# FINAL SAFETY ANALYSIS REPORT

# CHAPTER 19

# PROBABILISTIC RISK ASSESSMENT

# AND SEVERE ACCIDENT EVALUATION

## Table of Contents

## List of Tables

# 19.0 PROBABILISTIC RISK ASSESSMENT AND SEVERE ACCIDENT EVALUATION

This Chapter of the U.S. EPR Final Safety Analysis Report (FSAR) is incorporated by reference with supplements as identified in the following sections.

The U.S. EPR FSAR includes the following COL Item in Section 19.0:

> The COL applicant that references the U.S. EPR design certification will either confirm that the PRA in the design certification bounds the site-specific design information and any design changes or departures, or update the PRA to reflect the site-specific design information and any design changes or departures.

This COL Item is addressed as follows:

{There are no departures between the U.S. EPR standard design and the BBNPP site-specific design that would impact the PRA. Hence, the U.S. EPR PRA model can be used without modification as the BBNPP PRA model for the COL application. Site and plant parameters that could influence the U.S. EPR PRA results are addressed in COL FSAR Section 19.1 and the plant-specific items identified for BBNPP are adequately modeled in the U.S. EPR PRA.

Based on the evaluation performed, the U.S. EPR PRA:

- Bounds or sufficiently captures site and plant parameters, and
- The site and plant parameters do not have a significant impact on the PRA results and insights.

Therefore, it is not necessary to make any changes to the U.S. EPR PRA when considering specific BBNPP site and plant parameters.}

## 19.1 PROBABILISTIC RISK ASSESSMENT

This section of the U.S. EPR FSAR is incorporated by reference with the following supplements.

### 19.1.1 USES AND APPLICATION OF THE PRA

#### 19.1.1.1 Design Phase

The U.S. EPR FSAR includes the following COL Item in Section 19.1.1.1:

> A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of site-specific design programs and processes during the design phase.

This COL Item is addressed as follows:

{No additional site-specific PRA-related design activities are anticipated for BBNPP.} The adequacy of the PRA will be assessed relative to any future risk-informed application during the design phase.

The PRA maintenance and update activities described in Section 19.1.2.4.1 will be performed as needed during the design phase.

#### 19.1.1.2 Combined License Application Phase

The U.S. EPR FSAR includes the following COL Item in Section 19.1.1.2:

> A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the combined license application phase.

This COL Item is addressed as follows:

PRA uses in the combined license application phase include:

- identification of risk-informed safety insights associated with the design and operation.
- provide PRA importance measures for input to the Reliability Assurance Program (RAP).
- gain risk insights associated with establishing allowed outage times for certain equipment technical specifications.
- input to the procedure development process/human factors.

{The PRA is used to perform a conservative, quantitative screening of airplane hazard and tornado hazard in the assessment of external events. There are no additional risk-informed applications currently proposed for BBNPP.} The adequacy of the PRA will be assessed relative to any future risk-informed application during the Combined License Application Phase.

#### 19.1.1.3 Construction Phase

The U.S. EPR FSAR includes the following COL Item in Section 19.1.1.3:

> A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the construction phase.

This COL Item is addressed as follows:

{No specific PRA uses are anticipated during the construction phase. There are no risk-informed applications currently proposed.} The adequacy of the PRA will be assessed relative to any future risk-informed application during the construction phase.

#### 19.1.1.4 Operational Phase

The U.S. EPR FSAR includes the following COL Item in Section 19.1.1.4:

> A COL applicant that references the U.S. EPR design certification will describe the uses of PRA in support of licensee programs and identify and describe risk-informed applications being implemented during the operational phase.

This COL Item is addressed as follows:

The PRA risk insights will be used to support typical licensee programs such as:

- the Significance Determination Process (SDP).
- Mitigating System Performance Index (MSPI).
- 10 CFR50.65 Maintenance Rule and associated (a)(4) determinations.

{There are no additional risk-informed applications currently proposed for BBNPP.}

### 19.1.2 QUALITY OF PRA

No departures or supplements.

#### 19.1.2.1 PRA Scope

No departures or supplements.

#### 19.1.2.2 PRA Level of Detail

The U.S. EPR FSAR includes the following COL Item in Section 19.1.2.2:

> A COL applicant that references the U.S. EPR design certification will review as-designed and as-built information and conduct walk-downs as necessary to confirm that the assumptions used in the PRA, including PRA inputs to RAP and severe accident mitigation design alternatives (SAMDA), remain valid with respect to internal events, internal flooding and fire events (routings and locations of pipe, cable and conduit), and human reliability analyses (HRA) (i.e., development of operating procedures, emergency operating procedures and severe accident management guidelines and training), external events including PRA-based seismic margins, high confidence, low probability of failure (HCLPF) fragilities, and low power shutdown (LPSD) procedures.

This COL Item is addressed as follows:

As-designed and as-built information will be reviewed, and walk-downs will be performed, as necessary, to confirm that the assumptions used in the PRA, including PRA inputs to RAP and SAMDA, remain valid with respect to internal events, internal flooding and fire events (routings and locations of pipe, cable and conduit), and HRA (i.e., development of operating procedures, emergency operating procedures and severe accident management guidelines and training), external events including PRA-based seismic margins, HCLPF fragilities, and LPSD procedures. This shall be performed prior to fuel load.

#### 19.1.2.3 PRA Technical Adequacy

The U.S. EPR FSAR includes the following COL Item in Section 19.1.2.3:

> A COL applicant that references the U.S. EPR design certification will conduct a peer review of the PRA relative to the ASME PRA Standard prior to use of the PRA to support risk-informed applications or before fuel load.

This COL Item is addressed as follows:

A peer review of the PRA relative to the ASME PRA Standard shall be performed prior to use of the PRA to support risk-informed applications or before initial fuel load.

#### 19.1.2.4 PRA Maintenance and Upgrade

No departures or supplements.

##### 19.1.2.4.1 Description of PRA Maintenance and Upgrade Program

The U.S. EPR FSAR includes the following COL Item in Section 19.1.2.4.1:

> A COL applicant that references the U.S. EPR design certification will describe the applicant's PRA maintenance and upgrade program.

This COL Item is addressed as follows:

The PRA is treated as a living document. The PRA Configuration Control Program maintains (updates) or upgrades the PRA in the manner prescribed by ASME RA-Sc-2007, "Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications" (ASME, 2007) and as clarified by Regulatory Guide 1.200 (NRC, 2007a). Thus:

- Not later than the date of initial fuel loading, the site specific PRA will be upgraded to contain Level 1 and Level 2, and to include those events and modes for which NRC-endorsed consensus standards on PRA existed one year prior to scheduled fuel loading.
- The PRA will be upgraded every four years until permanent cessation of operations. The upgraded PRA will include initiating events and modes of operation contained in NRC-endorsed consensus standards in effect one year prior to each upgrade.
- Not later than the date on which a site specific application for a renewed license is submitted, the PRA will be upgraded to cover all modes and all initiating events.

