The relationships are such that the subtraction from rainfall to compute precipitation excess is greatest at the start of the storm and decreased to no subtraction when the storm rainfall totals from 7 to 16 inches, depending upon antecedent moisture conditions, week of year, and location. This variation causes precipitation excess to equal rainfall in the late part of extreme storms.

Enough storm arrangements including different centerings and consideration of dam failures were investigated to ensure selection of the arrangement which would produce the maximum possible discharge and elevation at BFN. The critical PMP storm was determined to be the 7,980-square-mile storm pattern centered at Bulls Gap, Tennessee (50 miles northeast of Knoxville), which would follow an antecedent storm commencing on March 15. The antecedent storm would produce an average precipitation of 5.5 inches on the Wheeler basin, would be followed by a three-day dry period, and then by the main storm which would produce an average precipitation of 13.6 inches in three days.

Median moisture conditions as determined from past records were used to determine the API at the start of the storm sequence. The antecedent storm is so large, however, that the precipitation excess computed for the main storm is not sensitive to variations in adopted initial moisture conditions. The precipitation excess from the critical PMP storm was 3.4 inches for the three-day antecedent storm and 12.0 inches for the three-day main storm.

Reservoir routings started with all reservoirs at the median observed mid-March elevation. Normal reservoir operating procedures were used. These make use of turbine and sluice discharge capacities in the tributary reservoirs. Turbine capacities are not used in the main river reservoirs after large flood flows develop because head differentials are so small in large floods that turbine discharge is not significant. All gates were assumed to be operable without failures during the flood. The flood from the antecedent storm occupied 55 percent of the reserved detention capacity by the time of the start of the flood generated by the main PMP storm. The operating rules had no effect on maximum flood levels or discharges because spillway capacities were reached early in the flood.

Failure of upstream dams during the adopted maximum possible flood would create maximum flood elevations at BFN. For this study maximum headwater levels were determined at each major upstream dam for the project maximum possible flood. Each dam where the computed headwater level exceeded that used in design was analyzed to determine if it would fail. This analysis revealed that only the earth portions of the main river dams from Fort Loudoun through Guntersville were subject to potential failure as a result of overtopping. The concrete portions of all dams, including the main river dams, were found to be stable in these situations.

Maximum Possible Flood

As described in BFN Units 1, 2, and 3 UFSAR Appendix 2.4.A, the hydrologic model used to determine flood hydrographs at BFN Nuclear Plant and downstream at Wheeler Dam is one in which the total basin is divided into unit areas, the outflows of which are combined to determine total basin outflows. Unit hydrographs are used to compute flows from unit areas. These flows are combined with appropriate time sequencing to compute inflows into the most upstream reservoirs which in turn are routed through the reservoirs using standard techniques. Resulting reservoir outflows are combined with the additional local inflows and continued downstream using appropriate time sequencing or routing procedures. The hydrologic model results ensure that each of the unit areas reflect watershed response to rainfall and the total system will reproduce the largest floods experienced since completion of the basic TVA reservoir system.

The total watershed for the Guntersville-Wheeler Reservoir inflow estimating system is divided into 41 unit areas. A unit hydrograph has been developed for each of the unit areas from flood hydrographs either recorded at stream gauging stations or estimated from reservoir headwater elevation, inflow, and discharge data.

Tributary reservoir routings were made using the Goodrich semigraphical method and flat pool storage conditions.

Except for Wheeler Reservoir, main river reservoir routings were made using standard storage flow routing techniques when dam failure was not involved. Unsteady flow techniques were used in Wheeler Reservoir and in all reservoirs when routing outflows from breached dams.

Main river storage routings when flood outflows could be gate-controlled were made using a four-variable relationship. When spillway dimensions controlled outflow and headwater elevation, main river routings were made using a semigraphical method with inflows used as a parameter to account for slope storage.

Unsteady flow routings were computer solved with a mathematical model based on the equations of unsteady flow. This model is described in a paper by Jack M. Garrison, Jean-Pierre Granju, and James T. Price entitled “Unsteady Flow Simulation in Rivers and Reservoirs,” Journal of the Hydraulics Division, ASCE, Volume 95, No. HY5, September 1969. Boundary conditions prescribed were inflow hydrographs at the upstream boundary, local inflows, and headwater discharge relationships at the downstream boundary based upon standard operating rules or rating curves where geometry controlled, as appropriate.

The total area hydrologic model for estimating flood hydrographs was verified by using it to reproduce the January-February 1957 flood, the maximum observed regulated flood, and the March 1963 flood, the second largest after closure of South Holston Dam in 1950. Observed volumes of precipitation excess were used in verification. The reproduction of the 1963 flood was comparable with that for the 1957 flood.

The unsteady flow model for Wheeler Reservoir was verified using the maximum observed regulated flood (1957) at four points within the reservoir. Verification was made within all reservoirs using maximum observed floods where unsteady flow routing was used.

The main river dams upstream from Guntersville include earth embankments which could fail if overtopped. Maximum flood level determinations at BFN, therefore, require predicting if overtopped dams would fail and, if so, the hour and rate of failure and the resulting outflow hydrograph.

The relationship used to compute the rate of erosion in an earth dam failure was that developed and used by the Bureau of Reclamation. The expression used relates the volume of eroded fill material to the volume of water flowing through the breach.

The solution to determine if an earth embankment would fail begins by solving the erosion equation using a headwater elevation hydrograph assuming no failure. Erosion is assumed to occur across the entire earth section and to start at the downstream edge when headwater elevations reach 0.1 ft above the dam top elevation. When erosion began to lower the dam top elevation, the computations included headwater elevation adjustments for increased reservoir outflow resulting from the breach.

The maximum possible flood discharge at BFN is 1,200,000 cfs. Velocities at the site would average 6 feet per second in the channel and up to 4 feet per second in the overbank at the time of peak discharge.

The maximum possible flood elevation is 572.5 ft.

Some wind waves are likely when the maximum possible flood is cresting at BFN. The flood would be near its crest elevation for a day beginning about 6-1/2 days after cessation of the PMP storm.

A reasonably severe windstorm producing 45 mph sustained wind speeds could occur coincidentally with the maximum possible flood. A wind from the SE will produce the largest waves at the site. A wind of this magnitude and from this direction can generate five-foot waves (crest to trough). The analysis of wave heights used the “1% wave” of which about five per hour will occur. Consequent wave runup above the flood level would be about five feet on a vertical wall.

A maximum flood elevation of elevation 578 ft. at the plantsite results from a combination of the maximum possible flood and wind wave runup on a vertical wall.

Effects of Local Intense Precipitation

As described in BFN Units 1, 2, and 3 UFSAR Appendix 2.4.A, in addition to flooding from the Tennessee River, BFN could possibly be flooded by intense local storms. Flooding sources include: (1) the small unnamed stream northwest of the plant, a portion of which has been relocated (Area 1), (2) the area draining to the switchyard drainage channel (Area 2), (3) the main plant area (Area 3), and (4) the area draining to the cooling tower system of channels (Area 4).

These areas were evaluated for a local storm producing PMP as defined for TVA by the Hydrometeorological Branch of the National Weather Service in Hydrometeorological Report No. 56, "Probable Maximum and TVA Precipitation Estimates with Areal Distribution for Tennessee River Drainages Less Than 3,000 Square Miles in Area." A six-hour storm which would produce a total of 34.4 inches of rainfall with a maximum one-hour amount of 16.7 inches was determined to be critical and was used to develop probable maximum flood inflows. Runoff was conservatively assumed equal to rainfall. Ice accumulation would occur only at infrequent intervals because of the temperate climate. Maximum winter precipitation concurrent with ice accumulation would impose less severe conditions on the drainage system than would the local PMP, which is associated with severe summer thunderstorm activity.

Area 1, Local Stream

An unnamed stream northwest of the plant with drainage area of 1.35 square miles formerly flowed through the plant area. The stream has now been diverted to flow along the west boundary of the plant. The channel is designed with capacity sufficient to carry the maximum possible (probable maximum) flood without flooding the plant.

The peak flood discharge was estimated using a one-hour unit hydrograph developed synthetically by comparison with gauged watersheds in the region. The maximum possible (probable maximum) peak discharge is 17,200 cfs. Maximum water surface elevations were completed using standard step backwater methods. The channel will pass 17,200 cfs with maximum water surface elevations below the ground, the dike, and the road which protect the plant and cooling tower areas from flooding.

Area 2, Switchyard Drainage Channel

Runoff from the 100-acre area draining to the switchyard drainage channel is diverted through the channel to the Tennessee River southeast of the plant. Two inflow hydrographs were developed: (1) a lateral inflow hydrograph from the 35-acre area adjacent to the channel, distributed uniformly along the length of the channel, and (2) a point inflow hydrograph from the 65-acre area draining to the upstream end of the channel. The lateral inflow hydrograph is equivalent to the PMP hyetograph using five-minute intervals. The point inflow hydrograph was developed by considering overland flow travel time for a number of discrete points within the 65-acre area. Travel times were estimated for runoff from each respective point to the channel. Peak flood elevations in the channel were computed using unsteady flow routing methods. In the routing it was conservatively assumed that the three culverts at the oil skimmer structure at the downstream end of the channel would be clogged with debris and would provide no discharge capacity during the flood. The channel can pass the maximum possible (probable maximum) flood without flooding safety-related structures. The maximum water surface elevation at the holding pond at the downstream end of the channel would be elevation 574.8 ft. The maximum water surface elevation at the north corner of the switchyard would not exceed the switchyard elevation of 578 ft.

Area 3, Main Plant Area

Plant buildings could possibly be flooded by an intense local storm which would exceed the capacity of the yard drainage system. The main plant area drains 41 acres. Plant surface drainage was investigated to determine if a plant maximum possible (probable maximum) storm would exceed plant grade elevation 565.0 ft and cause flooding of safety-related plant structures. All underground drains were assumed to be clogged.

All surface drainage with the exception of that between the office building and service building (patio plaza area) is adequate. Flow from the 3.3-acre patio plaza area northwest of the service building will drain to the employee courtyard west of the service building. Flooding at this location results from runoff collecting in a low point in the area with flood elevations controlled by the narrow opening between the temporary plant engineering building and the radwaste evaporator building. The peak elevation was determined to be elevation 566.6 ft, which is 1.6 ft above plant grade elevation 565.0 ft. The elevation was computed by storage routing the inflow hydrograph equivalent to the PMP hyetograph using five-minute intervals. The time available between the start of the most intense rainfall and the time flood levels exceed plant grade elevation 565.0 ft varies from 5 to 21 minutes, depending on the assumed distribution within the critical local PMP six-hour storm.

In the vicinity of the Radioactive Waste, Reactor, and Diesel Generator Buildings, water-surface elevations will not exceed elevation 565.0 ft. Peak water-surface elevations were determined by storage routing the inflow hydrograph using standard weir formulas and flat pool assumptions. The control section was taken to be the perimeter road south of the Reactor Building with elevation at 564.0 ft. The total inflow hydrograph was determined by considering overland flow travel time for a number of discrete points within the 41-acre area. Travel times were determined for runoff from each respective point to the perimeter road. The total area was then divided into subareas of equal travel time, with the longest travel times for those areas farthest from the perimeter road. Each subarea contributes to total flow, with respective subarea inflow hydrographs equivalent to the PMP hyetograph using five-minute time intervals. The total inflow hydrograph was then computed by summing the respective subarea inflow hydrographs, with each lagged by an amount equal to its travel time. Travel times ranged from 0 to 20 minutes, with 0 reflecting instantaneous watershed response.

Water-surface elevations at the Radioactive Waste, Reactor, and Diesel Generator Buildings at the time of maximum possible (probable maximum) flood flow would be increased if maximum water levels in the cooling water discharge channel downstream were to exceed elevation 564.0 ft. Maximum water-surface levels in this channel for combined condenser water and peak maximum possible (probable maximum) flood runoff were determined for all modes of plant operation and found not to exceed elevation 564.0 ft.

Area 4, Cooling Tower System

Runoff from the 157-acre area draining to the cooling tower system of channels is diverted to the Tennessee River through the operation of several gate structures. The cooling tower system of channels has sufficient capacity to pass the combined maximum possible (probable maximum) flood runoff and condenser water without flooding the plant for any mode of plant operation.

Peak water-surface elevations were determined using storage routing methods. Local inflow hydrographs for each of the basins within the cooling tower system of channels were equivalent to the PMP hyetograph using five-minute intervals. These hydrographs were augmented where appropriate for condenser water and main plant area runoff.

3.0 PREVENTION AND MITIGATION FEATURES

2b - Describe protection and mitigation features that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety.

The BFN protection and mitigation features that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety are described in the BFN Units 1, 2, and 3 UFSAR. The design loads to be considered for safety-related structures are described taking into account a maximum possible flood of elevation 572.5 ft plus wind waves where applicable. Therefore, the flooding evaluation report is based on the design of these structures that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety, and are further described below as presented in the BFN UFSAR.

Flooding Protection Design Features

<u>Reactor Building</u>

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.2.11, the watertight doors for the two personnel access locks and the two equipment access locks in the Reactor Building seal the openings and provide adequate flood protection for the maximum possible flood. The doors are designed to withstand static water pressure to elevation 572.5 ft and the Design Basis Earthquake (0.20g). The doors will remain intact and retain their seal after the occurrence of either of these conditions, or any combination of conditions as listed in UFSAR Table 12.2-38.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-38, the Reactor Building personnel access locks and equipment access locks watertight doors (Door and Frame Assemblies of A36 Steel) are designed for allowable stresses resulting from a dead load of the structure plus 7.5 ft static head load (maximum possible flood) of 32,400 psi (0.9 fy) in tension and compression, and 21,600 psi (0.6 fy) in shear. The other parts of the watertight doors are designed for allowable stresses resulting from a dead load of the structure plus 7.5 ft static head load (maximum possible flood) of 0.9 fy in tension and compression, and 0.6 fy in shear.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-7, the Reactor Building concrete structure exterior wall adjacent to Turbine Building is designed for allowable stresses resulting from a maximum possible flood load of elevation 572.5 ft. These stresses are fc = 0.85 fc' and fs = 0.90 fy.

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.9.3, the equipment access flood gate is located on the outside face of the equipment access lock and is part of the Reactor Building flood protection for the maximum possible flood. The gate will normally be in the open position for access into or from the equipment access lock, but may be lowered in the event of impending high water. The gate is approximately 23-feet-wide by 14-feet-high and of welded steel construction, with structural parts fabricated from A36 steel. It consists of a structural steel frame with a solid steel skin plate on one side. Rubber seals provide sealing to elevation 578.0 ft. Load combinations and corresponding allowable stresses used in designing the gate are listed in Table 12.2-43. This gate provides adequate protection against flooding of the Reactor Building. The gate will normally be in the open position for access into or from the equipment access lock. Gate operation from raised to lowered position takes less than five minutes. The gate can be lowered manually should the machinery fail to operate. Also, the plant mobile crane provides an additional means for lowering the gate. The gate is designed for static head to elevation 578.0 ft and for all static heads, broken waves, and surge forces due to flood conditions ranging from mean flood levels of elevation 556.0 ft to 568.0 ft, with concurrent winds of 85 mph, to the maximum possible flood, with a mean flood level of elevation 572.5 ft concurrent with 45-mph winds.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-43, the Equipment Access Lock flood gate in the Reactor Building (Gate Structural Members of A36 Steel) is designed for allowable stresses of 32,400 psi (0.9 fy) in tension and compression, and 21,600 psi (0.6 fy) in shear for two loading combinations. Dead load plus static water head to elevation 578 ft, and dead load plus wind load plus static water head plus broken waves to elevation 578.0 ft (wave height varies with flood level and wind from 10 feet maximum to 5 feet at maximum possible flood but does not exceed elevation 578.0 ft).

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.9.4, the Reactor Building watertight personnel access door is located at the south (outside) end of the personnel corridor, which is on the east side of the equipment access lock. This door is a part of the flood protection for the Reactor Building from the maximum possible flood. Physical description, design load combinations, safety evaluation, and inspection and testing criteria are the same as for the condenser cooling water system personnel access doors.

Radwaste Building

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.5, the Radwaste Building will not flood because all entrances are either above flood level or are protected by appropriately designed sealed doors. All piping penetrations below flood level are sealed to exclude the water and withstand the water pressure. Thus, the Radwaste Building is adequately protected from the maximum possible flood.

The flood protection doors are closures for all personnel and equipment access openings into the Radwaste Building and are identified as follows:

- Door for 10-foot by 10-foot exterior opening located in the south wall between column lines W2 and W3.
- Door for 15-foot 10-1/8-inch-high by 14-foot-wide exterior opening located in the south wall between column line W1 and the outside wall line.
- Two doors, each 3 feet 0-3/4 inch by 6 feet 7-1/4 inches, for the openings between the Turbine Building and Radwaste Building on column line T1.
- Two doors, one 3 feet 6-1/4 inches by 7 feet 1-1/4 inches adjacent to column line W4 and one 4 feet 5-1/2 inches by 7 feet 10-1/4 inches at column line W7, for the openings between the Service Building and Radwaste Building on column line Wa.
- One door 2-feet wide by 4-feet-1-inch high for the opening to the pipe and cable tunnel on column line T1 between column lines k and m at elevation 554.2 ft.

The four doors for the openings from the Turbine and Service Buildings and the door from the pipe and cable tunnel are the sealed, hinged, manually operated, welded-steel type. The doors are latched by dogs to provide watertight units. The dogs are operated by a single mechanism which is actuated by handwheels on both sides of the doors. The two doors from the Turbine Building are to serve as exit doors only from the Radwaste Building and are normally closed. The handwheels on the Turbine Building sides of these doors latch the dogs only. The door from the Service Building to the waste baler room is normally closed. The door to the corridor leading to the radiochemical lab and the radwaste control room is normally open for personnel and equipment to access but may be closed and latched by dogs to provide watertight units.

The doors for the two exterior openings in the Radwaste Building seal the openings and provide adequate flood protection for the maximum possible flood. These doors are designed to withstand wind to 100 miles per hour; water to elevation 578.0 ft resulting from floods to elevation 572.5 ft and wave runup or from floods to a lower elevation and greater wave runup; broken waves; and an Operating Basis Earthquake (0.10g) when in the closed position.

The four doors for the openings to the Turbine and Service Buildings and the door for the pipe and cable tunnel provide adequate flood protection for the personnel access openings against the maximum possible flood and are designed to withstand a static water pressure to elevation 572.5 ft.

All the doors will remain intact and retain their seal after the occurrence of any one of the above listed conditions, or any combination of conditions listed in the applicable load combination table, UFSAR Table 12.2-39 for doors in exterior walls and UFSAR Table 12.2-40 for doors in interior walls.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-39, the Radwaste Building double doors for exterior openings (Door and Frame Assemblies of A36 Steel) are designed for allowable stresses of 32,400 psi (0.9 fy) in tension and compression and 21,600 psi (0.6 fy) in shear, with other parts designed for allowable stresses of 0.9 fy in tension and compression and 0.6 fy in shear, for two loading combinations. These combinations are dead load plus 10-foot wave with water level at elevation 561.0 ft plus 60 mph wind +0.1g earthquake (OBE), and dead load plus 13 ft static head.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-40, the Radwaste Building personnel access doors (Door and Frame Assemblies of A36 Steel) are designed for allowable stresses of 32,400 psi (0.9 fy) in tension and compression and 21,600 psi (0.6 fy) in shear, with other parts designed for allowable stresses of 0.9 fy in tension and compression and 0.6 fy in shear, for dead load plus 7.5 ft static head (18.3 ft static head for pipe and cable tunnel door).

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-26, the Radwaste Building is designed for allowable stresses resulting from a dead load of the structure plus floor live loads or equipment loads plus maximum possible flood load of elevation 572.5 ft plus wave forces. These stresses are fc = 0.85 fc' and fs = 0.90 fy.

<u>Condenser Cooling Water System Pumping Station Structures</u>

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.7.1, the walls of the Condenser Cooling Water System Pumping Station Structures from the deck and grade elevation 565.0 ft to elevation 578.0 ft are designed to protect the Residual Heat Removal Service Water (RHRSW) pumps from water and wave forces resulting from the maximum possible flood. The design is in accordance with the design method given in paragraph 8.1 of

American Concrete Institute (ACI) Code 318-71. The members are proportioned such that they have a strength capability 1.24 times that required for the water and wave forces from the maximum possible flood. Full hydrostatic heads measured from the reservoir surface are applied to the entire area of the structure.

The deck was investigated for a flood to elevation 578.0 ft creating maximum water pressure on the underside and no pressure on the top. The design method given in paragraph 8.1 of ACI Code 318-71 was used for this investigation, with the determination that the deck has a strength capability of 1.4 times that required to resist this flood condition.

The seismic analysis was performed for the DBE case with water elevation at 529.0 ft and for the OBE case with water elevation at 556.0 ft. This was done so that the analyses would be consistent with the load cases given in UFSAR Table 12.2-27, as summarized below. The mass of the water enclosed by the structure was included as a lumped mass in the model. The effects of the water in the channel were not included in the analysis.