The PRA will be periodically updated, as necessary according to update methods described below. When reviewing pending design changes and proposed model improvements, effect on core damage frequency (CDF) and large release frequency (LRF) will be estimated. Based on estimated effect, one of the following update methods will be used:

1. If the cumulative effect of pending changes is judged to either increase CDF to 1.0E-06 per year or greater, or increase LRF to 1.0E-07 per year or greater, then a PRA model revision will be made in a timely manner, regardless of the next routine update-cycle schedule.
2. If the cumulative effect of pending changes is judged to not meet the above conditions, then the PRA model will be revised during the next scheduled update.

The PRA Configuration Control Program performs the following key functions:

1. Monitors PRA inputs and collects new information.
2. Maintains the PRA consistent with the as-built, as-operated plant.
3. Periodically upgrades the PRA to maintain consistency with developments of new methodologies, or to accommodate new requirements in scope and capability.
4. Ensures that the cumulative effect of pending changes is considered when applying the PRA.
5. Evaluates the effect of changes on previously implemented risk-informed decisions that used the PRA.
6. Maintains configuration control of computer codes used to support PRA quantification.
7. Documents the PRA Program, including changes and updates.

The key PRA terms “Maintenance” and “Upgrade” are defined as follows:

- **PRA Maintenance:** Update of PRA models to reflect plant changes such as design modifications, procedure changes, or plant performance (data).
- **PRA Upgrade:** Incorporation into a PRA system of a new PRA methodology or a significant change in PRA scope or capability. This could include, for instance, items such as a new human error analysis methodology, new data update method, new approach to quantification or truncation, or new treatment of common cause failure.

Industry peer review will be performed for the PRA upgrades, as they are defined above. Appendix A of ASME RA-Sc-2007 (ASME, 2007) provides example revisions to increase clarity on what constitutes an upgrade, versus an update and, therefore, what requires a peer review. When assessing a need for a peer review, consideration will also be given to scope or number of PRA maintenance activities performed. Although individual changes to a PRA model may be considered PRA maintenance activities, the integrated nature of several changes may make a peer review desirable. This is because multiple PRA maintenance activities can, over time, lead to considerable changes in the PRA insights (e.g., relative risk importance of SSCs), and a periodic peer review might be prudent.

Peer reviews will be performed in accordance with Regulatory Guide 1.200 (NRC, 2007a), which endorses NEI 00-02, Probabilistic Risk Assessment (PRA) Peer Review Process Guidance (NEI, 2002), with exceptions. Peer review findings and observations using this process will indicate what improvements are needed to raise the grade given for each PRA technical element. Review findings and observations will be dispositioned based on their importance.

### 19.1.3 SPECIAL DESIGN/OPERATIONAL FEATURES

No departures or supplements.

### 19.1.4 SAFETY INSIGHTS FROM THE INTERNAL EVENTS PRA FOR OPERATIONS AT POWER

#### 19.1.4.1 Level 1 Internal Events PRA for Operations at Power

{Two BBNPP site-specific items have been identified as having the potential to affect the PRA model:

- Loss of Offsite Power (LOOP) frequency and duration
- Balance of plant systems (e.g., Circulating Water System, Auxiliary Water System, Normal Heat Sink)

These items are evaluated as follows for potential deviations from the U.S. EPR FSAR.

<u>Loss of Offsite Power</u>

LOOP frequencies used in the U.S. EPR PRA model are consistent with NUREG/CR-6890 guidelines (NRC, 2005). The LOOP frequency value used in the U.S. EPR PRA model is 1.9E-02/yr, based on the generic USA LOOP frequency value of 3.6E-02/yr from NUREG/CR-6890, modified by crediting U.S. EPR full load rejection capability for grid-related events and by excluding consequential LOOP events (consequential LOOP is treated separately in the PRA model).

The base value for LOOP frequency at the SSES Units 1 and 2 site from NUREG/CR-6890 is approximately 2.9E-02/yr. A composite LOOP frequency is calculated by using the U.S. EPR FSAR PRA-generated frequency values for plant- and switchyard-centered LOOP events, and site-specific values for weather- and grid-centered LOOP events. This results in a LOOP event frequency (adjusted for consequential LOOP and full load rejection) of approximately 1.7E-02/yr for BBNPP. This LOOP event frequency is smaller than the value used in the U.S. EPR PRA model (1.9E-02/yr); therefore the U.S. EPR PRA model is conservative for LOOP event frequency at BBNPP. In general, given that the generic LOOP frequency for the USA is used in the U.S. EPR PRA, this frequency is likely to be conservative for advanced plants because better plant and switchyard performances are expected. Generic U.S. data is also considered applicable for LOOP recovery values, consequential LOOP values and shutdown LOOP frequency. A summary of LOOP related conclusions is given below:

- The U.S. EPR PRA Loss of Offsite Power frequency bounds the BBNPP site-specific frequency.
- The U.S. EPR PRA Loss of Offsite Power recovery probabilities bound BBNPP site-specific values.
- The U.S. EPR PRA consequential LOOP probabilities do not need to be changed for BBNPP because they are not site dependent (they are initiating event dependent)
- The U.S. EPR PRA shutdown LOOP frequency and recovery probabilities are based on generic values and do not need to be changed for BBNPP.

Site-Specific Balance of Plant Systems

Site-specific balance of plant (BOP) systems that are evaluated for potential site specific deviations are the Circulating Water System (CWS), the Closed Cooling Water System (CLCWS), the Auxiliary Cooling Water System (ACWS) and the Normal Heat Sink (NHS).

These site-specific systems were evaluated for differences between the U.S. EPR PRA assumptions and the BBNPP site-specific design. It was concluded that the U.S. EPR PRA inputs for the NHS, CWS, CLCWS, and ACWS provide a reasonable and conservative representation of these systems for BBNPP. This conclusion is based on the following:

- Loss of Balance of Plant" initiating event is modeled by the fault tree for the BOP support systems. For "Loss of Condenser" and "Loss of Main Feedwater" initiating events the generic initiating event frequencies are used, based on current industry experience. The advanced plants are expected to perform better. Also, the modeling of both loss of main feedwater (generic data) and loss of balance of plant (fault tree) initiating events is conservative since the loss of main feedwater contribution is double-counted (due to a loss of the BOP supporting systems).
- In the U.S. EPR PRA, unavailability of the NHS is estimated based on the unavailability of the safety UHS that requires operation of one of two cooling fans. This unavailability is expected to bound the unavailability for the BBNPP NHS that uses natural draft cooling towers.
- The CWS is not explicitly modeled in the U.S. EPR PRA. Failures of the CWS are assumed to be enveloped by the failure probability of the NHS. The U.S. EPR PRA model also does not credit the CWS pumps to cool ACWS loads. BBNPP has the ability to utilize either the CWS pumps or the ACWS pumps to supply auxiliary cooling water flow to turbine building equipment. Therefore, the ACWS unavailability in the U.S. EPR PRA is expected to bound the unavailability for the BBNPP ACWS.
- The Fussell-Vesely importance measures for the evaluated BOP SSCs are low (<0.01%). Based on these importance measures, the applicable U.S. EPR PRA inputs and assumptions would not have a significant impact on the BBNPP PRA results and insights.

Conclusions for Level 1 Internal Events PRA for Operations at Power

Based on the above discussion, it is concluded that the U.S. EPR PRA for Level 1 internal events at power is applicable and bounding for the BBNPP site. The site and site-specific parameters do not have a significant impact on the PRA results and insights. Therefore, no changes to the U.S. EPR Level 1 internal events PRA are necessary to accommodate specific BBNPP site and plant parameters}

### 19.1.4.2 Level 2 Internal Events PRA for Operations at Power

{The U.S. EPR FSAR Section 19.1.4.2 is incorporated by reference with the following supplemental information.

The discussion presented in Section 19.1.4.1 is also applicable to the U.S. EPR PRA for Level 2 internal events at power because Level 1 and Level 2 event trees are linked together and the initiating events and the systems are merged. The Level 2 PRA also considers two additional

LOOP long term recovery probabilities. The conclusions are the same as in the preceding section.

The U.S. EPR PRA for Level 2 internal events at power is applicable and bounding for BBNPP. The site and site-specific parameters do not have a significant impact on the PRA results and insights. Therefore, no changes to the U.S. EPR Level 2 internal events PRA are necessary when considering specific BBNPP site and plant parameters.

### 19.1.5 SAFETY INSIGHTS FROM THE EXTERNAL EVENTS PRA FOR OPERATIONS AT POWER

#### 19.1.5.1 Seismic Risk Evaluation

No departures or supplements.

#### 19.1.5.1.1 Description of the Seismic Risk Evaluation

No departures or supplements.

#### 19.1.5.1.2 Results from the Seismic Risk Evaluation

##### 19.1.5.1.2.1 Risk Metrics

No departures or supplements.

##### 19.1.5.1.2.2 Significant Initiating Events and Sequences

No departures or supplements.

##### 19.1.5.1.2.3 Significant Functions, SSCs, and Operator Actions

No departures or supplements.

##### 19.1.5.1.2.4 Key Assumptions and Insights

The U.S. EPR FSAR includes the following COL Item in Section 19.1.5.1.2.4:

> A COL applicant that references the U.S. EPR design certification will confirm that the design-specific U.S. EPR PRA-based seismic margins assessment is bounding for their specific site.

This COL Item is addressed as follows:

The PRA-based seismic margins assessment performed for the U.S. EPR FSAR is based on the assumption that the U.S. EPR is designed using the EUR-based certified seismic design response spectra (CSDRS) anchored to 0.3g for selected generic soil profiles. The seismic margins assessment used CSDRS times 1.67 to define the Review Level Earthquake (RLE), which is the targeted seismic margin. The seismic margins assessment for U.S. EPR FSAR remains valid if it can be demonstrated that the U.S. EPR FSAR seismic design parameters bound those for the site-specific seismic parameters, including the ground motion response spectra (GMRS) and site-specific soil profiles.

{A comparison of the GMRS versus the CSDRS is provided in Section 3.7.1. The BBNPP horizontal GMRS is significantly below the envelope of EUR-S, EUR-M and EUR-H ground motion for frequencies less than about 21 Hz. The BBNPP horizontal GMRS is above the envelope of the EUR ground motions for frequencies greater than about 21 Hz. In the vertical direction, the BBNPP final GMRS exceeds the EUR design envelope for frequencies greater than about 23 Hz. The horizontal and vertical GMRS have peak ground acceleration (PGA) values of about 0.21g and 0.19g, respectively.

Based on a similar evaluation of these low-frequency and high-frequency exceedances performed for the BBNPP site, it is expected that the BBNPP specific seismic margin evaluation for the U.S. EPR will demonstrate compliance with the requirement of plant HCLPF at least as great as 1.67 times the CSDRS. It is also expected that these low-frequency and high-frequency exceedances will not significantly impact PRA results and insights. This will be verified using as-designed and as-built information in accordance with the COL Item 19.1-9 prior to fuel load}.

#### 19.1.5.1.2.5 Sensitivities and Uncertainties

No departures or supplements.

### 19.1.5.2 Internal Flooding Risk Evaluation

{The U.S. EPR FSAR Section 19.1.5.2 is incorporated by reference with the following supplemental information. Design-specific and site-specific systems were considered as flood sources in the PRA Internal Flooding analysis described in the U.S. EPR FSAR. The flooding frequency from design-specific systems was derived based on the available design information.

The flooding frequency from site-specific systems such as the Circulating Water System, the Closed Cooling Water System and the Auxiliary Cooling Water System was not derived using design information. Instead the U.S. EPR FSAR internal flooding frequency for the turbine building is based on a conservative generic frequency, which is judged to include contributions from all of these site-specific systems. Therefore the U.S. EPR FSAR internal flooding PRA is applicable for BBNPP.}

### 19.1.5.3 Internal Fires Risk Evaluation

No departures or supplements.

### 19.1.5.4 Other External Risk Evaluations

The U.S. EPR FSAR includes the following COL Item in Section 19.1.5.4:

> A COL applicant that references the U.S. EPR design certification will perform the site-specific external event screening analysis for external events applicable to their site.

This COL Item is addressed as follows:

{The U.S. EPR FSAR scope of external event screening includes a high level assessment of high winds and tornadoes, external flooding and external fires. This section provides supplemental information specific to the BBNPP site.

A progressive screening approach using the guidance in ANSI/ANS-58.21-2007 (ANSI, 2007) was applied. This document provides a standard for the treatment of external events in PRA, referencing NUREG-1407 (NRC, 1991) and NUREG-0800 (NRC, 2007b). All of the external events listed in Appendix A of ANSI/ANS-58.21-2007 (ANSI, 2007) have been addressed.

The plant design bases for external events are compared against ANSI/ANS-58.21-2007 and NUREG-0800 screening criteria. If the event cannot be qualitatively screened, a quantitative PRA assessment is performed to assess the risk posed by that external event against quantitative screening criteria.

As defined in the ANSI/ANS-58.21-2007, Table 19.1-1 provides a list of all external events considered. Also provided is the reason for screening each event or the relevant section where screening is discussed.}

#### 19.1.5.4.1 High Winds and Tornado Risk Evaluation

{The risks posed by high winds, tornado wind loads and tornado missiles events at the BBNPP site on U.S. EPR FSAR structures were evaluated using ANSI/ANS-58.21.-2007 (ANSI, 2007) and NUREG-0800 (NRC, 2007b) screening criteria.

A screening evaluation was performed for high winds, tornadoes and tornado missile as defined in ANSI/ANS-58.21-2007. Additionally a conservative quantitative evaluation was performed for tornadoes and tornado missiles. Screening and quantitative evaluations are summarized below.