The personnel access doors are closures for the four 3 feet 11 inches wide x 7 feet 4 inches high openings at elevation 565.0 ft in the intake structure north wall, which provide personnel access to the RHRSW pump compartments. The doors are normally closed and latched by dogs to provide watertight units. These personnel access doors provide adequate flood protection against the maximum possible flood for the RHRSW pumps and are designed to withstand a wind velocity of 300 mph, static water pressure to elevation 578.0 ft (13 ft) and the Design Basis Earthquake (0.20g). The doors will remain intact and retain their seal after the occurrence of any one of these conditions or any combination of conditions listed in UFSAR Table 12.2-41 as summarized below.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-27, the Intake Building high walls forming the four compartments around the RHRSW pumps shall be designed to provide protection against natural phenomena such as DBE, tornadoes, and wind waves from 45 mph winds associated with maximum possible flood. These allowable stresses are fc = 0.85 fc' and fs = 0.90 fy.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-41, the Intake Structure and equipment access lock personnel access doors (Door and Frame Assemblies of A36 Steel) are designed for allowable stresses of 32,400 psi (0.9 fy) in tension and compression and 21,600 psi (0.6 fy) in shear, with other parts designed for allowable stresses of 0.9 fy in tension and compression and 0.6 fy in shear, for dead load plus 13 ft static head.

Diesel Generator Buildings

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.8.2, the BFN Units 1 and 2 Diesel Generator Building access doors provide adequate protection for the diesel-generator units and are designed to withstand tornado conditions and missiles generated by tornadoes, flood conditions, or earthquakes, with only one of these conditions occurring at any one time. During plant operation, the doors are normally closed, latched, and locked. Replaceable rubber seals on the doors are always in place and seal anytime the doors are closed. Flood conditions consist of floods up to and including a PMF to elevation 572.5 ft, with wave runup to elevation 578.0 ft. Broken waves and surge forces may occur during floods, and wave runup for floods less than the maximum may vary, but not exceed elevation 578.0 ft.

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.13, the BFN Unit 3 Diesel Generator Building lower floor is at elevation 565.5 ft. The building is protected against flood-water and wave action and kept dry to elevation 578.0 ft. There are five sets of large double doors in the east wall of the building for both personnel and maintenance access. These doors are designed for all static heads, broken waves, and surge forces up to elevation 578.0 ft with replaceable seals which are always in place. The electrical boards are located in rooms in the building conforming to the appropriate separation criteria required. If a diesel compartment must be blocked open for maintenance, provisions are made to protect the remainder of the building. The access doors for the Unit 3 building are identical to those for the Units 1 and 2 building.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-29, the Diesel Generator Buildings are designed for allowable stresses resulting from a dead load of the structure plus earth loads plus expansion joint loads plus maximum possible flood load of elevation 572.5 ft plus wave forces. These stresses are fc = 0.85 fc' and fs = 0.90 fy.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-30, the Diesel Generator Buildings access doors are designed for allowable stresses of 32,400 psi (0.9 fy) in tension and compression, and 21,600 psi (0.6 fy) in shear for two loading combinations. These combinations are dead load plus static water head to elevation 578 ft, and dead load plus wind load plus static water head plus broken waves to elevation 578.0 ft (wave height varies with flood level and wind from 10 feet maximum to 5 feet at maximum possible flood but does not exceed elevation 578.0 ft).

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.8.4, Diesel Generator Building portable bulkhead is part of the Diesel Generator Building flood protection for the maximum possible flood. It will be used to seal any one of the four rear interior doorways between the affected Diesel Generator Room and the pipe and electrical corridor, to protect the other Diesel Generator Rooms from the flood water. When an exterior watertight door to a Diesel Generator Room is inoperable and not capable of performing its flood protection function and flooding is imminent, the rear interior door in the affected Diesel Generator Room will be removed from its hinges and the portable bulkhead bolted over the doorway. Flooding is considered imminent when the Lake Elevation High alarm at the Intake Pumping Station is activated at elevation 564.0 ft and all upstream dams have been breached as discussed in Appendix 2.4A of USFAR Chapter 2. Load combinations and corresponding allowable stresses used in designing the bulkhead are listed in UFSAR Table 12.2-42 as summarized below. The resulting stresses do not exceed the allowable for any load combination used. This bulkhead provides adequate protection against flooding of adjacent Diesel Generator Rooms due to water traveling through an open access door, into the pipe and electrical corridor, and through the doorways between the corridor and other Diesel Generator Rooms. It is equipped with replaceable seals to seal against static flood heads to elevation 578.0 ft.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-42, the Diesel Generator Buildings portable bulkhead is designed for allowable stresses of 32,400 psi (0.9 fy) in tension and compression, and 21,600 psi (0.6 fy) in shear resulting from a dead load plus static water head to elevation 578.0 ft.

Offgas Treatment Building

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.14, Offgas Treatment Building is sealed against flood to the elevation of the stairway entrance at elevation 568.0 ft. PVC seals are provided in all construction joints in the exterior walls, roof, and base slabs to prevent leakage through the joint. The structure is designed for water pressure, earth pressure with surcharge, equipment loads, and Design Basis Earthquake. The structure is designed to remain in the elastic range for the Design Basis Earthquake and remain waterproof. The exterior walls and bottom slab are designed to remain in the elastic range, assuming the roof slab has collapsed, and they will not permit water leakage into or out of the building below elevation 566.25 ft.

Radwaste Evaporator Building

As described in BFN Units 1, 2, and 3 UFSAR Subsection 12.2.15, the Radwaste Evaporator Building is designed to be flood-proof for the maximum possible flood (water level elevation 572.5 ft) plus waves. The construction interface between the structure and the radwaste building is sealed for flood protection to elevation 578.0 ft.

As described in BFN Units 1, 2, and 3 UFSAR Table 12.2-45, the Radwaste Evaporator Building is designed for allowable stresses resulting from a dead load of the structure plus maximum possible flood load of elevation 572.5 ft plus wave forces. These stresses are $f_c = 0.85 f_c'$ and $f_s = 0.90 f_y$.

Plant Operation During Floods Above Grade

The BFN Units 1, 2, and 3 UFSAR does not describe required actions in the event of an impending maximum possible flood at the site, except for the previous discussions involving the Diesel Generator Buildings portable bulkhead. However, plant procedure 0-AOI-100-3, Flood Above Elevation 558', includes the steps to be taken for flooding events.

According to 0-AOI-100-3, flood preparations begin when the water level in Wheeler Reservoir is greater than or equal to elevation 558.0 ft or when water is detected in the corridor from the lunchroom to the Turbine Building due to PMP. When this occurs, River Operations is contacted. If River Operations projects that the river level will rise above elevation 565.0 ft, shutdown of all three units (if not already shutdown) will begin and the flood preparation outlined in the flood response AOI will be executed. For purposes of the tabletop simulation it was assumed all three units were initially in full power operation. However, the actions driven by 0-AOI-100-3 are applicable to the plant for all modes of operation.

As determined from the updated BFN Units 1, 2, and 3 UFSAR Figure 20, BFN Maximum Possible Flood Elevations, there are approximately 4-1/2 days between the time that the actions given in the AOI begin and the flood level reaches elevation 565.0 ft. Plant flood protection must be in place before the elevation 565.0 ft water level is reached.

The water level is expected to remain above elevation 565.0 ft for over four days. The figure does not extend past the point where the water level has receded below elevation 567.5 ft.

Flood protection features include structural design requirements for the Reactor Building, Radwaste Building, Condenser Cooling Water System Pumping Station Structures, Diesel Generator Buildings, Offgas Treatment Building, and Radwaste Evaporator Building as previously described in this Section. Specific design features required for flood protection are addressed as necessary in the AOI, and include watertight doors, flood gates, and portable bulkheads. Additional design features addressed in the AOI include manholes, equipment hatches, valves, and drain plugs.

4.0 FLOOD WARNING SYSTEMS

2c - Describe any warning systems to detect the presence of water in rooms important to safety

There are no room level detection devices at BFN credited for detection of external flooding inside protected buildings.

Although not credited for detection or mitigation of external flooding, Alarm Response Procedures (ARP) 0-ARP-25-17A discusses that the reactor building floor drain sump level is monitored continuously by a level detecting device. The reactor building basement, on each unit, is also monitored by level detecting devices in the Core Spray/Reactor Core Isolation Cooling pump rooms and the RHR pump rooms as discussed in ARP 1-, 2-, and 3-ARP-9-4C.

As discussed in 0-AOI-100-9, the turbine building is monitored for internal flooding by level detecting devices located at the turbine building floor drain sump, turbine building equipment drain sump, condenser pump pit floor drain sump and the condenser pump pit equipment drain sump.

5.0 EFFECTIVENESS OF FLOOD PROTECTION SYSTEMS

2d - Discuss the effectiveness of flood protection systems and exterior, incorporated, and temporary flood barriers. Discuss how these systems and barriers were evaluated using the acceptance criteria developed as part of Requested Information Item 1.h.

TVA used the industry developed and NRC endorsed guidance (NEI 12-07) for assessment of the effectiveness of flood protection systems and flood barriers. As discussed in Appendix D of NEI 12-07, Section 6 of NEI 12-07 is consistent with the requested information item 1.h.

Civil features

The site topography drawings were reviewed to identify topographical variations from the existing conditions. The flood walkdown team made observations of the local topography during the walkdowns including security barrier installations, looking for significant changes in the site drainage plan.

Effectiveness of Flood Mode Barriers

The Browns Ferry flood walkdown team visually inspected all accessible incorporated temporary and exterior passive and active flood protection features in accordance with the NEI 12-07 guidance. The visual inspection compared the physical condition of a structure, system, or component to verify the feature could perform its flood protection function.

Effectiveness of Procedures

A reasonable simulation was performed for the BFN flood response Abnormal Operating Instruction (AOI). A currently licensed Senior Reactor Operator (SRO) stepped through the AOI and was supported by representatives from various impacted plant organizations including Operations, Licensing, Maintenance, and Project Management as well as the walkdown team. As each step of the procedure was reviewed, estimates of time to perform the actions in the procedure were made and resources required to implement the actions were estimated.

As part of these activities, actual performance of the necessary activities to install the bulkhead door to the diesel generator room and operation of the EAL Floodgate (including installation and inspection of the railroad seals) was performed since these activities had not previously been performed and documented.

Effectiveness of Maintenance Procedures

Implementation of maintenance activities addressed in the reasonable simulation requires special tools, spool pieces, gaskets and other temporary flood mode components. Walkdowns were performed to confirm availability and material condition of these components to ensure the ability to respond to the PMF event. These walkdowns were documented on Form C of NEI 12-07.

6.0 IMPLEMENTATION OF THE WALKDOWN PROCESS

2e - Present information related to the implementation of the walkdown process (e.g., details of selection of the walkdown team and procedures,) using the documentation template discussed in Requested Information Item 1.j, including actions taken in response to the peer review.

Walkdown Team Selection and Training

The BFN external flood protection features were visually inspected and operator and maintenance actions were reasonably simulated in accordance with NEI Guidance document 12-07. The NEI walkdown record forms included in Appendix B of the guidance document were used as a template for the inspections.

Training was provided, as recommended in the guidance document and TVA procedure CTP-FWD-100. All walkdown team members completed the Nantel Flood Protection Training and the complete team was provided site specific training prior to performing the inspections. The content of this training was consistent with the recommendations included in the guidance document, Appendix C – Sample Training Content.

The walkdown team was made up of four engineers consisting of one senior mechanical engineer with knowledge of the design and operation of the Browns Ferry Nuclear Plant, one senior civil engineer with knowledge of hydrology and storm drainage, and two mechanical engineers with nuclear experience.

The walkdown team was supported by a retired SRO and active auxiliary unit operators in planning and performance of the walkdowns.

7.0 RESULTS OF THE WALKDOWN

2f - Results of the walkdown including key findings and identified degraded, non-conforming, or unanalyzed conditions. Include a detailed description of the actions taken or planned to address these conditions using the guidance in Regulatory Issues Summary 2005-20, Rev 1, Revision to NRC Inspection Manual Part 9900 Technical Guidance, "Operability Conditions Adverse to Quality or Safety," including entering the condition in the corrective action program.

TVA performed an update to the hydrologic analysis subsequent to the issuance of NRC Notices of Violation in 2008 associated with the Bellefonte Units 3 and 4 Combined Operating License Application. The BFN Units 1, 2, and 3 UFSAR Section 2.4 and Appendix 2.4.A are being revised under 10 CFR 50.59 to adopt a revised hydrologic analysis for the BFN Units 1, 2, and 3 site, consistent with the latest approved calculations. As a result of the proposed changes, the calculated probable maximum flood (PMF) elevations at the BFN Units 1, 2, and 3 site, are revised. However, the current licensing basis uses a fixed bounding PMF elevation of 572.5 ft, which is greater than the previous and currently calculated PMF at the BFN Units 1, 2, and 3 site.

TVA has performed the flooding walkdowns as discussed in Section 6.0 of this Report. The results of the walkdowns indicate that no new degraded, non-conforming conditions were identified and BFN can withstand the DBF. Individual key findings from those walkdowns are discussed below. TVA evaluated the findings from the walkdowns for both deficiencies and observations. Five deficiencies and 20 observations were made at made at BFN. Twenty two Corrective Action Program (CAP) entries were initiated at BFN to document both deficiencies and observations.

Walkdowns were performed in the flood protected areas at BFN including the Reactor Building, Radwaste Building, Diesel Generator Buildings, and RHRSW Pump Rooms. Additionally, reasonable simulations were performed for the flood response procedure, operation of the EAL Floodgate, and installation of a Diesel Generator Building Portable Bulkhead. A simulation of BFN's response AOI is discussed in Section 5.0. Issues identified from the walkdowns, which have been entered in the CAP, include the following:

Flood Mode Barrier Deficiencies

As a result of flood mode barrier inspections the following deficiencies were observed by the walkdown teams.

- A radwaste building watertight door was identified as having a small portion of missing seal material. This was entered into the CAP and work is scheduled to further inspect and repair the degraded seal material.
- The south access portal watertight door was identified, by BFN personnel independent of the flooding walkdowns, to have a cracked weld on the door frame. This was entered into the CAP and the cracked weld on the door frame is repaired.

- The equipment access lock floodgate rail seals were found to be shaped improperly to effectively seal the rail pocket below the gate. This was entered into the CAP and work is scheduled to replace the floodgate rail seals.
- Six reactor building penetration seals and five intake structure penetration seals were identified as a potential deficiency. These were entered into the CAP and work is schedule to further inspect and perform penetration seal repairs as necessary.
- Seven potentially end of service life seals on manholes and hatches at the RHRSW Pump Rooms were identified. These were entered into the CAP and work is schedule to further inspect and replace any end of service life seals during the next available system work week.
- Additionally, independent to the flooding walkdowns, the RHRSW pump room flood doors have been listed as degraded and non-conforming due to reliability. These were previously addressed in the CAP and work is scheduled to replace the degraded and non-conforming condition

Other Observations:

- Flood Mode Preparation Timeline – As discussed in Section 3.0, when river water level reaches elevations 558.0 ft and flood mode preparations are initiated, it takes approximately 4-1/2 days from when the river water level is at Elevation 558 ft until the level reaches the plant grade elevation of 565 ft. Based on the of the flood mode procedure reasonable simulation, it was determined that BFN meets its current licensing basis flood mode preparations timeline with no challenges. Due to the complexity of flood mode preparations, a number of observations were entered into the CAP, as noted during reasonable simulations and procedure reviews, which would improve BFN's flood preparation response and timeline.
  - Procedure Adequacy - As a result of reasonable simulations and procedure reviews, the flood mode procedures were determined to be adequate. However, a number of areas were identified which would improve the flood preparations timeline. These included providing additional direction for procedure implementation and clarification of procedure steps. The nature of the clarifications include grouping of operator actions in the same area to be performed at the same time for efficiency and other execution improvements. These have been entered into the corrective action program.
- Flood Mode Equipment Testing, Monitoring, and Inspection Program – Several permanently installed flood response components were found not to be currently included in a preventive maintenance program. These issues were entered into the CAP. Flood mode equipment testing, monitoring, and inspection programs are being reviewed by BFN and TVA corporate engineering to ensure that flood mode equipment reliability is maintained. This process will include review of equipment classification and creation of appropriate preventative maintenance procedures.
- Inaccessible/Restricted Access SSCs – It is noted that there were no "inaccessible" flood protection items and no "restricted access" items identified during the flooding

walkdowns for BFN Unit 1. The main steam tunnel flood walls were unable to be inspected due to inaccessibility at Browns Ferry Nuclear Plant, Units 2 and 3.

8.0 AVAILABLE PHYSICAL MARGIN (APM)

2g - Document any cliff-edge effects identified and the associated basis. Indicate those that were entered into the corrective action program. Also include a detailed description of the actions taken or planned to address these effects.

As part of the exterior flood barrier walkdowns performed in response to the NRC Request For Information (RFI) for Recommendation 2.3 (Flooding), available physical margin (APM) was reviewed for equipment required to be operable during a PMF. As discussed in Appendix D of NEI 12-07, which was endorsed by the NRC in a letter dated May 31, 2012, items identified with low APM have been entered into the CAP and are available for NRC audits and inspections, but are not being reported in response to this RFI. As also discussed in NEI 12-07, cliff-edge effects will be reported during the Recommendation 2.1 flood hazard reevaluations. During the flood hazard reevaluations, the cliff-edge effects will be determined using the APMs as well as other information, such as the specific SSCs that are subjected to flooding and the potential availability of other systems used to mitigate risk.

9.0 RECOMMENDED CHANGES FROM THE WALKDOWNS

2h - Describe any other planned or newly installed flood protection systems or flood mitigation measures including flood barriers that further enhance the flood protection. Identify results and any subsequent actions taken in response to the peer review

TVA has no planned or newly installed flood protection systems or flood mitigation systems at BFN to further enhance the flood protection of BFN in the event of a DBF. However, BFN is scheduled to replace 4 watertight personnel access doors, the hinges, and the door frames at the exterior walls of the RHRSW pump rooms at the Intake Pumping Station at approximate grade elevation 565 ft. The existing doors have been classified as degraded and non-conforming due to repeated failures. The new doors will be similar to the existing doors in shape, size, and function; however, the new doors have been strengthened and incorporate improvements, primarily with the door hinges and the latching mechanisms, to withstand frequent opening and closing. The condition associated with the RHRSW access doors was previously captured in the BFN CAP.

ENCLOSURE 3

Fukushima Near-Term Task Force Recommendation 2.3: Flooding Response Report
Sequoyah Nuclear Plant Report

1.0 INTRODUCTION

On March 12, 2012, the Nuclear Regulatory Commission issued a letter to all power reactor licensees and holders of construction permits in active or deferred status entitled “Request For Information Pursuant to Title 10 of the Code of Federal Regulation 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of the Near-Term Task Force Review of Insights From the Fukushima Dai-Ichi Accident.” For Recommendation 2.3: Flooding, the NRC requested that licensees take the following actions:

1) Perform flood protection walkdowns using and NRC-endorsed walkdown methodology,
2) Identify and address plant specific degraded, non-conforming, or unanalyzed conditions, as well as, cliff edge effects through the corrective action program, and consider these findings in the Recommendation 2.1 hazard evaluations, as appropriate,
3) Identify any other actions taken or planned to further enhance the site flood protection,
4) Verify the adequacy of programs, monitoring and maintenance for protection features, and
5) Report to the NRC the results of the walkdowns and corrective actions taken or planned.

The NRC issued a letter on May 31, 2012 endorsing Nuclear Energy Institute (NEI) 12-07, “Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features”. To conduct the walkdowns, TVA issued a corresponding document CTP-FWD-100 “Flood Protection Walkdowns NEI 12-07” to implement the endorsed industry guidance. A walkdown team was established with personnel knowledgeable in hydrology, Sequoyah design criteria, and operational procedures. The team was trained for walkdowns using the industry standard training module on the INPO NANTEL website. The team was also trained on TVA procedure CTP-FWD-100 and NEI 12-07 and site-specific requirements for performance of walkdowns.

Sequoyah is designed to meet Regulatory Position 2 of Regulatory Guide 1.59, “Design Basis Floods For Nuclear Power Plants.” The Turbine, Control and Auxiliary buildings will be allowed to flood. For the condition where flooding exceeds plant grade, all equipment required to maintain the plant safely during the flood, and for 100 days after the beginning of the flood, is either designed to operate submerged, located above the maximum flood level, or otherwise protected.

The flood walkdowns reviewed procedures, tools and components required to maintain the plant safely during a design basis flood. The walkdowns included components and tools associated with flood response procedures, penetrations, and observations of the site drainage paths. Reasonable simulations were performed to evaluate flood response procedures.

As a result of the walkdowns and simulations, items were entered into the corrective action program to address potential deficiencies in flood response operating or maintenance instructions and flood protection features.