**Screening Evaluation**

<u>High Wind Loads</u>

The BBNPP safety-related structures are designed to withstand high wind load characteristics as specified in NUREG-0800, Section 3.3.1. The SRP acceptance criteria for high winds specify that the design velocity pressure for safety-related structures must be greater than or equal to the velocity pressure corresponding to the speed of the 100-year return period 3-second wind gust. The design basis wind speed for safety-related structures is 145 mph (233 kph) in open terrain with a 50-year mean recurrence interval. This design wind is increased by an importance factor of 1.07 to obtain a 100-year mean recurrence interval.

As documented in FSAR Section 2.3.1.2.2.15, the 50 year return period 3-second wind gust for the Bell Bend NPP site is 90 mph (40.23 m/s). This is significantly lower than the design basis wind speed for safety-related structures of 145 mph (233 kph). Therefore, all BBNPP safety-related structures satisfy the SRP acceptance criteria for high winds. High wind loads can be screened for BBNPP.

Non safety-related structures design wind speed will comply with local building codes, including ASCE/SEI 7-05 (ASCE, 2007), which stipulates that structures shall be designed for the 50 year return period wind gust of 90 mph (145 kph) for BBNPP with an importance factor of 1.15. This is equivalent to designing non-safety structures for the local 100-year return period wind gust.

Non safety-related structures that house SSCs modeled in the BBNPP PRA include:

- Switchyard Area
- Auxiliary Transformer Area

- Switchgear Building
- Turbine Building
- Nuclear Auxiliary Building
- Normal Heat Sink

A bounding evaluation of the plant risk associated with the loss of those structures is provided below for a tornado scenario and in the Quantitative Evaluation section.

<u>Tornado Wind Loads</u>

The U.S. EPR safety-related structures are designed to meet the design-basis tornado wind characteristics of Tornado Intensity Region I as specified in NUREG-0800, Section 3.3.2. Tornado Intensity Region 1 (Central U.S.) is the most limiting for tornado wind loads and is characterized by a maximum tornado wind speed of 230 mph (370 kph) (184 mph (296 kph) maximum rotational speed, 46 mph (74 kph) maximum translational speed). Therefore, all U.S. EPR safety-related structures satisfy the SRP acceptance criteria for tornadoes at the BBNPP site. Tornado wind loads can be screened for BBNPP.

<u>Tornado Missiles</u>

The U.S. EPR safety-related structures are designed to withstand the tornado missile loads of Tornado Intensity Region I. Region I (Central U.S.), as defined in Reg. Guide 1.76 (NRC, 2007c) is the most limiting for tornado missiles; therefore, the U.S. EPR satisfies the SRP acceptance criteria for the BBNPP site.

A more detailed analysis of the risk to an U.S. EPR at the BBNPP site is performed in the Quantitative Evaluation section below in order to assess the risk posed by the effect of tornadoes and tornado missiles on non-safety structures.

**<u>Quantitative Evaluation</u>**

A more detailed analysis was performed to evaluate plant risk as a result of tornado impact on non-safety-related structures. The detailed analysis considers a bounding tornado event plant impact scenario and tornado event frequency. The screening core damage frequency associated with the bounding scenario is the plant impact (conditional core damage probability) multiplied by the event frequency.

Safety-related structures are screened from further evaluation based on comparison of the design to NUREG-0800 criteria. Therefore, it is assumed that a tornado event will not affect safety-related structures or associated systems and components. A bounding plant impact scenario is used to develop risk insights associated with a tornado wind loading on non-safety-related BBNPP plant structures, which contain systems and components credited in the PRA model. The following non-safety-related structures of the BBNPP plant and associated systems and components are considered in the bounding impact scenario.

1. Auxiliary Power Transformer Area and Switchyard Area - contain components related to offsite power. Unrecoverable loss of offsite power (LOOP) event is assumed in the bounding scenario.

2. Switchgear Building - contains the two station black-out diesel generators (SBO DG), non-1E switchgear equipment, load centers, motor control centers and 12-hour severe accident battery divisions. Failure of both SBO DGs and failure of all non-1E electrical buses and buses powered by the 12-hour severe accident battery divisions is assumed in the bounding scenario.
3. Turbine Building/Normal Heat Sink - contains systems and components associated with secondary heat removal, for example, main condenser and feedwater. The risk impact from a loss of these locations is enveloped by the loss of the switchgear building.
4. Nuclear Auxiliary Building - contains the operational chilled water system (OCWS). Note - because of its proximity to safety-related structures, the Nuclear Auxiliary Building is a reinforced concrete structure and designed for tornado loading per Regulatory Guide 1.76 (NRC, 2007c). Therefore, the plant impact scenario assumes that this structure and associated equipment are not affected by the postulated tornado event.

The BBNPP FSAR Level 1 PRA LOOP event tree model is used to calculate the conditional core damage probability (CCDP) of this scenario. Based on the above scenario, the CCDP is approximately 8.8E-04. The dominant CCDP sequence involves common cause failure of all four emergency diesel generators (EDGs), resulting in a station blackout event.

NUREG/CR-4461, Tornado Climatology of the Contiguous United States (NRC, 2007d) is used to determine the tornado strike frequency. The tornado strike frequency is the likelihood that a tornado will strike a given point or structure on an annual basis. It is calculated as the sum of two terms: (1) point structure probability (which is calculated based on recorded tornado dimensions within a certain area) and (2) the life-line term (which is based on the dimensions of the plant-specific target structure).

As defined in FSAR Table 2.1.1-1, the geographical coordinates of the BBNPP site are (41°05' N, 76°09' W). The point structure probability, life-line term, and the total strike probability are calculated for the local 2° square box containing the BBNPP site (40-42° N, 75-77° W). The characteristic dimension used to calculate the plant-specific life-line term is the Turbine Building length of 300 ft (91 m).

Based on the NUREG/CR-4461 information, the BBNPP site-specific strike frequency of a tornado with a wind speed greater than 96 mph (43 mps) (the design wind velocity for non-safety related structures at BBNPP) is determined as approximately 8.7E-05/yr.

The screening core damage frequency associated with the bounding scenario is the plant impact CCDP (8.8E-04) multiplied by the event frequency (8.7E-05/yr). The core damage frequency (CDF) for this scenario is approximately 7.7E-08/yr, which meets the ANSI/ANS-58.21-2007 screening criteria.

The bounding tornado strike scenario defined and quantified above conservatively assumes failure of all non-safety-related structures of the plant. The tornado strike scenario is judged bounding for all credible tornado and tornado missile events. Therefore, tornado missile effect on unprotected plant structures is not evaluated further.