2.0 DESIGN BASIS FLOOD HAZARDS

***2a - Describe the design basis flood hazard level(s) for all flood-causing mechanisms, including groundwater ingress*.**

The SQN design basis flood hazards for all flood-causing mechanisms, including groundwater egress, are described in SQN Units 1 and 2 Updated Final Safety Analysis Report (UFSAR) Section 2.4, Hydrologic Engineering. However, the design basis flood hazards described in SQN UFSAR Section 2.4 are being revised as described in a License Amendment Request (LAR) submitted August 10, 2012, "Application to Revise Sequoyah Nuclear Plant Units 1 and 2 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, (SQN-TS-12-02)." The flooding evaluation report is based on the LAR updated design basis flood (DBF) elevations because they are more conservative (higher) than the current licensing basis. In addition, the SQN LAR addresses changes to the results of the flood warning time evaluations, which form the basis for flooding protection procedures. The flood-causing mechanisms included in the licensing basis include the probable maximum flood (PMF) resulting from the limiting probable maximum precipitation (PMP) event, the peak flooding levels resulting from the limiting seismically-induced dam failure combination, and local intense precipitation, and are further described below as presented in the SQN LAR. In addition, the flood warning time evaluations are further described below as presented in the SQN LAR. Other possible flood-causing mechanisms have been evaluated in the SQN UFSAR and found to not be credible, including probable maximum surge and seiche flooding, probable maximum tsunami flooding, and ice effects.

Probable Maximum Flood (PMF) on Streams and Rivers

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.1, PMP for the watershed above SQN has been defined for TVA by the Hydrometeorological Report No. 41. This report defines depth-area-duration characteristics, seasonal variations, and antecedent storm potentials and incorporates orographic effects of the Tennessee River Valley. Due to the temperate climate of the watershed and relatively light snowfall, snowmelt is not a factor in generating maximum floods for the Tennessee River at the plant site.

Two basic storms with three possible isohyetal patterns and seasonal variations described in Hydrometeorological Report No. 41 were examined to determine which would produce maximum flood levels at the SQN plant site.

- The first storm would produce PMP depths on the 21,400-square-mile watershed above Chattanooga. Two isohyetal patterns are presented in Hydrometeorological Report No. 41 for this storm. The isohyetal pattern with downstream center would produce maximum rainfall on the middle portion of the watershed.
- The second storm described in Hydrometeorological Report No. 41 would produce PMP depths on the 7,980-square-mile watershed above Chattanooga and below the five major tributary dams. The isohyetal pattern for the 7,980-square-mile storm is not geographically fixed and can be moved parallel to the long axis, northeast and southwest, along the Tennessee Valley. The isohyetal pattern centered at Bulls Gap, Tennessee, would produce maximum rainfall on the upper part of the watershed.

Seasonal variations were also considered. The two seasons evaluated were March and June. The March storm was evaluated because the PMP was maximum and surface runoff was also maximum. The June storm was evaluated because the June PMP was the maximum for the summer season and reservoir elevations were at their highest levels. Although September PMP is somewhat higher than in June, less runoff and lower reservoir levels more than compensate for the higher rainfall.

All PMP storms are nine-day events. A three-day antecedent storm was postulated to occur three days prior to the three-day PMP storm in all PMF determinations. Rainfall depths equivalent to 40% of the main storm were used for the antecedent storms with uniform areal distribution as recommended in Report No. 41.

A standard time distribution pattern was adopted for the storms based upon major observed storms transposable to the Tennessee Valley and in conformance with the usual practice of Federal agencies. The adopted distribution is within the limits stipulated in Chapter VII of Hydrometeorological Report No. 41. This places the heaviest precipitation in the middle of the storm. The adopted sequence closely conforms to that used by the U.S. Army Corps of Engineers.

The PMF discharge at SQN was determined to result from the 21,400-square-mile storm producing PMP on the watershed with the downstream storm pattern, as defined in Hydrometeorological Report No. 41. The PMP storm would occur in the month of March and would produce 16.25 inches of rainfall in three days on the watershed above Chickamauga Dam. The storm producing the PMP would be preceded by a three-day antecedent storm producing 6.18 inches of rainfall, which would end three days prior to the start of the PMP storm. Precipitation temporal distribution is determined by applying the mass curve to the basin rainfall depths.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.2, a multi-variable relationship, used in the day-to-day operation of the TVA reservoir system, has been applied to determine precipitation excess directly. The relationships were developed from observed storm and flood data. They relate precipitation excess to the rainfall, week of the year, geographic location, and antecedent precipitation index (API). In their application, precipitation excess becomes an increasing fraction of rainfall as the storm progresses in time and becomes equal to rainfall in the later part of extreme storms. An API determined from an 11-year period of historical rainfall records (1997-2007) was used at the start of the antecedent storm. The precipitation excess computed for the main storm is not sensitive to variations in adopted initial moisture conditions because of the large antecedent storm.

The average precipitation loss for the watershed above Chickamauga Dam is 2.33 inches for the three-day antecedent storm and 1.86 inches for the three-day main storm. The losses are approximately 38% of antecedent rainfall and 11% of the PMP, respectively. The precipitation loss of 2.33 inches in the antecedent storm compares favorably with that of historical flood events.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.3, the runoff model used to determine Tennessee River flood hydrographs at SQN is divided into 45 unit areas and includes the total watershed above Chickamauga Dam. Unit hydrographs are used to compute flows from the unit areas. The unit area flows are combined with appropriate time sequencing or channel routing procedures to compute inflows into the most upstream tributary reservoirs which in turn are routed through the reservoirs using standard routing techniques. Resulting outflows are combined with additional local inflows and carried downstream using appropriate time sequencing or routing procedures including unsteady flow routing.

Unit hydrographs were developed for each unit area for which discharge records were available from maximum flood hydrographs either recorded at stream gauging stations or estimated from reservoir headwater elevation, inflow, and discharge data using the procedures described by Newton and Vineyard. For non-gauged unit areas synthetic unit graphs were developed from relationships of unit hydrographs from similar watersheds relating the unit hydrograph peak flow to the drainage area size, time to peak in terms of watershed slope and length, and the shape to the unit hydrograph peak discharge in cubic feet per second (cfs) per square mile.

Tributary reservoir routings, except for Tellico and Melton Hill, were made using standard reservoir routing procedures and flat pool storage conditions. The main river reservoirs, Tellico, and Melton Hill routings were made using unsteady flow techniques.

Unsteady flow routings were computer solved with the Simulated Open Channel Hydraulics (SOCH) mathematical model based on the equations of unsteady flow. The SOCH model inputs include the reservoir geometry, upstream boundary inflow hydrograph, local inflows, and the downstream boundary headwater discharge relationships based upon operating guides or rating curves when the structure geometry controls.

Discharge rating curves are calculated for the reservoirs in the watershed at and above Chickamauga. The discharge rating curve for Chickamauga Dam is for the current lock configuration with all 18 spillway bays available. Above SQN, temporary flood barriers have been installed at four reservoirs (Watts Bar, Fort Loudoun, Tellico and Cherokee Reservoirs) to increase the height of embankments and are included in the discharge rating curves for these four dams. Increasing the height of embankments at these four dams prevents embankment overflow and failure of the embankment. The vendor supplied temporary flood barriers were shown to be stable for the most severe PMF headwater/tailwater conditions using vendor recommended base friction values. A single postulated Fort Loudoun Reservoir rim leak north of the Marina Saddle Dam which discharges into the Tennessee River at Tennessee River Mile (TRM) 602.3 was added as an additional discharge component to the Fort Loudoun Dam discharge rating curve. Seven Watts Bar Reservoir rim leaks were added as additional discharge components to the Watts Bar Dam discharge rating curve. Three of the rim leak locations discharge to Yellow Creek, entering the Tennessee River three miles downstream of Watts Bar Dam. The remaining four rim leak locations discharge to Watts Creek, which enters Chickamauga Reservoir just below Watts Bar Dam. A single postulated Nickajack Reservoir rim leak just northeast of Nickajack Dam and back into the Tennessee River below Nickajack Dam was added as an additional discharge component for the Nickajack Dam
.

The specific unsteady flow and steady-state flow mathematical model configurations for upstream reservoirs and Chickamauga Reservoir are described further in SQN Units 1 and 2 UFSAR Subsection 2.4.3.3.

The reservoir operating guides applied during the SOCH model simulations mimic, to the extent possible, operating policies and are within the current reservoir operating flexibility. In addition to spillway discharge, turbine and sluice discharges were used to release water from the tributary reservoirs. Turbine discharges were also used at the main river reservoirs up to the point where the head differentials are too small and/or the powerhouse would flood.

Median initial reservoir elevations for the appropriate season were used at the start of the PMF storm sequence. Use of median elevations is consistent with statistical experience and avoids unreasonable combinations of extreme events.

The flood from the antecedent storm occupies about 70% of the reserved system detention capacity above Watts Bar Dam at the beginning of the main storm (day seven of the event). Reservoir levels are at or above guide levels at the beginning of the main storm in all but Appalachia and Fort Patrick Henry Reservoirs, which have no reserved flood detention capacity.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.4, the PMF discharge at SQN was determined to be 1,331,623 cfs. This flood would result from the 21,400-square-mile storm in March with a downstream orographically-fixed storm pattern. The West Saddle Dike at Watts Bar Dam would be overtopped and the earth embankment breached. The discharge from the failed West Saddle Dike flows into Yellow Creek which joins the Tennessee River at mile 526.82, 41.82 miles above SQN.

Chickamauga Dam downstream would be overtopped. The dam was postulated to remain in place, and any potential lowering of the flood levels at SQN due to dam failure at Chickamauga Dam was not considered in the resulting water surface elevation.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.5, the controlling PMF elevation at SQN was determined to be 722.0 ft, produced by the 21,400-square-mile storm in March and coincident with overtopping failure of the West Saddle Dike at Watts Bar Dam. Elevations were computed concurrently with discharges using the SOCH unsteady flow reservoir model.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.6, some wind waves are likely when the probable maximum flood crests at SQN. The flood would be near its crest for a day beginning about 2-1/2 days after cessation of the probable maximum storm. The day of occurrence would be in the month of March or possibly the first week in April.

A conservatively high velocity of 45 miles per hour over water was adopted to associate with the probable maximum flood crest. A 45-mile- per-hour overwater velocity exceeds maximum March one-hour velocities observed in severe March windstorms of record in a homogeneous region as reported by the Corps of Engineers.

That a 45-mile-per-hour overwater wind is conservatively high, is supported also by an analysis of March day maximum winds of record collected at Knoxville and Chattanooga, Tennessee. The records analyzed varied from 30 years at Chattanooga to 26 years at Knoxville, providing samples ranging from 930 to 806 March days. The recorded fastest mile wind on each March day was used rather than hourly data because this information is readily available in National Weather Service publications. Relationships to convert fastest mile winds to winds of other durations were developed from Knoxville and Chattanooga wind data contained in USWB Form 1001 and the maximum storm information contained in Technical Bulletin No. 2. From the wind frequency analysis it was determined that the 45-mile-per-hour overwater wind for the critical minimum duration of 20 minutes had an 0.1 percent chance of occurrence on any given March day.

Computation of wind waves was made using the procedures of the Corps of Engineers. The critical directions were from the north-northwest and northeast with effective fetches of 1.7 and 1.5 miles, respectively. For the 45-mile-per-hour wind, 99.6 percent of the waves approaching the plant would be less than 4.2- and 4.0-foot-high crest to trough for the 1.7- and 1.5-mile fetches. Only the most critical fetch length of 1.7 miles is used to determine the design basis flood elevations.

The maximum water level attained due to the PMF plus wind-wave activity is elevation 726.2 ft at the Essential Raw Cooling Water (ERCW) pump station and the nuclear island structures (Shield, Auxiliary, and Control Buildings).

The wind waves approaching the Diesel Generator Building and cooling towers break before reaching the structures due to the shallow depth of water. The topography surrounding these structures is such that the wind waves will break on a steeper slope (4H:1V) than the slope immediately adjacent to the structures.

Wind-wave runup coincident with the maximum flood level for the Diesel Generator Building and cooling towers is elevation 723.2 ft. The level inside structures that are allowed to flood is elevation 722.5 ft.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14, an evaluation is performed to determine the methods by which the SQN is capable of tolerating floods above plant grade without jeopardizing public safety. The design basis flood (DBF) is the calculated upper-limit flood that includes the PMF plus the wave runup caused by a 45 mph overland wind as discussed in SQN Units 1 and 2 UFSAR Subsection 2.4.3.6. In the SQN LAR, the DBF elevations at various plant locations that would result for the controlling PMF are increased from those currently provided in the SQN Units 1 and 2 UFSAR as follows:

Plant Location	Current DBF Level (ft.)	New DBF Level (ft.)
Probable Maximum Flood (still reservoir)	719.6	722.0
DBF Runup on Diesel Generator Building	N/A	723.2
DBF Runup on vertical external, unprotected walls	723.8	726.2
DBF Surge level within flooded structures	720.1	722.5

The lower flood elevations listed above are actual DBF elevations and are not normally used for the purpose of design but are typically used in plant procedures including procedures which direct plant actions in response to postulated DBF. For purposes of designing the flood protection for systems, structures, and components, the following higher elevations are used thus ensuring additional margin has been included in the development of design analysis.

Design Analysis Flood Levels	
Maximum still reservoir	723.5 ft
Runup on vertical external, unprotected walls	729.5 ft
Surge level within flooded structures	724.0 ft

Potential Dam Failures, Seismically Induced

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.4.1, the procedures described in Appendix A of Regulatory Guide 1.59 were followed when evaluating potential flood levels from seismically induced dam failures.

There are 20 major dams above SQN. These are Watts Bar and Fort Loudoun Dams on the Tennessee River; Watauga, South Holston, Boone, Fort Patrick Henry, Cherokee, and Douglas Dams above Fort Loudoun; Norris, Melton Hill, Fontana, and Tellico Dams between Fort

Loudoun and Watts Bar; and Chatuge, Nottely, Hiwassee, , Blue Ridge, Ocoee No. 1, Ocoee No. 2, and Ocoee No. 3 emptying into Chickamauga Reservoir. These were examined individually, and in combinations, to determine if failure might result from a seismic event and if so, would failure concurrent with storm runoff create maximum flood levels at the plant.

In accordance with the guidance of RG 1.59, Appendix A, seismic dam failure is examined using the two specified alternatives:

(1) the Safe Shutdown Earthquake (SSE) coincident with the peak of the 25-year flood and a two-year wind speed applied in the critical direction,
(2) the Operating Basis Earthquake (OBE) coincident with the peak of the one-half PMF and a two-year wind speed applied in the critical direction.

The OBE and SSE are defined in SQN Units 1 and 2 UFSAR Subsection 2.5.2.4 as having maximum horizontal rock acceleration levels of 0.09 g and 0.18 g respectively. As described in SQN Units 1 and 2 UFSAR Subsection 2.5.2.4, TVA agreed to use 0.18 g as the maximum bedrock acceleration level for the SSE.

From the seismic dam failure analyses made for TVA's operating nuclear plants, it was determined that five separate, combined events have the potential to create flood levels above plant grade at Sequoyah Nuclear Plant. These events are as follows:

(1) The simultaneous failure of Fontana and Tellico Dams in the OBE coincident with one-half PMF.
(2) The simultaneous failure of Fontana, Tellico, Hiwassee, Appalachia, and Blue Ridge Dams in the OBE coincident with one-half PMF.
(3) The simultaneous failure of Norris and Tellico Dams in the OBE coincident with one-half PMF.
(4) The simultaneous failure of Cherokee, Douglas, and Tellico Dams in the OBE coincident with one-half PMF.
(5) The simultaneous failure of Norris, Cherokee, Douglas, and Tellico Dams in the SSE coincident with a 25-year flood.

Tellico has been added to all five combinations in the SQN LAR which was not included in the original analyses for TVA's operating nuclear plants. It was included because the seismic stability analysis of Tellico is not conclusive. Therefore, Tellico was postulated to fail.
The runoff model of SQN Units 1 and 2 UFSAR Subsection 2.4.3.3 was used to evaluate these potentially five critical seismic events involving dam failures above the plant. Reservoir operating procedures used were those applicable to the season and flood inflows.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.4.2, unsteady flow routing techniques were used to evaluate plant site flood levels from postulated seismically induced dam failures wherever their inherent accuracy was needed. In addition to the flow models described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.3, the models described below were used to develop the outflow hydrographs from the postulated dam failures. The Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) storage routing was used to compute the outflow hydrograph from the postulated failure of each dam except main river dams. In the case of dams which were postulated to fail completely (Hiwassee, and Blue Ridge), Hydrologic Engineering Center River Analysis System (HEC-RAS) or SOCH was used to develop the outflow hydrograph. For Tellico Dam, the complete failure was analyzed with the SOCH model.

The failure time and initial reservoir elevations for each dam were determined from a pre-failure TRBROUTE analysis. HEC-HMS was used to develop the post failure outflow hydrographs based on the previously determined dam failure rating curves. The outflow hydrographs were validated by comparing the HEC-HMS results with those generated by simulations using TRBROUTE.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.4.3, the unsteady flow analyses of the five postulated combinations of seismic dam failures coincident with floods analyzed yields a maximum elevation of 708.6 ft at SQN excluding wind wave effects. The maximum elevation would result from the OBE failure of Cherokee, Douglas and Tellico Dams coincident with the one-half PMF flood postulated to occur in March.

Coincident wind wave activity for the PMF is described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.6. Wind waves were not computed for the seismic events, but superimposed wind wave activity from guide specified two-year wind speed would result in water surface elevations several ft below the PMF elevation 722.0 ft described in SQN Units 1 and 2 UFSAR Subsection 2.4.3. Therefore, the DBF elevations described in Section 2.1 of this report are the limiting design basis flood hazard levels for external flood events originating offsite.

Effects of Local Intense Precipitation

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.2.3, maximum water levels expected to result from the local plant PMP were determined using two methods: (1) when flow conditions controlled, standard-step backwater from the control section using peak discharges estimated from rainfall intensities corresponding to the time of concentration of the area above the control section or (2) when ponding or reservoir-type conditions controlled, storage routing the inflow hydrograph equivalent to the PMP hydrograph with 2-minute time intervals.

Structures housing safety-related facilities, systems, and equipment are protected from flooding during a local PMF by the slope of the plant yard. The yard is graded so that the surface runoff will be carried to Chickamauga Reservoir without exceeding the elevation of the external accesses given in SQN Units 1 and 2 UFSAR Subsection 2.4.1.1 except those at the intake pumping station whose pumps can operate submerged.

PMP for the plant drainage system and roofs of safety-related structures was determined from Hydrometeorological Report No. 45. The probable maximum storm used to test the adequacy of the local drainage system would produce 27.5 inches of rainfall in six hours with a maximum one-hour depth of 14 inches. Depths for each of the six hours in sequence were 1.5, 2.3, 5.0, 14.0, 3.0, and 1.7 inches.

Runoff from the 24.5 acre western plant site will flow either northwest to a 27-foot channel along the main plant tracks and then across the main access highway or to the south over the swale in Perimeter Road near the 161-kV switchyard and across Patrol Road to the river. Because the 500-kV switchyard and Temporary Access Control Point building areas are essentially level, peak outflows from this subarea were determined using method (2). These peak outflows were then combined with discharge estimates from the remaining areas, using method (1), to establish peak water surface profiles from both the north channel and south swale. The maximum water surface elevation is below critical floor elevation 706 ft and occurs near the east-west centerline of the Turbine Building.

The 28.9 acre eastern plant site was evaluated as two areas. Area 1 (19.7 acres) including the diesel generator, unit two reactor building, field services/storage buildings and adjacent areas. Runoff from area 1 will flow to the south along the perimeter road and across the pavement with low point elevation 705.0 ft to the discharge channel. Maximum water surface elevations computed using method (1) were less than elevation 706.0 ft. Area 2 (9.2 acres) includes the office/service, unit one reactor building, office/power stores buildings, intake pumping station, and adjacent areas. Runoff from area 2 will flow to the north and west along the ERCW pumping station access road to the intake channel and river. Maximum water surface elevation computed using method (2) is less than elevation 706 ft.

Underground drains were assumed clogged throughout the storm. For fence sections, the Manning's n value was doubled to account for increased resistance to flow and the potential for debris blockage.

Flooding Protection Requirements

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14, the plant grade elevation at SQN can be exceeded by large rainfall (PMP) and seismically-induced dam failure floods. The limiting flood event for establishing the limiting DBF elevations for the protection of equipment results from the limiting PMP event.

Large Rainfall (PMP) Floods

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.1.1, in addition to flood level considerations, plant flood preparations cope with the "fastest rising" flood which is the calculated flood, including seismically induced dam failure floods, that can exceed plant grade with the shortest warning time. Reservoir levels for large rainfall floods in the Tennessee Valley can be predicted well in advance. A minimum of 27 hours, divided into two stages, is provided for safe plant shutdown by use of this prediction capability. Stage I, a minimum of 10 hours long, will commence upon a prediction that flood-producing conditions might develop. Stage II, a minimum of 17 hours long, will commence on a confirmed estimate that conditions will provide a flood above plant grade. This two-stage scheme is designed to prevent excessive economic loss in case a potential flood does not fully develop.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2, "flood mode" operation is defined as the set of conditions described below by means of which the plant will be safely maintained during the time when flood waters exceed plant grade (elevation 705.0 ft) and during the subsequent period until recovery is accomplished.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.9.1, large Tennessee River floods can exceed plant grade elevation 705.0 ft at SQN. Plant safety in such an event requires shutdown procedures which may take 24 hours to implement. TVA flood forecast procedures will provide at least 27 hours of warning before river levels reach elevation 703.0 ft. Use of elevation 703.0 ft, 2 ft below plant grade, provides enough freeboard to prevent waves from 45-mile-per-hour, overwater winds from endangering plant safety during the final hours of shutdown activity. For conservatism the fetches calculated for the PMF were used to calculate maximum wind wave additive to the reservoir surface at elevation 703.0 ft feet. The maximum wind additive to the reservoir surface would be 4.2 ft and would not endanger plant safety during the final hours of preparation. This is due to the long shallow approach and the waves breaking at the perimeter road (elevation 705.0 ft). After the waves break there is not sufficient depth or distance between the perimeter road and the safety-related facilities for new waves to be generated. Forecast will be based upon rainfall already reported to be on the ground. Different target river level criteria are needed for winter use and for summer use to allow for seasonally varied reservoir levels and rainfall potential.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.8.2, four postulated combinations of seismically induced dam failures and coincident storm conditions were shown to result in floods which could exceed elevation 703.0 ft at the plant. SQN's notification of these floods utilizes TVA's RO forecast system to identify when a critical combination exists. Stage I shutdown is initiated upon notification that a critical dam failure combination has occurred or loss of communication prevents determining a critical case has not occurred. Stage I shutdown continues until it has been determined positively that critical combinations do not exist. If communications do not document this certainty, shutdown procedures continue into Stage II activity. Stage II shutdown continues to completion or until lack of critical combinations is verified.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.9.3, the forecast procedure to assure safe shutdown of SQN for flooding is based upon an analysis of nine hypothetical PMP storms up to PMP magnitude. The storms enveloped potentially critical areal and seasonal variations and time distributions of rainfall. To ensure that fastest rising flood conditions were included, the effects of varied time distribution of rainfall were tested by alternatively placing the maximum daily PMP in the middle and the last day of the three-day main storm. Earlier analysis of 17 hypothetical storms demonstrated that the shortest warning times resulted from storms in which the heavy rainfall occurred on the last day and that warning times were significantly longer when heavy rainfall occurred on the first day. Therefore, heavy rainfall on the first day was not reevaluated. The warning system is based on those storm situations which resulted in the shortest time interval between watershed rainfall and elevation 703.0 ft at SQN, thus assuring that this elevation could be predicted at least 27 hours in advance.

The procedures used to compute flood flows and elevations for those flood conditions which establish controlling elements of the forecast system are described in SQN Units 1 and 2 UFSAR Subsection 2.4.3.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.9.4, minimum of 27 hours has been allowed for preparation of the plant for operation in the flood mode, three hours more than the 24 hours needed. An additional 4 hours for communication and forecasting computations are provided to allow TVA's RO to translate rain on the ground to river elevations at the plant. Hence, the warning plan must provide 31 hours from arrival of rain on the ground until elevation 703.0 ft could be reached. The 27 hours allowed for shutdown at the plant are utilized for a minimum of 10 hours of Stage I preparation and an additional 17 hours for Stage II preparation that is not concurrent with the Stage I activity. This 27 hour allocation includes a 3-hour margin.

Although river elevation 703.0 ft, 2 ft below plant grade to allow for wind waves, is critical during final stages of plant shutdown for flooding, lower forecast target levels are used in most situations to assure that the 27 hours preflood transition interval will always be available. The target river levels differ with season.

During the "winter" season, Stage I shutdown procedures will be started as soon as target river elevation 694.5 ft has been forecast. Stage II shutdown will be initiated and carried to completion if and when target river elevation 703.0 ft at SQN has been forecast. Corresponding target river elevations for the "summer" season at SQN are elevation 699.0 ft and elevation 703.0 ft.

Even though the hydrologic procedures and target river elevations have been designed to provide adequate shutdown time in the fastest rising flood, longer times will be available in other floods. In such cases there may be a waiting period after the Stage I, 10-hour shutdown activity during which activities shall be in abeyance until weather conditions determine if plant operation can be resumed, or if Stage II shutdown should be implemented.

Resumption of plant operation following Stage I shutdown activities will be allowable only after flood levels and weather conditions, as determined by TVA's RO, have returned to a condition in which 27 hours of warning will again be available.

Seismically-Induced Dam Failure Floods

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.10, plant grade would be exceeded by four of the five candidate seismic failure combinations evaluated, thus requiring emergency measures. The combination producing the shortest time interval between seismic event and plant grade crossing is a OBE located so as to fail Fontana, Tellico, Hiwassee, Appalachia, and Blue Ridge Dams during the one-half PMF.

The time between the seismic event and the resulting flood wave crossing plant grade elevation 705.0 ft is 40 hours. The time to elevation 703.0 ft, which allows a margin for wind wave considerations, is 32 hours. The event producing the next shortest time interval to elevation 703.0 ft involves the OBE failure of Tellico and Norris during the one-half PMF resulting in a time interval of 34 hours. These times are adequate to permit safe plant shutdown in readiness for flooding.

Dam failure during non-flood periods was not evaluated, but would be bounded by the four critical failure combinations.

The warning plan for safe plant shutdown is based on the fact that a combination of critically centered large earthquake conditions must coincide before the flood wave from seismically caused dam failures will approach plant grade. In flood situations, an extreme earthquake must be precisely located to fail two or more major dams before a flood threat to the site would exist. The warning system utilizes TVA's flood forecast system to identify when flood conditions will be such that seismic failure of critical dams could cause a flood wave to exceed elevation 703.0 ft at the plant site. In addition to the critical combinations, failure of a single major upstream dam will lead to an early warning. A Stage I warning is declared once failure of (1) Norris, Cherokee, Douglas, and Tellico Dams or (2) Norris and Tellico Dams, or (3) Fontana, Tellico, Hiwassee, and Blue Ridge Dams, or (4) Cherokee, Douglas and Tellico Dams has been confirmed.

If loss of or damage to an upstream dam is suspected based on monitoring by TVA's RO, efforts will be made by TVA to determine whether dam failure has occurred. If the critical case has occurred or it cannot be determined that it has not occurred, Stage I shutdown will be initiated. Once initiated, the flood preparation procedures will be carried to completion unless it is determined that the critical case has not occurred.

Flood Recovery

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.1.3, because of the improbability of a flood above plant grade, no detailed procedures will be established for return of the plant to normal operation unless a flood actually occurs. If flood mode should become necessary, it will be possible to maintain this mode of operation for a sufficient period of time (100 days) so that appropriate recovery steps can be formulated and taken. The actual flood waters are expected to recede below plant grade within 1 to 6 days.

3.0 PREVENTION AND MITIGATION FEATURES

2b - Describe protection and mitigation features that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety.

The SQN protection and mitigation features that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety are described in SQN Units 1 and 2 UFSAR Subsection 2.4.14, Flooding Protection Requirements, and assurance that SQN can be safely shut down and maintained in these extreme flood conditions is provided by the discussions given in SQN Units 1 and 2 UFSAR Subsections 3.4, 3.8.1, 3.8.2, and 3.8.4. However, the protection and mitigation features described in SQN Units 1 and 2 UFSAR Section 2.4 are being revised as described in a License Amendment Request (LAR) submitted August 10, 2012, "Application to Revise Sequoyah Nuclear Plant Units 1 and 2 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, (SQN-TS-12-02)." The flooding evaluation report is based on the LAR updated descriptions of the protection and mitigation features that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety, and are further described below as presented in the SQN LAR.

Flooding Protection Design Features

As described in SQN Units 1 and 2 UFSAR Subsection 3.8.1.3, the Shield Building cylinder wall is subjected to uplift forces and lateral static pressure computed using the full hydrostatic head measured from the water surface. The following water surface elevations were used in determining hydrostatic heads:

Design flood (flood of record)	=	Elevation 687.0
Maximum probable flood	=	Elevation 700.0
Probable maximum flood with wave runup (PMF)	=	Elevation 726.8

Due to water seals between the Shield Building and adjacent structures, the lateral hydrostatic pressure was applied only to one-half of the circumference for the design flood and maximum probable flood. For the PMF the adjacent structures are allowed to flood, and lateral hydrostatic pressure was applied around the full circumference.

SQN Units 1 and 2 UFSAR Subsection 3.8.4.1.1, "Pressure Confining Personnel Doors," references the water tight annulus access doors (one per unit, doors A65 and A78) and states that these doors are secured during external flood warnings.

As described in SQN Units 1 and 2 UFSAR Subsection 3.8.4.1.2, the Condenser Cooling Water Pumping Station is a reinforced concrete box-type structure housing the fire protection/flood mode pumps.

As described in SQN Units 1 and 2 UFSAR Subsection 3.8.4.1.5, the manholes and handholes shown in SQN Units 1 and 2 UFSAR Figures 3.8.4-6 and 3.8.4-8 are typical of those that house the electrical cables that must remain in operation when flood levels rise above the plant grade. The manholes and handholes are rectangular box-type structures of reinforced concrete built essentially below plant grade with their top slab projecting above the surrounding soil.

As described in SQN Units 1 and 2 UFSAR Subsection 3.8.5.4.2, the Auxiliary-Control Building is designed for maximum flood conditions with water at grade elevation 705 ft.

Plant Operation During Floods Above Grade

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2, "flood mode" operation is defined as the set of conditions described below by means of which the plant will be safely maintained during the time when flood waters exceed plant grade (elevation 705.0 ft) and during the subsequent period until recovery is accomplished.

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2.1, the Reactor Building, the Diesel Generator Building, and the Essential Raw Cooling Water (ERCW) Intake Station will be maintained dry during the flood mode. Walls and penetrations are designed to withstand static and dynamic forces imposed by the DBF.

The lowest floor of the Diesel Generator Building is at elevation 722.0 ft with its doors on the uphill side facing away from the main body of flood water. With the PMF elevation of 722.0 ft, wind wave runup at the Diesel Generator Building is elevation 723.2 ft. Therefore, flood levels exceed floor elevation of 722.0 ft. The entrances into safety-related areas and all mechanical and electrical penetrations into safety-related areas are sealed either prior to or during flood mode to prevent major leakage into the building for water up to the PMF, including wave runup. Redundant sump pumps are provided within the building to remove minor leakage.

The ERCW Intake Station is designed to remain fully functional for floods up to the PMF, including wind-wave runup. The deck elevation (elevation 720.0 ft) is below the PMF plus wind wave runup, but it is protected from flooding by the outside walls. The traveling screen wells extend above the deck elevation up to the design basis surge level. The wall penetration for water drainage from the deck in non-flood conditions is below the DBF elevation, but it is designed for sealing in event of a flood. All other exterior penetrations of the station below the PMF are permanently sealed. Redundant sump pumps are provided on the deck and in the interior rooms to remove rainfall on the deck and water seepage.

All other structures, including the service, turbine, auxiliary, and control buildings, will be allowed to flood as the water exceeds their grade level entrances. All equipment, including power cables, that is located in these structures and required for operation in the flood mode is either above the DBF or designed for submerged operation.

Fuel Cooling

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2.2, fuel in the spent fuel pit will be cooled by the normal Spent Fuel Pit Cooling (SFPC) System. The pumps are located on a platform at elevation 721.0 ft which is below the surge level of elevation 722.5 ft. However, the pumps are located in an enclosure that provides flooding protection up to elevation 724.5 ft. During the flood mode of operation, heat will be removed from the heat exchangers by ERCW instead of component cooling water.

As backup to spent fuel cooling, water from the Fire Protection (FP) System can be dumped into the spent fuel pool, and steam removed by the area ventilation system.
For fuel in the reactor, residual core heat will be removed from the fuel in the reactors by natural circulation in the Reactor Coolant (RC) system. Heat removal from the steam generators will be

accomplished by adding river water from the FP System and relieving steam to the atmosphere through the power relief valves. Primary system pressure will be maintained at less than 500 pounds per square inch gauge (psig) by operation of the pressurizer relief valves and heaters. This low pressure will lessen leakage from the system. Secondary side pressure will be maintained at or below 90 psig by operation of the steam line relief valves.

An analysis has been performed to ensure that the limiting atmospheric relief capacity would be sufficient to remove steam generated by decay heat. At times beyond approximately 10 hours following shutdown of the plant two relief valves have sufficient capacity to remove the steam generated by decay heat. Since a minimum of 27 hours flood warning is available it is concluded that the plant could be safely shutdown and decay heat removed by operation of only two relief valves.

The main steam power operated relief valves will be adjusted to maintain the steam pressure at or below 90 psig. If this control system malfunctions, then the controls in the main control room can be utilized to operate the valves in an open-closed manner. Also, a manual loading station and the relief valve handwheel provide additional backup control for each relief valve. The secondary side steam pressure can be maintained for an indefinite time by the means outlined above.

The cooling water flow paths conform to the single failure criteria as defined in SQN Units 1 and 2 UFSAR Subsection 3.1.1. In particular, all active components of the secondary side feedwater supply and ERCW supply are redundant and can therefore tolerate a single failure in the short or long term. A passive failure, consistent with the 50 gpm loss rate specified in SQN Units 1 and 2 UFSAR Subsection 3.1.1, can be tolerated for an indefinite period without interrupting the required performance in either supply.

If one or both reactors are open to the containment atmosphere as during the refueling operations, then the decay heat of any fuel in the open unit(s) and spent fuel pit will be removed in the following manner. The refueling cavity will be filled with borated water (approximately 2000 ppm boron concentration) from the refueling water storage tank. The SFPC System pump will take suction from the spent fuel pit and will discharge to the SFPC System heat exchangers. The SFPC System heat exchanger output flow will be directed by a piping connection to the Residual Heat Removal (RHR) System heat exchanger bypass line. The tie-in locations in the SFPC System and the RHR System are shown in SQN Units 1 and 2 UFSAR Figures 9.1.3-1 and 5.5.7-1, respectively. This connection will be made using prefabricated, in- position piping which is normally disconnected. During flood mode preparations, the piping will be connected using prefabricated spool pieces.

Prior to flooding, valve number 78-513 and valves FCV 74-33, and 74-35 will be closed; valves HCV 74-36, 74-37, FCV 74-16, 74-28, 63-93, and 63-94 will be opened or verified open. This arrangement will permit flow through the RHR heat exchangers and the four normal cold leg injection paths to the reactor vessel. The water will then flow downward through the annulus, upward through the core (thus cooling the fuel), then exit the vessel directly into the refueling cavity. This results in a water level differential between the spent fuel pit and the refueling cavity with sufficient water head to assure the required return flow through the 20-inch diameter fuel transfer tube thereby completing the path to the spent fuel pit.

Except for a portion of the RHR System piping, the only RHR System components utilized below flood elevation are the RHR System heat exchangers. Inundation of these passive components will not degrade their performance for flood mode operation. After alignment, all valves in this cooling circuit located below the maximum flood elevation will be disconnected from their power source to assure that they remain in a safe position.

The modified cooling circuit for open reactor cooling will be assured of two operable SFPC System pumps (a third pump is available as a backup) as well as two SFPC System heat exchangers. Also, the large RHR System heat exchangers are supplied with essential raw cooling water during the open reactor mode of fuel cooling; these heat exchangers provide an additional heat sink not available for normal spent fuel cooling.

Fuel coolant temperature calculations, assuming conservative heat loads and the most limiting, single active failure in the SFPC System, indicate that the coolant temperatures are acceptable. The temperatures can be maintained at a value appreciably less than the fuel pit temperature calculated for the non-flood spent fuel cooling case when assuming the loss of one equipment train.

As further assurance, the open reactor cooling circuit was aligned and tested, during pre-operational testing, to confirm flow adequacy. Normal operation of the RHR System and SFPC System heat exchangers will confirm the heat removal capabilities of the heat exchangers.

High spent fuel pit temperature will cause an annunciation in the MCR, thus indicating equipment malfunction. Additionally, that portion of the cooling system above flood water will be frequently inspected to confirm continued proper operation.

For either mode of reactor cooling, leakage from the Reactor Coolant System will be collected, to the extent possible, in the reactor coolant drain tank; non-recoverable leakage will be made up from supplies of clean water stored in the four cold leg accumulators, the pressurizer relief tank, the cask decontamination tank, and the demineralized water tank. If these sources prove insufficient, the FP System can be connected to the Auxiliary Charging System as a backup. Whatever the source, makeup water will be filtered, demineralized, tested, and borated, as necessary, to the normal refueling concentration, and pumped by the Auxiliary Charging System into the reactor.

Cooling of Plant Loads

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2.3, plant cooling requirements, with the exception of the FP System which must supply feedwater to the steam generators, will be met by the ERCW System.

Power

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2.4, electric power will be supplied by the onsite diesel generators starting at the beginning of Stage II or when offsite power is lost, whichever occurs first.

Plant Water Supply

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2.5, the plant water supply is thoroughly discussed in SQN Units 1 and 2 UFSAR Subsection 9.2.2. The following is a summary description of the water supply provided for use during flooded plant conditions. The ERCW station is designed to remain fully functional for all floods up to and including the DBF.

The CCW intake forebay will provide a water supply for the fire/flood mode pumps. If the flood approaches DBF proportions, there is a remote possibility that Chickamauga Dam will fail. Such an event would leave the Sequoyah Plant CCW intake forebay isolated from the river as flood water recedes below elevation 665 ft. Should this event occur, the CCW forebay has the capacity of retained water to supply two steam generators in each unit and provide spent fuel pit with evaporation makeup flow until CCW forebay inventory makeup is established. The ERCW station is designed to be operable for all plant conditions and includes provisions for makeup to the forebay.

Preparations for Flood Mode, Reactors Initially Operating at Power

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.4.1, if both reactors are operating at power, Stage I and then, if necessary, Stage II procedures will be initiated. Stage I procedures will consist of a controlled reactor shutdown and other easily revocable steps such as moving supplies necessary to the flood protection plan above the DBF level and making temporary connections and load adjustments on the onsite power supply. Stage II procedures will be the less easily revocable and more damaging steps necessary to have the plant in the flood mode when the flood exceeds plant grade. The fire/flood mode pumps may supply auxiliary feedwater for reactor cooling. Other essential plant cooling loads will be transferred from the component cooling water to the ERCW System. The Radioactive Waste System will be secured by filling tanks below DBF level with enough water to prevent flotation; one exception is the waste gas decay tanks, which are sealed and anchored against flotation. The CVCS hold up tank will also be filled and sealed to prevent flotation. Some power and communication lines running beneath the DBF and not designed for submerged operation will require disconnection. Batteries beneath the DBF will be disconnected.

Preparations for Flood Mode, Reactor Initially Refueling

As described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.4.2, if time permits, fuel is removed from the unit(s) undergoing refueling and placed in the spent fuel pit; otherwise fuel cooling will be accomplished as described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2.2. If the refueling canal is not already flooded, the mode of cooling described in SQN Units 1 and 2 UFSAR Subsection 2.4.14.2.2 requires that the canal be flooded with borated water from the refueling water storage tank. If the flood warning occurs after the reactor vessel head has been removed or at a time when it could be removed before the flood exceeds plant grade, the flood mode reactor cooling water will flow directly from the vessel into the refueling cavity. If the warning time available does not permit this, then the upper head injection piping will be disconnected above the vessel head to allow the discharge of water through the four upper head injection standpipes. Additionally, it is required that the prefabricated piping be installed to connect the RHR and SFPC Systems, and that ERCW be directed to the secondary side of the RHR System and SFPC System heat exchangers.

4.0 Flood Warning Systems

2c - Describe any warning systems to detect the presence of water in rooms important to safety

There are no level detection devices at SQN credited for detection of external flooding.

Although not credited for detection or mitigation of external flooding, SQN UFSAR Section 5.2.7.1.8 discusses that the reactor building containment floor and equipment drain sump level is annunciated (visual and audible) on high and low level in the Main Control Room. The pocket sump, installed inside the reactor building containment floor and equipment drain sump in order to separate the drains, is also annunciated in the Main Control Room.

As discussed in the SQN UFSAR, Section 2.4.2.2, Flood Design Considerations, the turbine, control and auxiliary buildings will be allowed to flood for conditions where flooding exceeds plant grade. As such, no equipment within the plant is credited for detection of external flooding as a means to mitigate an external flood. However, as discussed in SQN UFSAR Section 6.3.2.11, System Reliability, a flood detection system utilizing conductivity type water level detector devices is used to monitor and actuate alarms for the Emergency Core Cooling System (ECCS) rooms and other leakage at specific locations in the Auxiliary Building. Individual Detectors are located in each ECCS pump compartment, in the ECCS heat exchanger rooms, in the pipe gallery for each unit and in the pipe chase. A common alarm in the main control room will alert the operator when any of these flood detectors are tripped. A flood detector indicator panel, located immediately outside the control room, then identifies the exact location of the tripped detector. The detector panel is provided with a test switch which can be used to verify the availability of power to each individual detector.

5.0 EFFECTIVENESS OF FLOOD PROTECTION SYSTEMS

2d - Discuss the effectiveness of flood protection systems and exterior, incorporated, and temporary flood barriers. Discuss how these systems and barriers were evaluated using the acceptance criteria developed as part of Requested Information Item 1.h.