It is concluded that BBNPP satisfies the screening criteria set forth in NUREG-0800, RG 1.76, and, ANSI/ANS 58.21-2007. High winds can be screened directly based on the BBNPP design basis. A quantitative PRA analysis was performed to evaluate the risk associated with tornadoes (including tornado missiles). The results of this analysis show that the contribution to CDF from tornado winds and tornado generated missiles is about 7.7E-08/yr. As a result, high winds, tornadoes and tornado missiles can be screened from the PRA for BBNPP. }

#### 19.1.5.4.2 External Flooding Evaluation

{Section 2.4.3 through Section 2.4.7 provide an evaluation of the different flooding conditions considered for the BBNPP site, as well as the U.S. EPR FSAR's protection features against those conditions. The flooding conditions include the probable maximum flood (PMF) on streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami and ice effect flooding. Maximum flooding levels due to local intense precipitation are also addressed.

The maximum water level during a local probable maximum precipitation (PMP) event occurs in Walker Run, and is Elevation 670.96 ft (204.51 mps) at Cross Section 12,715. All safety-related facilities for BBNPP are located at approximately 674 ft (205.4 m) msl. Grading in the power block area around the safety related facilities is such that all grades slope away from the structures at a minimum of 1% towards collection ditches. The maximum estimated water surface elevations resulting from all design basis flood considerations, as discussed in FSAR Section 2.4.2 through Section 2.4.7, are below the entrance and grade slab elevations for the power block safety-related facilities. Therefore, flood protection measures are not required for the BBNPP power block area.

The Normal Heat Sink (NHS) is the only SSC modeled in the PRA which may not be located above PMP grade. Failure of the NHS would cause a Loss of Balance of Plant (loss of Closed Cooling Water or Auxiliary Cooling Water). Assuming that external flooding occurs that causes the NHS to fail, thereby causing a Loss of Balance of Plant, the conditional core damage probability would be 1.2E-07 per year. Combined with a potential flood hazard frequency, this is likely to result in a CDF of less than 1.0E-08 per year.

Therefore, the applicable SRP screening criteria in NUREG-0800, SRP Section 2.4.10 (NRC, 2007b), are met for the different types of external flooding events, and that the risk posed by external flooding can be screened for BBNPP.}

#### 19.1.5.4.3 External Fire Evaluation

{As described in Section 2.2.3.1.4, the cleared zones surrounding BBNPP are of sufficient size to afford substantial protection in the event of a fire, and it is not expected that there would be any hazardous effects from fires or heat fluxes associated with wild fires, fires in adjacent industrial plants or from onsite storage facilities.

In addition, the impact of external smoke on the habitability of the main control room is considered in the design of the control room envelope (CRE) and the control room air conditioning system (CRACS) (see Section 6.4 and Section 9.4). The CRE has isolation capability in the event of external fire/smoke and the CRACS can be operated in full recirculation mode. The CRACS maintains the control room envelop at a positive pressure to prevent uncontrolled, unfiltered in-leakage during normal and accident conditions. The CRACS can support occupancy for eight people in the MCR and associated rooms for 70 hours without outside makeup air. Portable self-contained breathing apparatus (SCBA) are also available for use by the control room operators.

Therefore, an external fire will not have an adverse impact on the operation of BBNPP. Therefore external fire events can be screened per NUREG-0800, Section 2.2.3.}

#### 19.1.5.4.4 Aircraft Crash Hazard Risk Evaluation

{This section is added as a supplement to the U.S. EPR FSAR.

The risk posed by random airplane crash events to BBNPP are evaluted using ANSI/AND-58.21-2007 and NUREG-0800 screening criteria. The location of the site with respect to airports, military training routes and airways was evaluted against the screening criteria presented in NUREG-0800, Section 3.5.1.6. A quantitative, demonstrably conservative screening analysis was also performed in order to screen the aircraft crash hazard for BBNPP.

<u>Screening Analysis for Airplane Crash</u>

NUREG-0800, Section 3.5.1.6 acceptance criteria for airplane crash hazard stipulates that the frequency of an event causing radiological consequences greater than the 10 CFR 100 (CFR, 2007) exposure guidlines should be less than 1.0E-07/yr. This acceptance criterion can be met provided that all of the following conditions exist:

- The plant-to-airport distance D is between 5 and 10 stature miles (8 and 16 km), and the projected annual number of operations is less than the numerical value of 500 $D^2$.
- The plant is at least 5 stature miles (8 km) from the nearest edge of military training routes, including low-level training routes, except for those military training routes associated with usage greater than 1000 flights per year, or where activities (such as practice bombing) may create an unusual stress situation.
- The plant is at least 2 stature miles (3.2 km) from the nearest edge of a Federal airway, holding pattern, or appoach pattern.

The following information is specific to the BBNPP site and can be found in Section 2.2.2:

- There are no public airports within 10 mi (16 km) of the BBNPP midpoint. Airports beyond 10 mi (16 km) from the BBNPP site midpoint were evaluated and determined to meet NUREG-0800 acceptance criteria. Small private airports exist within 10 mi (16 km) of the plant. These airports support only sporadic operations and are judged not to exceed the NUREG-0800 threshold.
- There are no military training routes within 5 mi (8 km) of the BBNPP site midpoint.
- The centerline of Airway V106 is 2.1 nautical miles (2.4 mi (3.9 km)) southeast of the BBNPP midpoint and the centerline of Airway V499 is about 2.7 nautical miles (3.1 mi (5.0 km)) west of the BBNPP midpoint. The width of a federal airway is typically 8 nautical miles (9.2 mi (14.8 km)), extending 4 nautical miles (4.6 mi (7.4 km)) on each side of the centerline. When airway width is considered, the edge of both those airways is closer to the plant than the two statute miles criterion for screening. Therefore this screening criterion from NUREG-0800 is not met and more analysis is required.

<u>Detailed Airplane Crash Assessment</u>

As discussed in Section 3.5.1.6 BBNPP employs a geographical separation or residence within shielded buildings to provide a minimum number of SSCs to achieve and maintain the plant in cold shutdown and prevent damage to fuel in the spent fuel pool following an aircraft hazard (ACH). Specifically, sufficient geograpical separation between redundant or diverse SSCs limits the extent of damage from an ACH. Similarly, placing SSCs within shield buildings designed to prevent penetration by aircraft provides protection of redundant or diverse SSCs to achieve and maintain the plant in cold shutdown and prevent damage to fuel in the spent fuel pool.

Given the BBNPP building design, a quantitative assessment of aircraft hazard was performed for various random aircraft hazard scenarios using the BBNPP PRA. This analysis was performed using the following steps:

1. Develop target sets based on similar building structural strength (shielded or non-shielded), site location and expected plant response.
2. Calculate the estimated impact frequency (initiating event frequency) for each target set based on representative dimensions of the buildings within each target set.
3. Define aircraft crash scenarios based on the target sets defined in 1) and on the frequency defined in 2).
4. Evaluate the aircraft crash scenarios using a bounding PRA alaysis in order to obtain a core damage (or a release) frequency estimate for each scenario.