TVA used the industry developed and NRC endorsed guidance (NEI 12-07) for assessment of the effectiveness of flood protection systems and flood barriers. A significant aspect of the flood protection for Sequoyah is implementation of operations, maintenance and chemistry procedures to maintain the plant in a safe condition in the event the flood exceeds plant grade. TVA used NEI 12-07 guidance for assessment of the flood response procedures.

Reasonable Simulation of Flood Mode Response Procedures

SQN is designed to withstand a flood up to plant elevation 705 ft. and still maintain normal services and functions. If the flood level should exceed plant grade (EL 705 ft.), the Auxiliary, Control, Turbine, and Service Buildings will be flooded. In this event reactor core decay heat will be removed by the flood protection provisions designed to remain operational up to the design basis flood elevation in accordance with position 2 of the Regulatory Guide 1.59.

TVA's climatic monitoring and flood predicting systems and flood control facilities allow rainfall floods which could exceed plant grade to be reliably predicted well in advance. Notification will be given to SQN at least 27 hours, plus an additional 4 hours for communication and forecasting computations, in advance of any rainfall flood that could exceed plant grade.

The flood response is governed by an abnormal operating procedure (AOP) for flood response. Maintenance and operations activities are directed from this AOP to align systems and components to a safe configuration for flood mode. All steps needed to prepare the plant for flood mode operation is to be accomplished within 24 hours of receipt of the initial warning that a flood above plant grade is possible. An additional 3 hours are available for contingency margin before wave runup from the rising flood might enter the buildings. Site grading and building design prevent any flooding before the end of the 27 hour preflood period.

Consistent with NEI 12-07 a reasonable simulation was performed of the AOP. This included reasonable simulation of additional abnormal operating procedures required in the implementation of the governing AOP. It also included reasonable simulation of maintenance procedures required in the implementation of the governing AOP.

A currently licensed Senior Reactor Operator (SRO) stepped through the procedure and, with the assistance of Maintenance, Chemistry, Engineering and Assistant Unit Operators (AUO), determined the time and resources required to complete each step. These determinations were made based on firsthand knowledge of the personnel performing the simulation of the location and complexity of the activities.

Operators also performed a reasonable simulation in the field of one procedure step in which an AUO simulated manipulation of hand valves to establish time and resource requirements.

For seven of the maintenance procedures that were determined to be the most challenging to the overall timeline, reasonable simulations were performed in the field to develop timelines and resource requirements. These simulations included having the personnel simulate activities required to complete the procedures, including locating tools, scaffolding and temporary flood mode components. Additionally, a first time installation was successfully performed on a spool piece for which the receiving flanges are slightly out of alignment, and another spool piece was partially rigged and lifted.

A timeline was developed using this data to determine the overall time and resources required to complete flood preparations.

NEI 12-07 guidance Form D was completed for each procedure reviewed in the simulation.

Effectiveness of Maintenance Procedures

Implementation of maintenance activities addressed in the reasonable simulation requires special tools, spool pieces, gaskets and other temporary flood mode components. Walkdowns were performed to confirm availability and material condition of these components to ensure the ability to respond to the PMF event. These walkdowns were documented on Form C of NEI 12-07.

Civil features

Site grading is designed such that water resulting from a local PMP will drain run away from the Service, Auxiliary, Control and Shield Buildings.

The civil evaluation of current plant design and licensing included a review of the existing site calculations, site topography and changes to the site topography that were used as the licensing basis flood evaluation. Field observations were performed in accordance with NEI 12-07.

Effectiveness of Flood Mode Barriers

Safety-related facilities, systems and equipment located in the Unit 1 and 2 containment structures are protected from flooding by the shield building. All accesses and penetrations below the maximum flood level in the shield building are designed and constructed as water-tight elements. Both Containment structure walls and penetrations are designed to withstand all static and dynamic forces imposed by the DBF. Penetrations in the Shield Building below the PMF elevation are designed and constructed as watertight elements.

The annulus between the Shield Building wall and the Steel Containment Vessel is maintained at a negative pressure during normal operation, any degradation in performance of the vacuum boundary would be addressed per Technical Specifications. Penetrations below PMF elevation were visually inspected in accordance with NEI 12-07.

The Spent Fuel Pit Cooling (SFPC) pumps are located on a platform at Elevation 721.0 ft. in the Auxiliary Building. The SFPC pumps are intended to remain dry (not submerged) and functioning during a Probable Maximum Flood (PMF) event and are protected from flooding by the Spent Fuel Pump Enclosure constructed of steel plating. During the walkdowns, the enclosure around the SFPC pumps was visually inspected in accordance with NEI 12-07.
The ERCW Intake Pumping Station is designed to remain fully functional for floods up to the PMF including wind-wave run-up. The ERCW Intake Pumping Station was visually inspected in accordance with NEI 12-07.

The Diesel Generator Building (DGB) is required to remain dry during the PMF event. Credited flood barriers were visually inspected in accordance with NEI 12-07.

6.0 IMPLEMENTATION OF THE WALKDOWN PROCESS

2e - Present information related to the implementation of the walkdown process (e.g., details of selection of the walkdown team and procedures,) using the documentation template discussed in Requested Information Item 1.j, including actions taken in response to the peer review.

Walkdown Team Selection and Training

The SQN external flood protection features were visually inspected and operator and maintenance actions were reasonably simulated in accordance with NEI Guidance document 12-07. The NEI walkdown record forms included in Appendix B of the guidance document were used as a template for the inspections.

Training was provided, as recommended in the guidance document and TVA procedure CTP-FWD-100. Walkdown team members completed the Nantel Flood Protection Training and the complete team was provided site specific training prior to performing the inspections. The content of this training was consistent with the recommendations included in the guidance document, Appendix C – Sample Training Content.

The walkdown team was made up of four engineers consisting of three civil engineers and one mechanical engineer. The team lead was a Senior Civil Engineer with knowledge of power plant design, hydrology and hydraulics and general plant operations. The one mechanical engineer on the team has extensive knowledge of Sequoyah Systems. The other two civil engineers are experienced design engineers with hydrology and power plant design experience. The walkdown team was supported by a retired SRO and a retired Shift Manager in planning and performance of the walkdowns. An active Maintenance Supervisor, Maintenance Personnel, an active SRO, and active AUO and Radiation Protection personnel assisted in the completion of the reasonable simulations.

Flooding Walkdown Scope

As defined in NEI 12-07 the flooding walkdowns included review of plant response procedures for external floods and visual inspection and verification of incorporated or exterior equipment important to safety to identify degraded, nonconforming, or unanalyzed conditions. This report reflects the results of those end user inspections.

Continuing Inspections

Based on identification of the WBN two main control room chilled water circulating pumps and two shutdown board room chilled water circulating pumps that were determined to be partially submerged during a PMF, TVA identified subcomponents that had not been inspected as part of the walkdown scope, as defined in NEI 12-07. TVA expanded its scope to include visual inspection of subcomponents and attendant equipment supporting the end devices credited in the flood response procedure, including cabling/conduits terminations, instrumentation, and controls. These expanded scope walkdowns are ongoing at both SQN and WBN. Any degraded, nonconforming, or unanalyzed conditions identified during these inspections will be entered into the corrective action program.

7.0 Results of the Walkdowns

2f - Results of the walkdown including key findings and identified degraded, non-conforming, or unanalyzed conditions. Include a detailed description of the actions taken or planned to address these conditions using the guidance in Regulatory Issues Summary 2005-20, Rev 1, Revision to NRC Inspection Manual Part 9900 Technical Guidance, "Operability Conditions Adverse to Quality or Safety," including entering the condition in the corrective action program.

As discussed in its application to revise the Sequoyah Nuclear Plant Units 1 and 2, Updated Final Safety Analysis Report (UFSAR), dated August 10, 2012, TVA has performed an update to the hydrologic analysis for Sequoyah. The updated hydrologic analysis was performed subsequent to the issuance of NRC Notices of Violation in 2008 associated with the Bellefonte Units 3 and 4 Combined Operating License Application.

At a public meeting between the NRC staff and TVA on May 31, 2012, TVA discussed the status of the reevaluation and provided an overview of the SQN current licensing basis. TVA submitted LER 50-327(328)/2009-09 on March 1, 2010 and supplemented the LER on April 14, 2010. TVA reported that the updated PMF elevation of 722.0 feet resulted in an unanalyzed condition in that the diesel generators and spent fuel pit cooling pumps could be adversely impacted by the new flood level. Compensatory measures were put in place to protect the equipment.

In addition to submitting LER 50-327(328)/2009-09 and 2009-09 Revision 1, TVA submitted a letter on June 13, 2012 containing several commitments. TVA committed to installing permanent plant modifications to provide flood protection with respect to the Design Basis Flood level for the common SQN, Units 1 and 2 Diesel Generator Building by March 31, 2013. In the same letter, TVA committed to implementing the design change to document the SQN, Units 1 and 2 Spent Fuel Pit Cooling Pump Enclosure caps as permanent plant features by March 31, 2013. In addition to the Diesel Generator Building and Spent Fuel Pit Cooling Pump modifications, a modification is being performed to install a barrier at the ERCW Pumping Station on the inside of the personnel access door on elevation 725.

TVA has performed the flooding walkdowns as discussed in Section 6.0 of this Report. The findings from those walkdowns are discussed below. TVA evaluated the findings from the walkdowns for both deficiencies and observations. Three deficiencies were identified at SQN during the walkdowns and 66 CAP entries were initiated to document both deficiencies and observations.

Walkdowns have been performed in the safety related buildings/structures at SQN including the Service, Control, Auxiliary, Turbine and Shield Buildings, and the ERCW Intake Pumping Station and Diesel Generator Buildings. Additionally reasonable simulations have been performed for flood response procedures. The generic issues identified from the walkdowns, which have been entered in the corrective action program, include:

Flood Mode Barrier Deficiencies

- As a result of flood mode barrier inspections, potential ERCW intake pumping station flooding pathways were identified including unsealed conduit penetrations. These have been entered into the corrective action program. This is considered a non conforming condition. Work is being performed to seal these potential flooding pathways. Also, compensatory actions have been taken and temporary sump pumps have been installed.

As a result of flood mode barrier inspections, two Diesel Generator Building drain manual isolation valves were found to be inoperable. These have been entered into the corrective action program. This is considered a non conforming condition. Drain plugs have been purchased and are staged in the Diesel Generator building with procedures currently being revised to direct installation.

The potential for water transport through conduits below the flood elevation in Shield Building penetrations is under evaluation. This item has been entered into the corrective action program.

Flood Mode Preparation Timeline Deficiency

- The SQN current licensing basis states that all flood mode preparation shall be completed within 24 hours of initial Stage 1 flood warning. An additional 3 hour contingency margin is available providing a maximum of 27 hours for flood preparations to be complete before flood waters exceed plant grade as described in the SQN UFSAR. Flood warning is divided into two Stages (Stage I warning (10 hours) and Stage II warning (17 hours)). As a result of the flood mode procedure reasonable simulation, it was determined that flood mode preparations would take 25 hours and 41 minutes to complete. As noted in Section 2.0 of Enclosure 1, the gap between SQN and WBN regarding the amount of time required and/or capable to prepare the plant for flood mode operation is being tracked as a fleet level issue for resolution. As the walkdown results were being developed, SQN identified the inability to complete the required actions with 24 hours as a nonconforming condition and entered the issue into the corrective action program. The final resolution of the licensing basis requirements for completion of flood mode preparations will be addressed as part of the fleet initiative.

  In addition, the below observations were made by the flooding walkdown teams and actions are being taken to reduce the flooding preparation timeline in accordance with these observations.

  - <u>Operating and Maintenance Procedure Improvements</u> – As a result of reasonable simulations and procedure reviews, the procedures were determined in general to be adequate. However, a number of areas were identified which would improve flood preparation timeline. These included addition of specific rigging direction, identification of specific tools required to complete some actions, correcting typographical errors and specific identification and clarification of manpower requirements, responsible organizations, and critical step sequencing to perform some actions. Additionally, enhancements, as noted by the walkdown teams, in flood mode equipment staging would improve the flood preparation timeline. These areas for improvement have been entered into the corrective action program. SQN has issued revisions to the governing flood response AOP to revise critical step sequencing and add compensatory actions to address as found deficiencies. Further operations and maintenance procedure revisions are being prepared based on the results of the reasonable simulations and procedure reviews.
  - <u>Tool and Flood Mode Equipment Accessibility</u> – As a result of reasonable simulations, it was determined that tools and equipment required for flood mode

preparations could be accessed. However, accessibility to flood mode credited manual isolation valves and spool piece installation points for ERCW to CCS connection proved to be challenging during the reasonable simulation activities. Improving accessibility would further reduce the flood mode preparation timeline. These areas for improvement have been entered into the corrective action program. Operations and maintenance procedure revisions are being prepared based on the results of the reasonable simulations and procedure reviews to improve tool and flood mode equipment accessibility.

  - Material Availability – In reviewing staging of materials for implementation of procedures it was determined that insufficient filter resins were available on site. The item has been entered into the corrective action program. The required quantity of filter resins will be procured and appropriately staged.
  - Flood Mode Equipment Condition – The flood mode credited plant "Jon Boat" was determined to require maintenance. This has been entered into the correction action program. The flood mode credited plant "Jon Boat" has been sent out for repairs to ensure it would be operable during flood event.
  - Operations and Maintenance Personnel Training – As a result of reasonable simulations, it was determined that both operations and maintenance personnel could perform all flood mode preparations, however improved training and familiarization of both operations and maintenance personnel would improve the flood preparation timeline. These areas for improvement have been entered into the corrective action program. Operations training needs analysis will be performed following procedure revisions.

- Flood Mode Equipment Testing, Monitoring, and Inspection Program – Several permanently installed flood response components were found not to be currently included in a preventive maintenance program. These were entered into the corrective action program. Flood mode equipment testing, monitoring, and inspection programs are being reviewed by SQN and TVA corporate engineering to ensure that flood mode equipment reliability is maintained. This process will include review of equipment classification and creation of appropriate preventive maintenance procedures.
- Inaccessible/Restricted Access SSCs – It is noted that there were no "inaccessible" flood protection items and no "restricted access" items identified during the flooding walkdowns.

8.0 Available Physical Margin (APM)

2g - Document any cliff-edge effects identified and the associated basis. Indicate those that were entered into the corrective action program. Also include a detailed description of the actions taken or planned to address these effects.

As part of the exterior flood barrier walkdowns performed in response to the NRC Request For Information (RFI) for Recommendation 2.3 (Flooding), available physical margin (APM) was reviewed for equipment required to be operable during a PMF. As discussed in Appendix D of NEI 12-07, which was endorsed by the NRC in a letter dated May 31, 2012, items identified with low APM have been entered into the CAP and are available for NRC audits and inspections, but are not being reported in response to this RFI. As also discussed in NEI 12-07, cliff-edge effects will be reported during the Recommendation 2.1 flood hazard reevaluations. During the flood hazard reevaluations, the cliff-edge effects will be determined using the APMs as well as other information, such as the specific SSCs that are subjected to flooding and the potential availability of other systems used to mitigate risk.

9.0 PLANNED OR NEWLY INSTALLED FLOOD PROTECTION BARRIERS

2h - Describe any other planned or newly installed flood protection systems or flood mitigation measures including flood barriers that further enhance the flood protection. Identify results and any subsequent actions taken in response to the peer review.

TVA has reevaluated flood levels for SQN plant and has identified flood protection improvements.

ERCW Intake Pumping Station Flood Protection Barriers

The Traveling Water Screens vent piping is to be extended to prevent the intrusion of water into the pumping station during a PMF event.

Flood protection is to be provided for personnel access door PS-5.

Diesel Generator Building (DGB) Flood Protection Barriers

Flood protection is to be provided for personnel access Door D5, emergency exit Doors D1-D-4 and equipment Doors D15-D18.

The fill ports for the 7-day tanks outside of the Diesel Generator Building are to be extended to prevent intrusion of flood water during a PMF event and will also allow filling of the tanks during such event. The fill piping will also be encased in concrete for protection. The urinal in the restroom at the DGB is also to be removed and the drain and supply lines will be capped in order to prevent water from intruding into the building during a PMF event.

ENCLOSURE 4

Fukushima Near-Term Task Force Recommendation 2.3: Flooding Response Report
Watts Bar Nuclear Plant

1.0 INTRODUCTION

On March 12, 2012, the Nuclear Regulatory Commission issued a letter to all power reactor licensees and holders of construction permits in active or deferred status entitled “Request For Information Pursuant to Title 10 of the Code of Federal Regulation 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of the Near-Term Task Force Review of Insights From the Fukushima Dai-Ichi Accident.” For Recommendation 2.3: Flooding, the NRC requested that licensees take the following actions:

1) Perform flood protection walkdowns using and NRC-endorsed walkdown methodology,
2) Identify and address plant specific degraded, non-conforming, or unanalyzed conditions, as well as, cliff edge effects through the corrective action program, and consider these findings in the Recommendation 2.1 hazard evaluations, as appropriate,
3) Identify any other actions taken or planned to further enhance the site flood protection,
4) Verify the adequacy of programs, monitoring and maintenance for protection features, and
5) Report to the NRC the results of the walkdowns and corrective actions taken or planned.

The NRC issued a letter on May 31, 2012 endorsing Nuclear Energy Institute (NEI) 12-07, “Guidelines for Performing Verification Walkdowns of Plant Flood Protection Features”. To conduct the walkdowns, TVA issued a corresponding document CTP-FWD-100, “Flood Protection Walkdowns NEI 12-07,” to implement the endorsed industry guidance. A walkdown team was established with personnel knowledgeable in hydrology, WBN design criteria, and operational procedures. The team was trained for walkdowns using the industry standard training module on the INPO NANTEL website. The team was also trained on TVA procedure CTP-FWD-100 and NEI 12-07 and site-specific requirements for performance of walkdowns.

WBN is designed to meet Regulatory Position 2 of Regulatory Guide 1.59, “Design Basis Floods For Nuclear Power Plants.” The Turbine, Control and Auxiliary buildings are allowed to flood. Equipment required to maintain the plant safely during the flood, and for 100 days after the beginning of the flood, is either designed to operate submerged, is located above the maximum flood level, or is otherwise protected.

The flood walkdowns reviewed procedures, tools and components required to maintain the plant safely during a design basis flood. The walkdowns included components and tools associated with flood response procedures, penetrations, and observations of the site drainage paths. Reasonable simulations were performed to evaluate flood response procedures.

As a result of the walkdowns and simulations, items were entered into the corrective action program to address potential deficiencies in flood response operating or maintenance instructions and flood protection features.

2.0 DESIGN BASIS FLOOD HAZARDS

2a - Describe the design basis flood hazard level(s) for all flood-causing mechanisms, including groundwater ingress.

Determination of the WBN design basis flood is described in WBN Unit 1 Updated Final Safety Analysis Report (UFSAR) Section 2.4, Hydrologic Engineering. The design basis flood levels described in WBN UFSAR Section 2.4 are being revised as described in a License Amendment Request (LAR) submitted July 19, 2012, "Application to Revise Watts Bar Nuclear Plant Unit 1 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, TAC No. ME8200 (WBN-UFSAR-12-01)." The flooding evaluation report is based on the LAR updated design basis flood (DBF) elevations because they are more conservative (higher) than the current licensing basis. In addition, the WBN LAR addresses changes based on the results of the flood warning time evaluations, which form the basis for flooding protection procedures. The flood-causing mechanisms included in the licensing basis include the probable maximum flood (PMF) resulting from the limiting probable maximum precipitation (PMP) event, the peak flooding levels resulting from the limiting seismically-induced dam failure combination, and local intense precipitation, and are further described below as presented in the WBN LAR. In addition, the flood warning time evaluations are further described below as presented in the WBN LAR. Other possible flood-causing mechanisms have been evaluated in the WBN UFSAR and found to not be credible, including probable maximum surge and seiche flooding, probable maximum tsunami flooding, and ice effects

Probable Maximum Flood (PMF) on Streams and Rivers

As described in WBN Unit 1 UFSAR Subsection 2.4.3.1, PMP for the watershed above Chickamauga and Watts Bar Dams for determining PMF has been defined for TVA by Hydrometeorological Report No. 41. This report defines depth-area-duration characteristics, seasonal variations, and antecedent storm potentials and incorporates orographic effects of the Tennessee River Valley.

Two basic storms with three possible isohyetal patterns and seasonal variations described in Hydrometeorological Report No. 41 were examined to determine which would produce maximum flood levels at the WBN plant site.

- The first storm would produce PMP depths on the 21,400-square-mile watershed above Chattanooga. Two isohyetal patterns are presented in Hydrometeorological Report No. 41 for this storm. The isohyetal pattern with downstream center would produce maximum rainfall on the middle portion of the watershed.
- The second storm described in Hydrometeorological Report No. 41 would produce PMP depths on the 7,980-square-mile watershed above Chattanooga and below the five major tributary dams. The isohyetal pattern for the 7,980-square-mile storm is not geographically fixed and can be moved parallel to the long axis, northeast and southwest, along the Tennessee Valley. The isohyetal pattern centered at Bulls Gap, Tennessee, would produce maximum rainfall on the upper part of the watershed.

Seasonal variations were also considered. The two seasons evaluated were March and June. The March storm was evaluated because the PMP was the maximum and surface runoff was also maximum. The June storm was evaluated because the June PMP was the maximum for the summer season and reservoir elevations were at their highest levels. Although September PMP is somewhat higher than in June, less runoff and lower reservoir levels more than compensate for the higher rainfall.

All PMP storms are nine-day events. A three-day antecedent storm was postulated to occur three days prior to the three-day PMP storm in all PMF determinations. Rainfall depths equivalent to 40% of the main storm were used for the antecedent storms with uniform areal distribution as recommended in Report No. 41.

A standard time distribution pattern was adopted for the storms based upon major observed storms transposable to the Tennessee Valley and in conformance with the usual practice of Federal agencies. The adopted distribution is within the limits stipulated in Chapter VII of Hydrometeorological Report No. 41. This places the heaviest precipitation in the middle of the storm. The adopted sequence closely conforms to that used by the U.S. Army Corps of Engineers.

The PMF discharge at the WBN was determined to result from the 21,400-square-mile storm producing PMP on the watershed with the downstream storm pattern, as defined in Hydrometeorological Report No. 41. The PMP storm would occur in the month of March and would produce 16.25 inches of rainfall in three days on the watershed above Chickamauga Dam. The storm producing the PMP would be preceded by a three-day antecedent storm producing 6.18 inches of rainfall, which would end three days prior to the start of the PMP storm. Precipitation temporal distribution is determined by applying the mass curve to the basin rainfall depths.

As described in WBN Unit 1 UFSAR Subsection 2.4.3.2, a multi-variable relationship, used in the day-to-day operation of the TVA reservoir system, has been applied to determine precipitation excess directly. The relationships were developed from observed storm and flood data. They relate precipitation excess to the rainfall, week of the year, geographic location, and antecedent precipitation index (API). In their application, precipitation excess becomes an increasing fraction of rainfall as the storm progresses in time and becomes equal to rainfall in the later part of extreme storms. An API determined from an 11-year period of historical rainfall records (1997-2007) was used at the start of the antecedent storm. The precipitation excess computed for the main storm is not sensitive to variations in adopted initial moisture conditions because of the large antecedent storm.

The average precipitation loss for the watershed above Chickamauga Dam is 2.33 inches for the three-day antecedent storm and 1.86 inches for the three-day main storm. The losses are approximately 38% of antecedent rainfall and 11% of the PMP, respectively. The precipitation loss of 2.33 inches in the antecedent storm compares favorably with that of historical flood events.

As described in WBN Unit 1 UFSAR Subsection 2.4.3.3, the runoff model used to determine Tennessee River flood hydrographs at WBN is divided into 40 unit areas and includes the total watershed above Chickamauga Dam. Unit hydrographs are used to compute flows from the unit areas. The unit area flows are combined with appropriate time sequencing or channel routing procedures to compute inflows into the most upstream tributary reservoirs which in turn are routed through the reservoirs using standard routing techniques. Resulting outflows are combined with additional local inflows and carried downstream using appropriate time sequencing or routing procedures including unsteady flow routing.

Unit hydrographs were developed for each unit area for which discharge records were available from maximum flood hydrographs either recorded at stream gauging stations or estimated from reservoir headwater elevation, inflow, and discharge data using the procedures described by Newton and Vineyard. For non-gauged unit areas synthetic unit graphs were developed from relationships of unit hydrographs from similar watersheds relating the unit hydrograph peak flow to the drainage area size, time to peak in terms of watershed slope and length, and the shape to the unit hydrograph peak discharge in cfs per square mile.

Tributary reservoir routings, except for Tellico and Melton Hill, were made using standard reservoir routing procedures and flat pool storage conditions. The main river reservoirs, Tellico, and Melton Hill routings were made using unsteady flow techniques.

Unsteady flow routings were computer solved with the Simulated Open Channel Hydraulics (SOCH) mathematical model based on the equations of unsteady flow. The SOCH model inputs include the reservoir geometry, upstream boundary inflow hydrograph, local inflows, and the downstream boundary headwater discharge relationships based upon operating guides or rating curves when the structure geometry controls.

Discharge rating curves are calculated for the reservoirs in the watershed at and above Chickamauga. The discharge rating curve for Chickamauga Dam is for the current lock configuration with all 18 spillway bays available. Above WBN, temporary flood barriers have been installed at four reservoirs (Watts Bar, Fort Loudoun, Tellico and Cherokee Reservoirs) to increase the height of embankments and are included in the discharge rating curves for these four dams. Increasing the height of embankments at these four dams prevents embankment overflow and failure of the embankment. The vendor supplied temporary flood barriers were shown to be stable for the most severe PMF headwater/tailwater conditions using vendor recommended base friction values. A single postulated Fort Loudoun Reservoir rim leak north of the Marina Saddle Dam which discharges into the Tennessee River at Tennessee River Mile (TRM) 602.3 was added as an additional discharge component to the Fort Loudoun Dam discharge rating curve. Seven Watts Bar Reservoir rim leaks were added as additional discharge components to the Watts Bar Dam discharge rating curve. Three of the rim leak locations discharge to Yellow Creek, entering the Tennessee River three miles downstream of Watts Bar Dam. The remaining four rim leak locations discharge to Watts Creek, which enters Chickamauga Reservoir just below Watts Bar Dam.

The specific unsteady flow and steady-state flow mathematical model configurations for upstream reservoirs and Chickamauga Reservoir are described further in WBN Unit 1 UFSAR Subsection 2.4.3.3.

The reservoir operating guides applied during the SOCH model simulations mimic, to the extent possible, operating policies and are within the current reservoir operating flexibility. In addition to spillway discharge, turbine and sluice discharges were used to release water from the tributary reservoirs. Turbine discharges were also used at the main river reservoirs up to the point where the head differentials are too small and/or the powerhouse would flood.

Median initial reservoir elevations for the appropriate season were used at the start of the PMF storm sequence. Use of median elevations is consistent with statistical experience and avoids unreasonable combinations of extreme events.

The flood from the antecedent storm occupies about 70% of the reserved system detention capacity above Watts Bar Dam at the beginning of the main storm (day seven of the event).

Reservoir levels are at or above guide levels at the beginning of the main storm in all but Fort Patrick Henry Reservoirs, which have no reserved flood detention capacity. As described in WBN Unit 1 UFSAR Subsection 2.4.3.4, the PMF discharge at WBN was determined to be 1,088,625 cfs. This flood would result from the 21,400-square-mile storm in March with a downstream orographically-fixed storm pattern. Chickamauga Dam downstream would be overtopped. The dam was postulated to remain in place, and any potential lowering of the flood levels at WBN due to dam failure at Chickamauga Dam was not considered in the resulting water surface elevation.

As described in WBN Unit 1 UFSAR Subsection 2.4.3.5, the controlling PMF elevation at the WBN was determined to be 739.2 ft, produced by the 21,400-square-mile storm in March and coincident with overtopping failure of the West Saddle Dike at Watts Bar Dam. Elevations were computed concurrently with discharges using the SOCH unsteady flow reservoir model.

As described in WBN Unit 1 UFSAR Subsection 2.4.3.6, some wind waves are likely when the probable maximum flood crests at WBN. The flood would be near its crest for a day beginning about two days after cessation of the probable maximum storm. The day of occurrence would be in the month of March or possibly the first week in April. Effective fetch accounts for the sheltering effect of several hills on the south riverbank which become islands at maximum flood levels. The maximum effective fetch in all cases, except for the west face of the WBN Intake Pumping Station (ISP) occurs from the northeast or east northeast direction. The maximum effective fetch for the west face of the IPS occurs from the west direction. The WBN Diesel Generator Building maximum effective fetch is 1.1 miles, and the critical west face of the IPS maximum effective fetch is 1.3 miles. The maximum effective fetch for the Auxiliary, Control, and Shield Buildings is 0.8 miles.

For the WBN plant site, the two-year extreme wind for the season in which the PMF could occur was adopted to associate with the PMF crest as specified in Regulatory Guide 1.59. The storm studies on which the PMF determination is based show that the season of maximum rain depth is the month of March. Wind velocity was determined from a statistical analysis of maximum March winds observed at Chattanooga, Tennessee.

Computation of wind waves used the procedures of the Corps of Engineers. Wind speed was adjusted based on the effective fetch length for over water conditions. For the Diesel Generator Building, the adjusted wind speed is 23.8 miles per hour. The IPS maximum adjusted wind speed is 24.2 miles per hour for the critical west face. For the Auxiliary, Control, and Shield Buildings the adjusted wind speed is 23.4 miles per hour.

For waves approaching the Diesel Generator Building, the maximum wave height (average height of the maximum 1 percent of waves) would be 1.7 ft high, crest to trough, and the significant wave height (average height of the maximum 33-1/3 percent of waves) would be 1.0 ft high, crest to trough. The corresponding wave period is 2.0 seconds. For the IPS, the maximum wave height would be 2.2 ft and the significant wave height would be 1.3 ft, with a corresponding wave period of 2.3 seconds. For the critical west face, the maximum wave height would be 1.9 ft high, and the significant wave height would be 1.1 ft high. The corresponding wave period is 2.1 seconds. The maximum wave height approaching the Auxiliary, Control, and Shield Buildings would be 1.5 ft high, and the significant wave height would be 0.9 ft high. The corresponding wave period is 1.9 seconds.

Computation of wind setup used the procedures of the Corps of Engineers. The maximum wind setup is 0.1 ft for all structures. Computation of run up used the procedures of the Corps of

Engineers. At the Diesel Generator Building, corresponding run up on the earth embankment with a 4:1 slope is 2.3 ft and reaches elevation 741.6 ft, including wind setup. The run up on the critical west face wall of the Intake Pumping Station is 2.1 ft and reaches elevation 741.7 ft, including wind setup. The configuration of the north face of the IPS, opposite of the intake channel, allows higher run up of 3.4 ft. The remaining south and east faces allow run up of 2.4 ft. However, there are no credible entry points to the structure on the north, south, or east faces. Therefore, the run up on these faces is discounted. The run up on the walls of the Auxiliary, Control, and Shield Buildings is 1.7 ft and reaches elevation 741.0 ft, including wind setup.

Run up does not exceed the design basis flood level for any of the structures. Additionally, run up at the Diesel Generator Building is maintained on the slopes approaching the structure and is below all access points to the building. Run up has no consequence at the Shield Building because the accesses and penetrations below run up are designed and constructed as watertight elements.

As described in WBN Unit 1 UFSAR Subsection 2.4.14, an evaluation is performed to determine the methods by which the WBN is capable of tolerating floods above plant grade without jeopardizing public safety. The design basis flood (DBF) is the calculated upper-limit flood that includes the PMF plus the wave run up caused by a 21 mph overland wind as discussed in WBN Unit 1 UFSAR Subsection 2.4.3.6. In the WBN LAR, the DBF elevations at various plant locations that would result for the controlling PMF are increased from those currently provided in the WBN Unit 1 UFSAR as follows:

Plant Location	Current DBF Level (ft.)	New DBF Level (ft.)
Probable Maximum Flood (still reservoir)	734.9	739.2
DBF Run up on 4:1 sloped surfaces	736.9	741.6
DBF Run up on critical vertical wall of the Intake Pumping Station	736.9	741.7
DBF Surge level within flooded structures	735.4	739.7

The DBF level on Watts Bar Lake is deleted in the WBN LAR proposed change.

Potential Dam Failures, Seismically Induced

As described in WBN Unit 1 UFSAR Subsection 2.4.4.1, the procedures described in Appendix A of Regulatory Guide 1.59 were followed when evaluating potential flood levels from seismically induced dam failures. The plant site and upstream reservoirs are located in the Southern n Tectonic Province and, therefore, subject to moderate earthquake forces with possible attendant failure. Upstream dams whose failure has the potential to cause flood problems at the plant were investigated to determine if failure from seismic events would endanger plant safety.

There are 12 major dams above WBN whose failure could influence plant site flood levels. These are Watts Bar and Fort Loudoun Dams on the Tennessee River; Watauga, South Holston, Boone, Fort Patrick Henry, Cherokee, and Douglas Dams above Fort Loudoun; and Norris, Melton Hill, Fontana, and Tellico Dams between Fort Loudoun and Watts Bar. These were examined individually, and in combinations, to determine if failure might result from a seismic event and, if so, would failure concurrent with storm runoff create maximum flood levels at the plant.

In accordance with the guidance of RG 1.59, Appendix A, seismic dam failure is examined using the two specified alternatives:

(1) the Safe Shutdown Earthquake (SSE) coincident with the peak of the 25-year flood and a two-year wind speed applied in the critical direction,
(2) the Operating Basis Earthquake (OBE) coincident with the peak of the one-half PMF and a two-year wind speed applied in the critical direction.

The OBE and SSE are defined in WBN Unit 1 UFSAR Subsections 2.5.2.4 and 2.5.2.7 as having maximum horizontal rock acceleration levels of 0.09 g and 0.18 g respectively. As described in WBN Unit 1 UFSAR Subsection 2.5.2.4, TVA agreed to use 0.18 g as the maximum bedrock acceleration level for the SSE.

From the seismic dam failure analyses made for TVA's operating nuclear plants, it was determined that five separate, combined events have the potential to create flood levels above plant grade at WBN. These events are as follows:

(1) The simultaneous failure of Fontana and Tellico Dams in the OBE coincident with one-half PMF.
(2) The simultaneous failure of Fontana, Tellico, Hiwassee, Appalachia, and Blue Ridge Dams in the OBE coincident with one-half PMF.
(3) The simultaneous failure of Norris and Tellico Dams in the OBE coincident with one-half PMF.
(4) The simultaneous failure of Cherokee, Douglas, and Tellico Dams in the OBE coincident with one-half PMF.
(5) The simultaneous failure of Norris, Cherokee, Douglas, and Tellico Dams in the SSE coincident with a 25-year flood.

Tellico has been added to all five combinations in the WBN LAR which was not included in the original analyses for TVA's operating nuclear plants. It was included because the seismic stability analysis of Tellico is not conclusive: therefore, Tellico was postulated to fail.
The runoff model of WBN Unit 1 UFSAR Subsection 2.4.3.3 was used to evaluate these potentially five critical seismic events involving dam failures above the plant. Reservoir operating procedures used were those applicable to the season and flood inflows.

As described in WBN Unit 1 UFSAR Subsection 2.4.4.2, unsteady flow routing techniques were used to evaluate plant site flood levels from postulated seismically induced dam failures wherever their inherent accuracy was needed. In addition to the flow models described in WBN Unit 1 UFSAR Subsection 2.4.3.3, the models described below were used to develop the outflow hydrographs from the postulated dam failures. The HEC-HMS storage routing was used to compute the outflow hydrograph from the postulated failure of each dam except main river dams. In the case of dams which were postulated to fail completely (Hiwassee, Appalachia and Blue Ridge), HEC-RAS or SOCH was used to develop the outflow hydrograph. For Tellico Dam, the complete failure was analyzed with the SOCH model.

The failure time and initial reservoir elevations for each dam were determined from a pre-failure TRBROUTE analysis. HEC-HMS was used to develop the post failure outflow hydrographs based on the previously determined dam failure rating curves. The outflow hydrographs were validated by comparing the HEC-HMS results with those generated by simulations using TRBROUTE.

As described in WBN Unit 1 UFSAR Subsection 2.4.4.3, the unsteady flow analyses of the five postulated combinations of seismic dam failures coincident with floods analyzed yields a maximum elevation of 731.17 ft at WBN excluding wind wave effects. The maximum elevation would result from the SSE failure of Norris, Cherokee, Douglas, and Tellico Dams coincident with the 25-year flood postulated to occur in June when reservoir levels are high.

Coincident wind wave activity for the PMF is described in WBN Unit 1 UFSAR Subsection 2.4.3.6. Wind waves were not computed for the seismic events, but superimposed wind wave activity from guide specified two-year wind speed would result in water surface elevations several feet below the PMF elevation 739.2 ft described in WBN Unit 1 UFSAR Subsection 2.4.3. Therefore, the DBF elevations described in Section 2.1 of this report are the limiting design basis flood hazard levels for external flood events originating offsite.

Effects of Local Intense Precipitation

As described in WBN Unit 1 UFSAR Subsection 2.4.2.3, all streams in the vicinity of the plant were investigated, including Yellow Creek, with probable maximum flows from a local storm and from breaching of the Watts Bar Dam West Saddle Dike and were found not to create potential flood problems at the plant. Local drainage which required detailed design is from the plant area itself and from a 150-acre area north of the plant.

The underground storm drainage system is designed for a maximum one-hour rainfall of four inches. The one-hour rainfall with 1% exceedance frequency is 3.3 inches. Structures housing safety-- related facilities, systems, and equipment are protected from flooding during a local PMF by the slope of the plant yard. The yard is graded so that the surface runoff will be carried to Chickamauga Reservoir without exceeding the elevation of the accesses given in WBN Unit 1 UFSAR Subsection 2.4.1.1. The exterior accesses that are below the grade elevation for that specific structure exit from that structure into another structure and are not exterior in the sense that they exit or are exposed to the environment. For any access exposed to the environment and located at grade elevation, sufficient drainage is provided to prevent water from entering the opening. This is accomplished by sloping away from the opening. PMP for the plant drainage systems has been defined for TVA by the Hydrometeorological Branch of the National Weather Service and is described in Hydrometeorological Report No. 56. Ice accumulation would occur only at infrequent intervals because of the temperate climate. Maximum winter precipitation concurrent with ice accumulation would impose less severe conditions on the drainage system than would the PMF.

In testing the adequacy of the site drainage system, all underground drains were assumed clogged. Peak discharges were evaluated using storm intensities for the maximum one-hour rainfall obtained from the PMP mass curve. Runoff was assumed equal to rainfall. Each watershed was analyzed using the more appropriate of two methods: (1) when flow conditions controlled, standard-step backwater from the control section using peak discharges estimated from rainfall intensities corresponding to the time of concentration of the area above the control or (2) when ponding or reservoir-type conditions controlled, storage routing the inflow hydrograph equivalent to the PMP hydrograph using two-minute time intervals.

Computed maximum water surface elevations are below critical floor elevation 729.0 ft. Runoff from the employee parking lot and the areas south of the office building and west of the Turbine Building will flow along the perimeter road west of the switchyard and drain into the area surrounding the chemical holding ponds. The control is the drainage ditch and road which acts as a channel between the west end of the switchyard and the embankment to the west. To be conservative it was assumed water would not flow into the switchyard. Maximum water surface elevations at the office and Turbine Buildings computed using method (1) were less than elevation 729.0 ft.

Flow from the area west of the Service, Auxiliary, Reactor, and Diesel Generator Buildings and north of the office building and gatehouse will drain along and then across the perimeter road, flow west through a swale and across the low point in the access road. The swale and the roads have sufficient capacity to keep water surface elevations below 729.0 ft at all buildings. Method (1) was used in this analysis.

The area east of the Turbine, Reactor, and Diesel Generator Buildings forms a pool bounded by the main and transformer yard railroad tracks with top of rail elevations at 728.0 ft and 728.25 ft respectively. Method (2) was used to route the inflow hydrograph through this pool from an initial elevation of 728.0 ft with outflow over the railroads. Maximum water surface elevations at the Turbine and Reactor Buildings were less than elevation 729.0 ft. Use of method (1) starting just downstream of the railroad confirmed this result.

The flow from the area east of the Turbine, Reactor, and Diesel Generator Buildings over the railroad north of the east-west baseline drains north along a channel between the main railroad and the essential raw cooling water (ERCW) maintenance road and east between the ERCW maintenance road and the north cooling tower. Flow over the railroad south of the east-west baseline drains south along a channel between the storage yard road and the switchyard past the storage yard to the river. Analysis using method (1) shows that flow over the Diesel Generator Building road controls the elevations at the Turbine and Reactor Buildings. Maximum water surface elevations were computed to be less than elevation 729.0 ft.

Flow from the switchyard and transformer yard will drain to the east, west, and south. Maximum water surface elevations at the Turbine Building obtained using method (2) were less than elevation 729.0 ft.

Flow from the 150-acre drainage area north of the site drains two ways: (1) 50 acres drain east through the double 96-inch culvert under the access railroad and (2) drainage from the remaining 100 acres is diverted to the west through an 81-inch by 59-inch pipe arch and, when flows exceed the pipe capacity, south over a swale in the construction access road. The flow over the construction access road drains to the west across the access highway. The following information provides details of the analysis.

The discharge hydrograph for the 100-acre area north of the plant and upstream from the construction access road was determined using a dimensionless unit graph based upon Soil Conservation Service (SCS) procedures and PMP defined by the National Weather Service. The PMP mass curve used in the determination is shown on WBN Unit 1 UFSAR Figure 2.4-40h. Runoff was assumed equal to rainfall. The construction access road will act as a dam with the 81-inch by 59-inch pipe arch acting as a low-level outlet. Flow is prevented from draining to the east above the construction access road by a dike with top elevation at 736.5 ft (dike location and cross-section shown on WBN Unit 1 UFSAR Figure 2.4-40c). The profile of the construction access road and the location of the pipe arch are shown on WBN Unit 1 UFSAR Figure 2.4-40c. The discharge hydrograph was routed using two-minute time intervals through the pipe arch and over the construction access road using standard storage routing techniques. The rating curve for flow over the construction access road was developed from critical flow relationships with losses assumed equal to 0.5 $V^2/2g$.