Target sets were screened when it was judged that one of the following conditions applies:

- a crash into the target set would not result in damages to SSCs modeled in the PRA (e.g., shielded buildings)
- the worst consequences of a crash into the target set would be eveloped by an initiating event already modeled in the PRA, and the frequency of this initiating event in several orders of magnitude higher than the postulated airplane crash frequency (e.g., a crash into the Normal Heat Sink is eveloped by the Loss of Balance of Plant initiating event).

Target sets that were retained for the analysis are: (1) Safeguard Building 1 (or 4) and (2) Turbine and Switchgear Building. Aircraft crash frequencies into these two target sets are estimated using the methodology of DOE Standard 3014-2006 (DOE, 2006). Bounding aircraft crash scenarios are developed for the two target sets define. The most limiting failures of all the components in the affected building are assumed. This is a very conservative approach since the aircraft crash frequency is dominated by events involving general aviation planes which are unlikely to cause extensive damage.

The assessment is judged to be a conservative and bounding approach for screening purposes to satisfy Section 3.5.1.6 of NUREG-0800. The core damage frequency associated with the conservative aircraft scenario is 9.9E-08 per year.

<u>Conclusion for Detailed Airplane Crash Hazard Assessment</u>

The NUREG-0800 acceptance criterion is met when the frequency of a release exceeding 10 CFR 100 (CFR, 2007) limits is realistically less than 1.0E-07 per year. The total CDF (CDF bounds large release frequency) from airplane crash into the BBNPP, using a demonstrably conservative analysis, is calculated to be 9.9E-08 per year. Based on a comparison of this analysis to NUREG-0800 and ANSI/ANS-58.21-2007, it is concluded that the BBNPP design satisfies the ANSI/ANS-58.21-2007 screening criteria for this external event. As a result, aircraft crash has been screened from the PRA.}

#### 19.1.5.4.5 Industrial and Transportation Accidents Risk Evaluation

{This section is added as a supplement to the U.S. EPR FSAR.

The risks posed by potential industrial and transportation accidents to BBNPP site are evaluated against the SRP screening criteria as defined in NUREG-0800, Section 2.2.3. The following approach is used: if the postulated hazard does not adversely affect the operation of the plant, or if the hazard has a frequency of less than 1.E-07/yr using realistic modeling assumptions, then the hazard may be screened.

The following types of hazards are evaluated: highway hazards, waterway hazards, pipeline hazards, railroad hazards, and nearby facilities hazards. Each of these hazards was evaluated with regard to the effects from potential accidents relating to explosions, flammable vapor clouds (delayed ignition), and toxic chemicals (vapors or gases), including liquid spills. The evaluation methods for these hazards were according to Regulatory Guides 1.91 and 1.78 (NRC, 1978) (NRC, 2001).

Bounding combinations of chemicals, volumes and locations were identified for further analysis, which were bounding for all of the hazards identified. These bounding chemicals are provided with the assumed quantity and location of the chemical. Other combinations are bounded and are not described. Following is a summary of the evaluation of these chemicals and the results.

<u>Highway Hazards</u>

In Section 2.2.3, an evaluation is made of the risks posed by an accident involving hazardous material occurring on the major roads within 5 mi (8 km) from the plant site. These are:

- Route 11 (Salem Blvd)
- Route 339 (Mifflin Nescopeck Highway)
- Route 93 (Berwick Hazleton Highway)
- Route 3036 (River Road)
- Route 239 (Wapwallopen Road)

BBNPP is located approximately 1.1 mi (1.8 km) from Route 11. Hazards on all other roads are bounded by the hazards from facilities. For each type of event and for the largest amount of hazardous material susceptible to be involved in that event, the minimum separation distance (i.e., safe distance) is calculated. The results are summarized in Section 2.2. In each case, either the largest minimum separation distance is found to be less than the actual distance, or a quantitative risk assessment was used to show that the rate of exposure to a peak positive incident overpressure in excess of 1 psi (6.89 kPa) was less than 1.0E-07 per year when based on realistic assumptions. Therefore it is judged that highway hazards would not adversely affect the safe operation of BBNPP.

Waterway Hazards

The Susquehanna River is the only waterway within 5 mi (8 km) of BBNPP, but it is too shallow to support navigation of any watercraft other than personal watercraft. Therefore, no releases or explosions are analyzed for any boats or barges. No chemicals or commodities presenting with a plausible capability of forming a vapor or toxic cloud are transported on the river. Thus, the river is not considered a nearby route (Section 2.2).

Pipeline Hazards

There are three pipelines within 5 mi (8 km) of the BBNPP site reactor building. These pipelines include:

- Transco Natural Gas Pipeline
- UGI Natural Gas Pipeline
- Sunoco Gasoline Pipeline

The minimum distance from the Transco 42 in (1.1 m) natural gas pipeline to the center of the BBNPP reactor building is 1.89 mi (3.04 km). The minimum distance from the UGI 12 in (31 cm) natural gas pipeline 0.44 mi (0.71 km). The minimum distance from the Sunoco 6.6 in (16.8 cm) pipeline is 2.03 mi (3.3 km). For the pipelines, a worst case break of the pipeline is assumed at the nearest approach of the pipeline to BBNPP. All of the pipelines are assumed to have an infinite pressure source. The results are summarized in Section 2.2. In each case, either the largest minimum separation distance is found to be less than the actual distance, or the analysis shows that more than 2 minutes elapses between the time of hazard detection and reaching the Immediately Dangerous to Life and Health (IDLH) threshold, or a quantitative risk assessment was used to show that the rate of exposure to a peak positive incident overpressure in excess of 1 psi (6.89 kPa) was less than 1.0E-07 per year when based on realistic assumptions. Therefore, it is judged that pipeline hazards would not adversely affect the safe operation of BBNPP.

Railroad Hazards

There are two railroads within 5 mi (8 km) of the BBNPP reactor building:

- North Shore Railroad
- Canadian Pacific Railroad

The North Shore Railroad is located approximately 1.3 mi (2.1 km) south of the site at its nearest approach. The Canadian Pacific Railroad is located approximately 1.7 mi (2.7 km) south at its nearest approach. For each type of event and for the largest amount of hazardous material susceptible to be involved in that event, the minimum separation distance (i.e., safe distance) is calculated. The results are summarized in Section 2.2. In each case, either the largest minimum separation distance is found to be less than the actual distance, or the analysis shows that more than 2 minutes elapses between the time of hazard detection and reaching the IDLH, or a quantitative risk assessment was used to show that the rate of exposure to a peak positive incident overpressure in excess of 1 psi (6.89 kPa) was less than 1.0E-07 per year when based on realistic assumptions. Therefore, it is judged that railroad hazards would not adversely affect the safe operation of BBNPP.