The maximum elevation reached at the construction access road was 735.28 ft. The pipe arch is designed for AASHTO H-20 loading which we judge is adequate for the loading expected. In the unlikely event of pipe arch failure and flow blockage, the maximum flood level at the construction access road would increase only 0.12 ft, from elevation 735.28 ft to 735.4 ft. The peak flow over the construction road was used in computations.

Flow over the construction access road discharges into the 67-acre area west of the Service, Auxiliary, Reactor, and Diesel Generator Buildings and north of the office building and gatehouse before flowing west across the access highway. Flow from 60 additional acres to the northwest of the site is also added to this area just upstream of the main access road.

Elevations for the area west of the Service, Auxiliary, Reactor, and Diesel Generator Buildings and north of the office building and gatehouse were examined to include these additional flows. Backwater was computed from downstream of the access highway, crossing the perimeter road, to the Reactor, Diesel Generator, and Waste Evaporation System Buildings. The elevation at the access highway control was computed conservatively assuming that the peak flows from this area and over the construction road added directly. The maximum flood elevation reached in the main plant area was less than elevation 729.0 ft.

The discharge hydrograph for the 50-acre area north of the plant was conservatively assumed equivalent to the PMP hydrograph using 2 minute time intervals. This hydrograph was routed using two-minute time intervals through the double 96-inch culvert using standard storage routing techniques.

The maximum elevation reached at the culvert was 725.67 ft. Flow is prevented from entering the main plant area by site grading.

WBN Unit 1 UFSAR Table 2.4-9 provides a description of drainage area, estimated peak discharge, and computed maximum water surface elevation for each subwatershed investigated in the site drainage analysis.

A local PMF on the holding pond does not pose a threat with respect to flooding of safety-related structures. The top of the holding pond dikes is set at elevation 714.0 ft, whereas water level must exceed the plant grade at elevation 728.0 ft before safety-related structures can be flooded. A wide emergency spillway is cut in original ground at an elevation 2 ft below the top of the dikes. During a local PMF the water trapped by the pond rise will be considerably less than the 14-ft difference between the top of the dikes and plant grade.

Flooding Protection Requirements

As described in WBN Unit 1 UFSAR Subsection 2.4.14, the plant grade elevation at WBN can be exceeded by large rainfall (PMP) and seismically-induced dam failure floods. The limiting flood event for establishing the limiting DBF elevations for the protection of equipment results from the limiting PMP event.

Large Rainfall (PMP) Floods

As described in WBN Unit 1 UFSAR Subsection 2.4.14.1.1, in addition to flood level considerations, plant flood preparations cope with the "fastest rising" flood which is the calculated flood, including seismically induced dam failure floods that can exceed plant grade with the shortest warning time. Reservoir levels for large rainfall floods in the Tennessee Valley can be predicted well in advance. By dividing the pre-flood preparation steps into two stages, a minimum of a 27 hour, pre-flood transition interval is available between the time a flood warning is received and the time the flood waters exceed plant grade. The first stage, a minimum of 10 hours long, commences upon receipt of a flood warning. The second stage, a minimum of 17 hours long, is based on a confirmed estimate that conditions will produce a flood above plant grade. This two-stage scheme is designed to prevent excessive economic loss in case a potential flood does not fully develop.

"Flood mode" operation is defined as the set of conditions described below by means of which the plant is safely maintained during the time when flood waters exceed plant grade (elevation 728.0 ft) and during the subsequent period until recovery is accomplished. The steps needed to prepare the plant for flood mode operation can be accomplished within 24 hours of notification that a flood above plant grade is expected. An additional 3 hours are available for contingency margin.

As described in WBN Unit 1 UFSAR Subsection 2.4.14.8.1, protection of WBN from rainfall floods that might exceed plant grade utilizes a flood warning issued by TVA's River Operations (RO). TVA's climatic monitoring and flood forecasting systems and flood control facilities permit early identification of potentially critical flood producing conditions and reliable prediction of floods which may exceed plant grade well in advance of the event.

The WBN flood warning plan provides a minimum of 27 hours to prepare for operation in the flood mode, 3 hours more than the 24 hours needed. Four additional preceding hours would be available to gather and analyze rainfall data and produce the warning. The first stage, Stage I, of shutdown begins when there is sufficient rainfall on the ground in the upstream watershed to yield a forecasted plant site water level of elevation 715.5 ft in the winter months and elevation 720.6 ft in the summer. This assures that additional rain will not produce water levels to elevation 727.0 ft in less than 27 hours from the time shutdown is initiated. The water level of elevation 727.0 ft (one ft below plant grade) allows margin so that waves due to winds cannot disrupt the flood mode preparation.

The plant preparation status is held at Stage I until either Stage II begins or TVA's RO determines that floodwaters will not exceed elevation 727.0 ft at the plant. The Stage II warning is issued only when enough additional rain has fallen to forecast that elevation 727.0 ft (winter or summer) is likely to be reached.

As described in WBN Unit 1 UFSAR Subsection 2.4.14.9.1, TVA flood forecast procedures are used to provide at least 27 hours of warning before river levels reach elevation 727.0 ft. Use of elevation 727.0 ft, one ft below plant grade, provides adequate margin to prevent wind generated waves from endangering plant safety during the final hours of plant shutdown activity. Forecast will be based upon rainfall already reported to be on the ground.

As described in WBN Unit 1 UFSAR Subsection 2.4.14.8.2, three postulated combinations of seismically induced dam failures and coincident storm conditions were shown to result in floods which could exceed elevation 727.0 ft at the plant. WBN’s notification of these floods utilizes TVA’s RO forecast system to identify when a critical combination exists. Stage I shutdown is initiated upon notification that a critical dam failure combination has occurred or loss of communication prevents determining a critical case has not occurred. Stage I shutdown continues until it has been determined positively that critical combinations do not exist. If communications do not document this certainty, shutdown procedures continue into Stage II activity. Stage II shutdown continues to completion or until lack of critical combinations is verified.

As described in WBN Unit 1 UFSAR Subsection 2.4.14.9.3, the forecast procedure to assure safe shutdown of WBN for flooding is based upon an analysis of nine hypothetical storms up to PMP magnitude. The storms enveloped potentially critical areal and seasonal variations and time distributions of rainfall. To ensure that fastest rising flood conditions were included, the effects of varied time distribution of rainfall were tested by alternatively placing the maximum daily PMP in the middle, and the last day of the three-day main storm. Earlier analysis of 17 hypothetical storms demonstrated that the shortest warning times resulted from storms in which the heavy rainfall occurred on the last day and that warning times were significantly longer when heavy rainfall occurred on the first day. Therefore, heavy rainfall on the first day was not reevaluated. The warning system is based on those storm situations which resulted in the shortest time interval between watershed rainfall and elevation 727.0 ft at WBN, thus assuring that this elevation could be predicted at least 27 hours in advance. The procedures used to compute flood flows and elevations for those flood conditions which establish controlling elements of the forecast system are described in WBN Unit 1 UFSAR Subsection 2.4.3.

As described in WBN Unit 1 UFSAR Subsection 2.4.14.9.4, a minimum of 27 hours has been allowed for preparation of the plant for operation in the flood mode, three hours more than the 24 hours needed. An additional 4 hours for communication and forecasting computations is provided to allow TVA's RO to translate rain on the ground to river elevations at the plant. Hence, the warning plan provides 31 hours from arrival of rain on the ground until elevation 727.0 ft could be reached. The 27 hours allowed for shutdown at the plant consists of a minimum of 10 hours of Stage I preparation and an additional 17 hours for Stage II preparation that is not concurrent with the Stage I activity.

Although river elevation 727.0 ft, one ft below plant grade to allow for wind waves, is the controlling elevation for determining the need for plant shutdown, lower forecast target levels are used in some situations to assure that the 27 hours pre-flood transition interval will always be available. The target river levels differ with season.

During the "winter" season, Stage I shutdown procedures will be started as soon as target river elevation 715.5 ft has been forecast. Stage II shutdown will be initiated and carried to completion if and when target river elevation 727.0 ft at WBN has been forecast. Corresponding target river elevations for the "summer" season at WBN are elevation 720.6 ft and elevation 727.0 ft.

Even though the hydrologic procedures and target river elevations have been designed to provide adequate shutdown time in the fastest rising flood, longer times will be available in other floods. In such cases there may be a waiting period after the Stage I, 10-hour shutdown activity during which activities shall be in abeyance until weather conditions determine if plant operation can be resumed, or if Stage II shutdown should be implemented.

Resumption of plant operation following just Stage I shutdown activities will be allowable only after flood levels and weather conditions, as determined by TVA's RO, have returned to a condition in which 27 hours of warning will again be available.

Seismically-Induced Dam Failure Floods

As described in WBN Unit 1 UFSAR Subsection 2.4.14.10, plant grade would be exceeded by three of the five candidate seismic failure combinations evaluated, thus requiring emergency measures. The seismic dam failure combination, the SSE failure of Norris, Cherokee, Douglas and Tellico Dams concurrent with the 25-year flood would result in a maximum flood elevation of 731.17 ft at WBN. The OBE failure of Norris and Tellico Dams and the OBE failure of Cherokee, Douglas, and Tellico Dams concurrent with the one-half PMF would result in flood elevations above WBN plant grade.

The times from seismic failure to the time elevation 727.0 ft is reached at WBN in the three critical events is about 35, 27, and 44 hours as shown in WBN Unit 1 UFSAR Figures 2.4-114, 2.4-115, and 2.4-116 for the Norris, Cherokee, Douglas and Tellico Dams SSE failure combination, the Norris and Tellico Dams OBE failure combination and the Cherokee, Douglas, and Tellico Dams OBE failure combinations, respectively. These times are adequate to permit safe plant shutdown in readiness for flooding.

Dam failure during non-flood periods was not evaluated, but would be bounded by the three critical failure combinations.

The warning scheme for safe plant shutdown is based on the fact that a combination of critically centered large earthquake conditions must coincide before the flood wave from seismically caused dam failures will approach plant grade. In flood situations, an extreme earthquake must be precisely located to fail Norris, Cherokee, Douglas, and Tellico Dams before a flood threat to the site would exist. This would also be the case with the failure of Norris and Tellico. Cherokee and Douglas Dams failures could occur when the OBE is located midway between the dams which are just 15 miles apart.

The warning system utilizes TVA's RO flood forecast system to identify when flood conditions will be such that seismic failure of critical dams could cause a flood wave to approach elevation 728.0 ft at the plant site. In addition to the critical combinations, failure of a single major upstream dam will lead to an early warning. A Stage I warning is declared once failure of (1) Norris, Cherokee, Douglas, and Tellico Dams or (2) Norris and Tellico Dams or (3) Cherokee, Douglas and Tellico Dams has been confirmed.

If loss of or damage to an upstream dam is suspected based on monitoring by TVA's RO, efforts will be made by TVA to determine whether dam failure has occurred. If the critical case has occurred or it cannot be determined that it has not occurred, Stage I shutdown will be initiated. Once initiated, the flood preparation procedures will be carried to completion unless it is determined that the critical case has not occurred.

Flood Recovery

As described in WBN Unit 1 UFSAR Subsection 2.4.14.1.3, because of the improbability of a flood above plant grade, no detailed procedures are established for return of the plant to normal operation unless a flood actually occurs. If flood mode operation should become necessary, it is possible to maintain this mode of operation for a sufficient period of time (100 days) so that appropriate recovery steps can be formulated and taken. The actual flood waters are expected to recede below plant grade within 1 to 5 days.

3.0 PREVENTION AND MITIGATION FEATURES

2b - Describe protection and mitigation features that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety.

The WBN protection and mitigation features that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety are described in WBN Unit 1 UFSAR Subsection 2.4.14, Flooding Protection Requirements, and assurance that WBN can be safely shut down and maintained in these extreme flood conditions is provided by the discussions given in WBN Unit 1 UFSAR Subsections 3.4, 3.8.1, and 3.8.4. However, the protection and mitigation features described in WBN Unit 1 UFSAR Section 2.4 are being revised as described in a License Amendment Request (LAR) submitted July 19, 2012, "Application to Revise Watts Bar Nuclear Plant Unit 1 Updated Final Safety Analysis Report Regarding Changes to Hydrologic Analysis, TAC No. ME8200 (WBN-UFSAR-12-01)." The flooding evaluation report is based on the LAR updated descriptions of the protection and mitigation features that are considered in the licensing basis evaluation to protect against external ingress of water into SSCs important to safety, and are further described below as presented in the WBN LAR.

Flooding Protection Design Features

As described in WBN Unit 1 UFSAR Subsection 3.8.1.1, the Shield Building is a reinforced concrete cylinder supported by a circular base slab and covered at the top with a spherical dome. It is located adjacent to the concrete Auxiliary and Valve Room Buildings and is physically separated from them by a one-inch fiberglass-filled expansion joint. There is a polyvinyl chloride seal placed in formed grooves on the face of the Shield Building where it abuts the Auxiliary Building, thus providing water tightness between the two buildings up to grade level of elevation 728.0 ft. The seal is embedded in the groove with epoxy adhesive mortar. The Shield Building is maintained watertight to elevation 742.0 ft.

As described in WBN Unit 1 UFSAR Subsection 3.8.4.1.1, the Auxiliary Building is a multistory reinforced concrete structure that provides housing for the Engineered Safety Feature Systems, which are necessary to the two reactor units. The Auxiliary Building is separated from the Reactor Buildings by a one-inch expansion joint filled with fiberglass insulation that prevents interaction of the buildings when subjected to seismic motion. Seals are provided in the expansion joint to prevent the inleakage of either water or air since the Auxiliary Building, at times, serves as secondary containment. Below grade the seals, which consist of a polyvinyl chloride (PVC) material, are designed to withstand external water pressure, possible detrimental effects of the environment, the anticipated horizontal seismic movement of the buildings, and an assumed differential settlement of 1 inch between the buildings without loss of integrity.

As described in WBN Unit 1 UFSAR Subsection 3.8.4.1.2, the Diesel Generator Building is a two-story rectangular reinforced concrete box-type structure that houses the diesel generators and associated auxiliary equipment. Interior walls of reinforced concrete separate the diesel generators into four compartments. The diesel fuel storage tanks are embedded in the base slab. The four exterior doors along the north wall of the Diesel Generator Building are at elevation 742.0 ft in the north wall of the Diesel Generator Building along with removable bulkheads above the doors provide closures for the 11 feet - 10 inches high by 8 feet - 8 inches wide access openings to the diesel generator units.

As described in WBN Unit 1 UFSAR Subsection 3.8.4.1.3, the pipe tunnels housing the piping extending from the primary and refueling water tanks to the Auxiliary Building are concrete box-type structures that vary in width and height. Protection against flooding of the Auxiliary Building in case of a tank or pipe rupture is provided by walls that separate the tanks from the main tunnel.

As described in WBN Unit 1 UFSAR Subsection 3.8.4.1.4, the manholes and duct runs that house the electrical cables that must remain in operation when flood levels rise above the plant grade and emergency power is required for safe shutdown of the plant lie in soil overburden that varies in depth from 30 to 35 feet. The Category 1E manholes are rectangular box-type structures of reinforced concrete built below plant grade with an access shaft projecting above the surrounding soil. Category 1E manholes are equipped with watertight covers and sump pumps.

As described in WBN Unit 1 UFSAR Subsection 3.8.4.1.6, the IPS is a cellular box-type, reinforced concrete, waterfront structure founded on bedrock and partially backfilled on three sides. On the land side, retaining walls hold back the fill to elevation 710.0 ft. Permanent openings are provided in the reservoir side of the pumping station to allow flooding of any unwatered pump wells when the reservoir level exceeds elevation 690.0 ft. The ERCW pumps, fire protection pumps, and screen wash pumps are located on the upper deck at elevation 741.0 ft above the PMF and are covered by a roof. This deck is completely enclosed by a concrete wall 13 feet high. The ERCW pumps are located on the deck at elevation 728.0 ft, which is below the PMF, but are not required for maintenance of plant safety. The mechanical and electrical equipment are located on the floors at elevation 722.0 ft and 711.0 ft, respectively. The heads of the travelling water screens, including drive components, are located above the PMF level. The screens are designed to operate during any flood, including a PMF, with water to elevation 737.5 ft and a two foot, six inch head loss above elevation 705.0 ft.

Plant Operation During Floods Above Grade

As described in WBN Unit 1 UFSAR Subsection 2.4.14.2, "flood mode" operation is defined as the set of conditions described below by means of which the plant is safely maintained during the time when flood waters exceed plant grade (elevation 728.0 ft) and during the subsequent period until recovery is accomplished.

As described in WBN Unit 1 UFSAR Subsection 2.4.14.2.1, the Reactor Building will be maintained dry during the flood mode. Walls and penetrations are designed to withstand static and dynamic forces imposed by the DBF; minor seepage through the concrete walls and through the leading penetrations into the annulus will be allowed to flow to the Reactor Building floor and equipment drain sump by removing the blind flange on penetration X-118. The Reactor Building floor and equipment drain sumps are capable of pumping this flow.
The Diesel Generator Buildings also will remain dry during flood mode operation since the lowest floor is at elevation 742.0 ft. Other structures, including the Service, Turbine, Auxiliary, and Control Buildings, will be allowed to flood as the water exceeds their grade level entrances. Equipment that is located in these structures and required for operation in the flood mode operation is either above the DBF or suitable for submerged operation.

Fuel Cooling

As described in WBN Unit 1 UFSAR Subsection 2.4.14.2.2, fuel in the spent fuel pool is cooled by the Spent Fuel Pool Cooling and Cleanup System (SFPCCS), the active components of which are located above PMF. During the flood mode of operation, heat is removed from the heat exchangers by essential raw cooling water instead of component cooling water. The SFPCCS cooling circuit is assured of two operable SFPCCS pumps (a third pump is available as a backup) as well as two SFPCCS heat exchangers. High spent fuel pool temperature is annunciated in the Main Control Room indicating equipment malfunction. Additionally, that portion of the cooling system above flood water is inspected approximately every eight hours to confirm continued proper operation. As a backup to spent fuel cooling, water from the High Pressure Fire Protection (HPFP) System can be added to the spent fuel pool.

Residual core heat is removed from the fuel in the reactors by natural circulation in the reactor coolant system. Heat removal from the steam generators is accomplished by adding river water from the HPFP System and relieving steam to the atmosphere through the power operated relief valves. This transition from auxiliary feedwater to river water is accomplished during Stage II of the flood preparation procedures. Reactor coolant system pressure is maintained at less than 350 psig by operation of the pressurizer relief valves and heaters. Secondary side pressure is maintained below 125 psig by operation of the power operated relief valves. At times beyond approximately ten hours following shutdown of the plant two relief valves have sufficient capacity to remove the steam generated by decay heat. Since ten hours is less than the minimum flood warning time available, the plant can be safely shut down and decay heat removed by operation of two power operated relief valves per unit.

The earliest that the HPFP pumps would be utilized to supply auxiliary feedwater would be about 20 hours after reactor shutdown. At this time, in order to remove the decay heat from the reactor unit, the water requirement to the steam generators would be approximately 300 gpm. Following reactor shutdown a gradually decreasing HPFP system makeup water flow rate would be required. With the steam generator secondary side pressure less than 125 psig, a single HPFP pump can supply makeup water well in excess of the requirement of 300 gpm. Additional surplus flow is available since there are four HPFP pumps, two powered from each emergency power train.

The main steam power operated relief valves are adjusted by controls in the auxiliary control room as required to maintain the steam pressure within the desired pressure range. The controls in the main control room also can be utilized to operate the valves in an open-closed manner. Also, a manual loading station and the relief valve handwheel provide additional backup control for each relief valve.

The power operated relief valves would be used to depressurize the steam generators as discussed above to maintain steam generator pressure sufficiently below the developed head of the fire pumps. Note that even in the event of a total loss of makeup water flow at the time of maximum decay heat load, approximately six hours are available to restore makeup water flow before the steam generators boil dry.

If the reactor is open to the containment atmosphere during the refueling operations, then the decay heat of the fuel in the reactor and spent fuel pool heat is removed in the following manner. The refueling cavity is filled with borated water (nominal ppm boron concentration) from the refueling water storage tank. The SFPCCS pump takes suction from the spent fuel pool and discharges to the SFPCCS heat exchangers. The SFPCCS heat exchanger output flow is directed by a temporary piping connection to the Residual Heat Removal (RHR) System upstream to the RHR heat exchangers. This piping (spool piece) connection is prefabricated and is installed only during preparation for flood mode operation.

After passing through the RHR heat exchangers, the water enters the reactor vessel through the normal cold leg RHR injection paths, flows downward through the annulus, upward through the core (thus cooling the fuel), then exits the vessel directly into the refueling cavity. This results in a water level differential between the spent fuel pool and the refueling cavity with sufficient water head to assure the required return flow through the 20-inch diameter fuel transfer tube thereby completing the path to the spent fuel pool.