Nearby Facilities Hazards

There are three facilities within 5 mi (8 km) of the BBNPP reactor building:

- Susquehanna Steam Electric Station (SSES)
- Heller's Gas and Custom Made Fireplaces
- Deluxe Building Systems (DBS)

Western International Distribution Center is not included in this evaluation because the hazards to BBNPP are shipments along U.S. Route 11. These hazards were evaluated in the “Highway Hazards” evaluation previously discussed. The distance between the BBNPP reactor building and the SSES is between 0.7 (1.12 km) and 1.1 mi (1.8 km) . The distance between Heller's Gas and the BBNPP reactor building is 1.93 mi (3.1 km) and the distance from Deluxe Building Systems to BBNPP is 4.63 mi (7.45 km). For each type of event and for the largest amount of hazardous material susceptible to be involved in that event, the minimum separation distance (i.e., safe distance) is calculated. The results are summarized in Section 2.2. In each case, either the largest minimum separation distance is found to be less than the actual distance, or the analysis shows that more than 2 minutes elapses between the time of hazard detection and reaching the IDLH, or a quantitative risk assessment was used to show that the rate of exposure to a peak positive incident overpressure in excess of 1 psi (6.89 kPa) was less than 1.0E-07 per year when based on realistic assumptions. Therefore, it is judged that nearby facilities hazards would not adversely affect the safe operation of BBNPP.}

#### 19.1.5.4.6 Other External Events Risk Evaluation

{This section is added as a supplement to the U.S. EPR FSAR.

Three types of external events from Table 19.1-1 are addressed in this section. These are turbine generated missiles, collisions with intake structure, and lightening strikes.

Turbine Missiles

NUREG-0800, Section 3.5.1.3 provides acceptance criteria for turbine missile hazard based on the frequency of a turbine failure resulting in the ejection of turbine rotor (or internal structure) fragments through the turbine casing. The acceptance criteria are 1.0E-04/year for favorably oriented turbines and 1.0E-05 per year for unfavorably oriented turbines. A favorable orientation is one that excludes the containment and all, or mostly all, safety-related structures, systems or components (SSCs) from the low trajectory missile (LTM) pathway. Meeting these criteria provides confidence that the frequency of unacceptable damage from turbine missiles is less than or equal to 1.0E-07/yr.

The BBNPP design requires a favorably oriented turbine with respect to containment. Detailed analyses and assessments show that the probability of turbine rotor failure resulting in ejection of the turbine rotor fragments through the turbine building casing is less than 1.0E-04 for a favorable oriented turbine with respect to containment. Therefore the risk to BBNPP from a turbine missile from the BBNPP turbine is within the NRC acceptance criteria as provided in NUREG-0800, Section 3.5.1.3.

Collisions with Intake Structure

There are no safety-related structures located near the shore line. In addition, the Susquehanna River is not used as a navigable waterway for other than small recreational boats, which do no constitute any hazard potential to the intake structure.

As discussed above in Section 19.1.5.4.2, the conditional core damage probability associated with the failure of the NHS would be 1.2E-07. Combined with a potential frequency for collisions with intake structures, this is likely to result in a CDF of less than 1.0E-08 per year. The NHS also provides long-term makeup to the safety UHS. However, each train of the safety UHS can provide sufficient plant cooling for 72 hours. Therefore, this dependency does not impact the risk from collisions with intake structures.

Lightning Strikes

The BBNPP site location is located in an area of moderate lightning strike frequency, with between 1 to 4 strikes per square kilometer per year (247 acres). BBNPP uses guidelines and requirements for the methods of protecting the plant from the effects of lightning strikes and other voltage strikes, in accordance with the latest IEEE Standards as endorsed and summarized in Regulatory Guide 1.204.

The most likely result of a lightning strike to BBNPP would be a loss of offsite power. Based on the recorded lightning frequency for the area of BBNPP, the impact of lightning strikes should be well represented by the loss of offsite power initiating events analyzed in the BBNPP PRA. The BBNPP PRA model calculates a CDF from loss of offsite power of approximately 1.0E-07 per year. Since lightning strikes result in only a fraction of the loss of offsite power events, lightning strikes are judged to not present a significant hazard to BBNPP.}

## 19.1.6 SAFETY INSIGHTS FROM THE PRA FOR OTHER MODES OF OPERATION

### 19.1.6.1 Description of the Low-Power and Shutdown Operations PRA

{The information in this section of the reference U.S. EPR FSAR, including all subsections, tables and figures, is incorporated by reference with no departure or supplement.}

### 19.1.6.2 Results from the Low-Power and Shutdown Operations PRA.

{The information in this section of the U.S. EPR FSAR, including all subsections, tables and figures, is incorporated by reference with the following supplemental information.

The discussion in Section 19.1.4.1 on the site-specific LOOP frequency and duration is also applicable to the U.S. EPR PRA for Low-Power and Shutdown Operations (LPSD). The LPSD PRA also considers LOOP frequency and the recovery probabilities. The conclusions are the same as in Section 19.1.4.1.

The U.S. EPR PRA for LPSD is applicable and bounding for BBNPP. The site-specific parameters do not have a significant impact on the PRA results and insights. Therefore, no changes to the U.S. EPR PRA for LPSD are necessary when considering the specific BBNPP site.}

### 19.1.6.3 Low-Power and Shutdown Operations - Level 2 Assessment

{The information in this section of the reference U.S. EPR FSAR, including all subsections, tables and figures, is incorporated by reference with no departure or supplement.}

### 19.1.6.4 Low Power and Shutdown Level 2 Risk Metrics (LRF)

{The information in this section of the reference U.S. EPR FSAR, including all subsections, tables and figures, is incorporated by reference with no departure or supplement.}

## 19.1.7 PRA-RELATED INPUT TO OTHER PROGRAMS AND PROCESSES

{No departures or supplements.}

## 19.1.8 CONCLUSIONS AND FINDINGS

No departures or supplements.

## 19.1.9 REFERENCES

{**ANSI, 2007**. External Events PRA Methodology, ANSI/ANS-58.21-2007, American National Standards Institute/American Nuclear Society, 2007.

**ASCE, 2007**. American Society of Civil Engineers, Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-05, 2007.

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**CFR, 2007.** Title 10, Code of Federal Regulation, CFR Part 100, Reactor Site Criteria, Nuclear Regulatory Commisions.

**DOE, 2006**. Accident Analysis for Aircraft Crash into Hazardous Facilities, DOE-STD-3014-2006, October 1996, Reaffirmed May 2006.

**NEI, 2002**. Probabilistic Risk Assessment (PRA) Peer Review Process Guidance, NEI 00-02, Revision A3, Nuclear Energy Institute, 2002.

**NRC, 1978.** Regulatory Guide 1.91, Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants, Revision 1,U.S. Nuclear Regulatory Commission, February 1978.

**NRC, 1991**. Procedural and Submittal Guidance for the Individual Plant Examination of External Events, NUREG-1407, U. S. Nuclear Regulatory Commission, May 1991.

**NRC, 2001**. Regulatory Guide 1.78, Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release, Revision 1, U.S. Nuclear Regulatory Commission, November 2001.