Any leakage from the reactor coolant system will be collected to the extent possible in the reactor coolant drain tank; nonrecoverable leakage is made up from supplies of clean water stored in the four cold leg accumulators, the pressurizer relief tank, and the demineralized water tank. Even if these sources are unavailable, the fire protection system can be connected to the auxiliary charging system as a backup. Whatever the source, makeup water is filtered, demineralized, tested, and borated, as necessary, to the normal refueling concentration, and pumped by the auxiliary charging system into the reactor vessel.

Cooling of Plant Loads

As described in WBN Unit 1 UFSAR Subsection 2.4.14.2.3, plant cooling requirements with the exception of the fire protection system which must supply makeup water to the steam generators, are met by the ERCW System. The IPS is designed to retain full functional capability of the ERCW system and HPFP system water intakes for all floods up to and including the DBF. The ERCW System and HPFP System water intakes also remain fully functional in the remote possibility of a flood induced failure of Chickamauga Dam.

Preparations for Flood Mode, Reactor Initially Operating at Power

As described in WBN Unit 1 UFSAR Subsection 2.4.14.4.1, if the reactor is operating at power, Stage I and then, if necessary, Stage II procedures are initiated. Stage I procedures consist of a controlled reactor shutdown and other easily revocable steps, such as moving flood mode supplies above the PMF elevation and making load adjustments on the onsite power supply. After reactor scram, the reactor coolant system is cooled by the auxiliary feedwater system and the pressure is reduced to less than 350 psig.

Stage II procedures are the less easily revocable and more damaging steps necessary to have the plant in the flood mode when the flood exceeds plant grade. HPFP System water will replace auxiliary feedwater for steam generator makeup water. Other essential plant cooling loads are transferred from the Component Cooling Water System to the ERCW System and the ERCW replaces raw cooling water to the ice condensers. The radioactive waste system will be secured by filling tanks below DBF level with enough water to prevent flotation. One exception is the waste gas decay tanks, which are sealed and anchored against flotation. Power and communication cables below the DBF level that are not required for submerged operation are disconnected, and batteries beneath the DBF level are disconnected.

Preparations for Flood Mode, Reactor Initially Refueling

If time permits, fuel is removed from the unit undergoing refueling and placed in the spent fuel pool; otherwise fuel cooling is accomplished as described in WBN Unit 1 UFSAR Subsection 2.4.14.2.2. If the refueling canal is not already flooded, the mode of cooling described in WBN Unit 1 UFSAR Subsection 2.4.14.2.2 requires that the canal be flooded with borated water from the refueling water storage tank. If the flood warning occurs after the reactor vessel head has been removed or at a time when it could be removed before the flood exceeds plant grade, the flood mode reactor cooling water flows directly from the vessel into the refueling cavity.
Flood mode operation requires that the prefabricated piping be installed to connect the RHR and SFPC Systems, that the proper flow to the spent fuel pit diffuser and the RHRS be established and that essential raw cooling water be directed to the secondary side of the RHRS and SFPCCS heat exchangers. The connection of the RHR and SFPC Systems is made using prefabricated in-position piping which is normally disconnected. During flood mode preparations, the piping is connected using prefabricated spool pieces.

4.0 FLOOD WARNING SYSTEMS

2c - Describe any warning systems to detect the presence of water in rooms important to safety

There are no water level detection devices at WBN credited for detection of external flooding.

As discussed in WBN UFSAR Section 2.4.2.2, safety-related facilities, systems and equipment located in the containment structure are protected from flooding by the shield building. All accesses and penetrations below the maximum flood level in the shield building are designed and constructed as water tight elements. Although not credited for detection or mitigation of external flooding, WBN UFSAR Section 5.2.7.3.2 discusses that the reactor building floor and equipment drain sump level is monitored continuously by two level detecting devices. The pocket sump, located inside the reactor building containment floor and equipment drain sump in order to isolate the drain system inside the crane wall, is also continuously monitored by two level detecting devices.

As discussed in the WBN UFSAR, Section 2.4.2.2, Flood Design Considerations, the turbine, control and auxiliary buildings will be allowed to flood for conditions where flooding exceeds plant grade. As such, no equipment within the plant is credited for detection of external flooding as a means to mitigate an external flood. However, as discussed in WBN UFSAR Section 6.3.2.11, System Reliability, a flood detection system utilizing water level detector devices is used to monitor and actuate alarms for ECCS and other leakage at specific locations in the Auxiliary Building. Individual detectors are located in each ECCS pump compartment, in the ECCS heat exchanger rooms, and in the pipe gallery for each unit. A common alarm in the main control room will alert the operator when any of these flood detectors are tripped. A flood detector indicator panel, located immediately outside the control room, then identifies the exact location of the tripped detector.

5.0 EFFECTIVENESS OF FLOOD PROTECTION SYSTEMS

2d - Discuss the effectiveness of flood protection systems and exterior, incorporated, and temporary flood barriers. Discuss how these systems and barriers were evaluated using the acceptance criteria developed as part of Requested Information Item 1.h.

TVA used the industry developed and NRC endorsed guidance (NEI 12-07) for assessment of the effectiveness of flood protection systems and flood barriers. A significant aspect of the flood protection for WBN is implementation of operations, maintenance and chemistry procedures to maintain the plant in a safe condition in the event the flood exceeds plant grade. TVA used NEI 12-07 guidance for assessment of the flood response procedures.

Reasonable Simulation of Flood Mode Response Procedures

WBN is designed to withstand a flood up to plant elevation 727 ft. and still maintain normal services and functions. If the flood level should exceed plant grade (EL 728 ft.), the Auxiliary, Control, Turbine, and Service Buildings and electrical equipment room at the IPS will be flooded. In this event reactor core decay heat will be removed by the flood protection provisions designed to remain operational up to the design basis flood elevation in accordance with position 2 of the Regulatory Guide 1.59.

TVA's climatic monitoring and flood predicting systems and flood control facilities allow rainfall floods which could exceed plant grade to be reliably predicted well in advance. Notification will be given to WBN at least 27 hours in advance of any rainfall flood that could exceed plant grade.

The flood response is governed by an Abnormal Operating Instruction (AOI) for flood response. Maintenance and operations activities are directed from this AOI to align systems and components for flood mode operation. These activities are required by the AOI to be completed within 17 hours of notification of a Stage II flood alert. Coupled with the minimum time of 10 hours for Stage I, preparations results in a required total preparation time of 27 hours for the AOI actions.

Consistent with NEI 12-07 a reasonable simulation was performed of the AOI. This included reasonable simulation of additional AOIs required in the implementation of the governing AOI. It also included reasonable simulation of maintenance procedures required in the implementation of the governing AOI.

A currently licensed Senior Reactor Operator (SRO) stepped through the procedure and, with the assistance of maintenance, chemistry, engineering and Assistant Unit Operators (AUO), determined the time and resources required to complete each step. These determinations were made based on firsthand knowledge of the personnel performing the simulation of the location and complexity of the activities. Operators also performed a reasonable simulation in the field of one AOI in which an AUO simulated manipulation of electrical switchgears to establish time and resource requirements.

Reasonable simulations for eight of the maintenance procedures determined to be the most challenging to the overall timeline, were performed in the field to develop timelines and resource requirements. These simulations included personnel simulations of activities required to complete the procedures, including locating tools and temporary flood mode components. Additionally one spool piece was partially rigged and lifted and maintenance tasks for stud removal were performed to establish time estimates of the activities. A timeline was developed using this data to determine the overall time and resources required to complete flood preparations.

NEI 12-07 guidance Form D was completed for each procedure reviewed in the simulation.

Effectiveness of Maintenance Procedures

Implementation of maintenance activities addressed in the reasonable simulation requires special tools, spool pieces, gaskets and other temporary flood mode components. Walkdowns were performed to confirm availability and material condition of these components to ensure the ability to respond to the PMF event. These walkdowns were documented on Form C of NEI 12-07.

Civil features

Site grading is designed such that water resulting from a local PMP will run away from the Auxiliary, Control and Shield Buildings.

The civil review of the current design and licensing included a review of the existing site calculations, topography and any changes to the site topography that was used as the licensing basis flood evaluation. Field observations were performed in accordance with NEI 12-07.

Effectiveness of Flood Mode Barriers

The Thermal Barrier Booster Pumps (TBBP) are located on Elevation 737.0 ft. in the Auxiliary Building. The TBBP's are intended to remain dry (not submerged) and functioning during a PMF event. A temporary flood protection barrier is installed around these TBBPs. The barrier was visually inspected in accordance with NEI 12-07.

Penetrations in the Shield Building below the PMF elevation are designed and constructed as watertight elements. The annulus between the Shield Building wall and the Steel Containment Vessel is maintained at a negative pressure during normal operation, any degradation in performance of the vacuum boundary would be addressed per Technical Specifications. Penetrations below elevation 742 ft. were visually inspected in accordance with NEI 12-07.

The personnel access doors at elevation 741 ft. in the IPS require installation of temporary flood barriers, completed during Stage I preparations. Materials required for the temporary barriers are located local to the doors and were visually inspected in accordance with NEI 12-07.

6.0 IMPLEMENTATION OF THE WALKDOWN PROCESS

2e - Present information related to the implementation of the walkdown process (e.g., details of selection of the walkdown team and procedures,) using the documentation template discussed in Requested Information Item 1.j, including actions taken in response to the peer review.

Walkdown Team Selection and Training

The WBN external flood protection features were visually inspected and operator and maintenance actions were reasonably simulated in accordance with NEI Guidance document 12-07. The NEI walkdown record forms included in Appendix B of the guidance document were used as a template for the inspections.

Training was provided, as recommended in the guidance document and TVA procedure CTP-FWD-100. Team members performing walkdowns completed the Nantel Flood Protection Training and the complete team was provided site specific training prior to performing the inspections. The content of this training was consistent with the recommendations included in the guidance document, NEI 12-07 Appendix C – "Sample Training Content."

The walkdown team was made up of four engineers consisting of one nuclear engineer, one structural engineer, one mechanical engineer, and one civil engineer with extensive experience that met the qualifications provided in the guidance document. The walkdown team was supported by a retired SRO, active maintenance personnel and active assistant unit operators in planning and performance of the walkdowns. This team and an active SRO, chemistry and Health Physics personnel assisted in the completion of the reasonable simulations.

Flooding Walkdown Scope

As defined in NEI 12-07 the flooding walkdowns included review of plant response procedures for external floods and visual inspection and verification of incorporated or exterior equipment important to safety to identify degraded, nonconforming, or unanalyzed conditions. This report reflects the results of those end user inspections.

Continuing Inspections

Based on identification of the WBN two main control room chilled water circulating pumps and two shutdown board room chilled water circulating pumps that were determined to be partially submerged during a PMF, TVA identified subcomponents that had not been inspected as part of the walkdown scope, as defined in NEI 12-07. TVA expanded its scope to include visual inspection of subcomponents and attendant equipment supporting the end devices credited in the flood response procedure, including cabling/conduits terminations, instrumentation, and controls. These expanded scope walkdowns are ongoing at both SQN and WBN. Any degraded, nonconforming, or unanalyzed conditions identified during these inspections will be entered into the CAP.

7.0 Results of the Walkdown

2f - Results of the walkdown including key findings and identified degraded, non-conforming, or unanalyzed conditions. Include a detailed description of the actions taken or planned to address these conditions using the guidance in Regulatory Issues Summary 2005-20, Rev 1, Revision to NRC Inspection Manual Part 9900 Technical Guidance, "Operability Conditions Adverse to Quality or Safety," including entering the condition in the corrective action program.

As discussed in its application to revise the WBN, Unit 1, Updated Final Safety Analysis Report (UFSAR), dated July 19, 2012, TVA has performed an update to the hydrologic analysis for WBN. The updated hydrologic analysis was performed subsequent to the issuance of NRC Notices of Violation in 2008 associated with the Bellefonte Units 3 and 4 Combined Operating License Application.

At a public meeting between the NRC staff and TVA on May 31, 2012, TVA discussed the status of the reevaluation and indicated that, based on then preliminary results, certain plant equipment important to flood mode operation would be potentially impacted. Subsequently, on July 19, 2012, TVA submitted a request to revise the WBN, Unit 1 UFSAR to revise the PMF level for WBN. On June 29, 2012, Event Notification (EN) 48056 identified that due to the new PMF levels, certain equipment would be potentially impacted. Specifically, the updated PMF Elevation 739.2 could impact the ability of the TBBPs and the IPS Elevation 722 ERCW equipment to perform their design accident protection functions. TVA stated that compensatory measures had been prepared to install a temporary flood protection barrier around the TBBPs and provide additional protection of Elevation 722 of the IPS in the event of a flood alert.

In addition to the notification provided in EN 40856, by letter dated June 13, 2012, TVA committed to performing permanent plant modification to provide flood protection with respect to the design basis flood for the WBN TBBP and Spent Fuel Cooling Pump and motors by March 31, 2013.

Finally, in a similar timeframe as the performance of the walkdowns, TVA was addressing several issues regarding flood protection at WBN. Specifically, as discussed in NRC Integrated Inspection Report 05000390/2012003, dated August 14, 2012, WBN was addressing issues associated with the performance of the WBN Auxiliary Charging Pumps which is required for flood mode operation (NCV 05000390/2012003-04). Additional issues included maintenance and performance of WBNIPS Sump Pumps 3A and 3B (Unresolved Item 05000390/2012003-2) and the maintenance of IPS sump pump discharge check valve (Unresolved Item 05000390/2012003-01). These issues are addressed in WBN's CAP.

TVA has performed the flooding walkdowns as discussed in Section 6.0 of this report. The findings from those walkdowns are discussed below. TVA evaluated the findings from the walkdowns for both deficiencies and observations. One deficiency was identified at WBN during the walkdowns and 56 CAP entries were initiated to document both deficiencies and observations.

Walkdowns have been performed in the safety related buildings/structures at WBN including the Control, Auxiliary, Turbine and Shield Buildings, and the IPS. Additionally reasonable simulations have been performed for flood response procedures. The issues identified from the walkdowns, which have been entered in the CAP, include:

Flood Mode Response Equipment Deficiency

- Two main control room chilled water circulating pumps and two shutdown board room chilled water circulating pumps were determined to be partially submerged during a PMF. This has been entered into the CAP. As a result of the as found condition, a design change has been issued to provide protection to both the main control room and shutdown board room chilled water circulating pumps and associated subcomponents to ensure operability during a PMF.

Other Observations

- Flood Mode Preparation Timeline – The WBN current licensing basis states that flood mode preparations can be completed within 24 hours of initial Stage 1 flood warning with an additional 3 hour contingency margin providing a maximum of 27 hours for flood preparations to be complete before flood waters exceed plant grade. Flood mode preparation is divided into two stages (stage I warning (10 hours) and stage II warning (17 hours)). As a result of the flood mode procedure reasonable simulation, it was determined that WBN meets its current licensing basis flood mode preparations timeline taking 25 hours and 57 minutes to complete. Stage 1 flood preparations were completed within the 10 hour time limits. Stage 2 preparations were complete in 15 hours and 57 minutes. Due to the complexity of flood mode preparations and the maximum allotted flood preparation timeline being approached, a number of items were entered into the corrective action program, as noted during reasonable simulations and procedure reviews, which would improve WBN's flood preparation response and timeline. As noted in Section 2.0 of Enclosure 1, the gap between SQN and WBN regarding the amount of time required and/or capable to prepare the plant for flood mode operation is being tracked as a fleet level issue for resolution.
  - Procedure Adequacy – As a result of reasonable simulations and procedure reviews, the flood mode procedures were determined to be adequate. However, a number of areas were identified which would improve the flood preparation timelines. These included addition of specific rigging instructions, identification of specific tools required to complete some actions, correcting typographical errors and specific identification and clarification of manpower requirements, responsible organizations, and critical step sequencing to perform some actions. Additional enhancements, noted by the walkdown teams, in flood mode tools and equipment staging would improve the flood preparation timeline. These areas for improvement have been entered into the corrective action program. WBN has issued revisions to the governing flood response AOI to specify manpower requirements, critical step sequencing, and responsible organizations. Further operations and maintenance procedure revisions are being prepared based on the results of the reasonable simulations and procedure reviews.
  - Tool and Flood Mode Equipment Accessibility – As a result of reasonable simulations, it was determined that tools and equipment required for flood mode

preparations could be accessed. However, accessibility could be improved for a number of components which would improve the flood preparation timeline. Proposed changed included providing ladders for installation of the spool piece connecting the Reactor Coolant Drain Tank and Flood Mode Boration Makeup System, staging ladders for accessing manual valves, and revising RCS sampling locations away from high radiation and high temperature areas. These areas for improvement have been entered into the CAP. Operations and maintenance procedure revisions are being prepared based on the results of the reasonable simulations and procedure reviews to improve tool and flood mode equipment accessibility.

  - Operations and Maintenance Personnel Training – As a result of reasonable simulations, it was determined that both operations and maintenance personnel could perform the flood mode preparations, however improved training of both operations and maintenance personnel would improve the flood preparation timeline. These areas for improvement have been entered into the CAP. An operations and maintenance training needs analysis will be performed following procedure revisions.

- Flood Mode Equipment Testing, Monitoring, and Inspection Program – It was discovered that some permanently installed flood response components were not included in a preventive maintenance program. These items were entered into the CAP. Flood mode equipment testing, monitoring, and inspection programs are being reviewed by WBN and TVA corporate engineering to ensure that flood mode equipment reliability is assured.

- Inaccessible/Restricted Access SSCs – There were no “inaccessible” flood protection items and no “restricted access” items identified during the flooding walkdowns.

8.0 AVAILABLE PHYSICAL MARGIN (APM)

2g - Document any cliff-edge effects identified and the associated basis. Indicate those that were entered into the corrective action program. Also include a detailed description of the actions taken or planned to address these effects.

As part of the exterior flood barrier walkdowns performed in response to the NRC Request For Information (RFI) for Recommendation 2.3 (Flooding), available physical margin (APM) was reviewed for equipment required to be operable during a PMF. As discussed in Appendix D of NEI 12-07, which was endorsed by the NRC in a letter dated May 31, 2012, items identified with low APM have been entered into the CAP and are available for NRC audits and inspections, but are not being reported in response to this RFI. As also discussed in NEI 12-07, cliff-edge effects will be reported during the Recommendation 2.1 flood hazard reevaluations. During the flood hazard reevaluations, the cliff-edge effects will be determined using the APMs as well as other information, such as the specific SSCs that are subjected to flooding and the potential availability of other systems used to mitigate risk.

9.0 PLANNED OR NEWLY INSTALLED FLOOD PROTECTION BARRIERS

2h - Describe any other planned or newly installed flood protection systems or flood mitigation measures including flood barriers that further enhance the flood protection. Identify results and any subsequent actions taken in response to the peer review.

TVA has identified the following flood protection improvements:

Thermal Barrier Booster Pumps (TBBP) Flood Protection Barrier

A temporary barrier has been installed to protect the TBBPs and their respective motors in the event of a PMF event. In accordance with TVA letter to the NRC, dated June 13, 2012, a permanent flood protection barrier surrounding the TBBPs will be installed by March 31, 2013. This barrier is designed to protect the TBBPs and their respective motors up to EL 742.0 ft. in the event of a PMF event.

Spent Fuel Pit (SFP) Pumps and Skimmer Pump Motors Barrier

As stated in TVA's letter to NRC dated June 13, 2012, TVA will install a permanent plant modification to provide flood protection with respect to the Design Basis Flood level for the WBN, Unit 1 Spent Fuel Pit Cooling pumps and motor by March 31, 2013.

Intake Pumping Station (IPS) Personnel Access Door Temporary Barriers

Temporary flood barriers are to be employed at the IPS to prevent floodwater intrusion through the Elevation 741 ft. Stairwell 1L door W1 and Stairwell 1R door W2 into the Elevation 722 ft. floor elevation. These barriers will protect the electrical equipment associated with the ERCW and HPFP pumps and motors during a PMF event. The temporary flood barrier door frames will be permanently mounted to the inside of the stairwells (1L and 1R) at the jambs for each door (W1 and W2 respectively) for installation of the barrier. The temporary barriers will be stored in frames mounted to the wall inside of their respective stairwells.

Main Control Room (MCR) and Shutdown Board Room (SDBR) AC System Chilled Water Circulating Pumps and Ancillary Equipment Protection

Permanent flood protection barriers and sealing of other ancillary equipment have been designed to protect the MCR and SDBR AC system chilled water circulating pumps and other ancillary equipment.

ENCLOSURE 5

LIST OF COMMITMENTS

LIST OF COMMITMENTS

1. TVA will complete flooding walkdowns of the main steam tunnel flood walls at Browns Ferry Nuclear Plant, Unit 2, during the next refueling outage scheduled for the spring of 2013.

2. TVA will complete flooding walkdowns of the main steam tunnel flood walls at Browns Ferry Nuclear Plant, Unit 3, during the next refueling outage scheduled for the spring of 2014.