**NRC, 2005**. Reevaluation of Station Blackout Risk at Nuclear Power Plants, NUREG/CR-6980, U.S. Nuclear Regulatory Commission, November 2005.

**NRC, 2007a.** An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities, Regulatory Guide 1.200, U. S. Nuclear Regulatory Commission, January 2007.

**NRC, 2007b.** Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, NUREG-0800, U. S. Nuclear Regulatory Commission, January 2007.

**NRC, 2007c.** Design Basis Tornado and Tornado Missiles for Nuclear Power Plants, Regulatory Guide 1.76, Revision 1, U. S. Nuclear Regulatory Commission, March 2007.

**NRC, 2007d.** Tornado Climatology of the Contiguous United States, NUREG/CR-4461, Revision 2, U. S. Nuclear Regulatory Commission, February 2007.}

**Table 19.1-1 {**Summary of External Events Evaluated for BBNPP**}**
(Page 1 of 2)

| External Event Hazard | Evaluation |
|---|---|
| Aircraft Impacts | Screened in Section 19.1.5.4.4. |
| Avalanche | Excluded due to lack of mountains near BBNPP. |
| Biological Events | This event is included in the definition of other events. Specifically, this is included in the Loss of Condenser Heat Sink initiating event, the Loss of Balance of Plant initiating event, and the Loss of Main Feedwater initiating event. |
| Coastal Erosion | Shore erosion would be a slowly developing condition. There would be adequate time to respond to any significant shore erosion. |
| Drought | The BBNPP safety-related Essential Service Water System (ESWS) consists of four safety-related ESWS cooling towers and basins with an inventory for 72 hours of heat removal under design basis accident conditions (2 of 4 trains available). Makeup is supplied from the 27-day safety-related Essential Service Water Emergency Makeup System (ESWEMS) Retention Pond. Makeup to the retention pond is supplied from the Susquehanna River. Periods of prolonged drought should not significantly impact the Susquehanna River's ability to provided retention pond makeup.<br>The normal heat sink takes makeup from the Susquehanna River. Periods of prolonged drought should not significantly impact the river's ability to provide makeup to the normal heat sink. |
| External Flooding | Screened in Section 19.1.5.4.2. |
| Extreme Winds and Tornadoes | Screened in Section 19.1.5.4.1. |
| Fog | Fog can be a contributor to transportation accidents. Airplane crash and transportation accidents are covered in Section 19.1.5.4.4 and Section 19.1.5.4.5, respectively. An additional scenario could be the collision of a boat with the BBNPP intake structure. See Section 19.1.5.4.6 for a discussion of this scenario. |
| Forest Fire | The cleared zones and fuel reduction zones surrounding BBNPP are of sufficient size to afford substantial protection in the event of a fire, and it is not expected that there would be any hazardous effects from fires or heat fluxes associated with wild fires, fires in adjacent industrial plants or from onsite storage facilities.<br>Screened in Section 19.1.5.4.3. |
| Frost | The impact of frost is bounded by snow and ice loads. |
| Hail | The impact of hail would be bounded by events such as tornado missiles. |
| High Tide | Not applicable to the BBNPP site as it is inland from the ocean. |
| High Summer Temperature | A maximum ambient air temperature of 115°F is assumed for buildings within the power block. The safety-related ESWS is designed for at least 27 days of operation without offsite makeup. |
| Hurricane | Hurricane flooding impacts are screened in Section 19.1.5.4.2 and hurricane winds are bounded be the analysis in Section 19.1.5.4.1. |
| Ice Cover | The U.S. EPR minimum design live load due to precipitaion (snow and ice) is 100 psf on the ground. This value includes the weight of the 100-year return period snowpack and the weight of the 48-hour probable maximum winter precipitation, in accordance with the requirements of NUREF-0800, Section 2.3.1. This bounds the BBNPP site-specific design snow load.<br>Ice blockage of river is included in Section 19.1.5.4.2. |
| Industrial or Military Facility Accident | Screened in Section 19.1.5.4.5. |
| Landslide | Excluded due to lack of nearby mountains or steep slopes in the vicinity of BBNPP. |
| Lightning | Screened in Section 19.1.5.4.6. |

**Table 19.1-1 {Summary of External Events Evaluated for BBNPP}**
(Page 2 of 2)

| External Event Hazard | Evaluation |
|---|---|
| Low Water Level | The BBNPP safety-related ESWS consists of four safety-related ESWS cooling towers and basins with an inventory for 72 hours of heat removal under design basis accident conditions (2 of 4 trains available). Makeup is supplied from the 27-day safety-related ESWEMS Retention Pond. Makeup to the retention pond is supplied from the Susquehanna River. Water levels reached in the Susquehanna River is not likely impact the river's ability to provided retention pond makeup.<br>The normal heat sink takes makeup from the Susquehanna River. Water levels reached in the Susquehanna River is not likely impact its ability to provide makeup to the normal heat sink. |
| Low Winter Temperature | A minimum ambient air temperature of -40°F is assumed for buildings within the power block. Generally, there is adequate warning of icing on the ESWS so that remedial action can be taken. |
| Meteorite/Satellite Strike | All sites have approximately the same frequency of occurence. Low probability event. |
| Intense Precipitation | Screened in Section 19.1.5.4.2. |
| Onsite Release of Chemicals | Screened in Section 19.1.5.4.5. |
| Pipeline Accident | Screened in Section 19.1.5.4.5 |
| River Diversion | The BBNPP safety-related ESWS consists of four safety-related ESWS cooling towers and basins with an inventory for 72 hours of heat removal under design basis accident conditions (2 of 4 trains available). Makeup is supplied from the 27-day safety-related ESWEMS Retention Pond.<br>River diversion would cause a loss of the normal heat sink. This event is included in the Loss of condenser, Loss of Balance of Plant, and Loss of Main Feedwater initiating events. |
| Sandstorm | No nearby sand dunes or desert. Potential blockage of air intakes with particulate matter is generally considered in plant design. |
| Seiche | Screened in Section 19.1.5.4.2. |
| Seismic Activity | Plant seismic capacity is evaluated in Section 19.1.5.1. |
| Snow/Ice Loads | The U.S. EPR minimum design live load due to precipitation (snow and ice) is 100 psf on the ground. This value includes the weight of the 100-year return period snowpack and the weight of the 48-hour probable maximum winter precipitation, in accordance with the requirements of NUREG-0800, Section 2.3.1. This bounds the BBNPP site-specific design snow load.<br><br>Snow melt causing river flooding is included in Section 19.1.5.4.2. |
| Soil Shrink-Swell | Site-suitability evaluation and site development for the plant are designed to preclude the effects of this hazard. |
| Storm Surge | Screened in Section 19.1.5.4.2. |
| Toxic Gas | Screened in Section 19.1.5.4.5. |
| Transportation Accidents (other than aircraft) | Screened in Section 19.1.5.4.5. |
| Tsunami | Screened in Section 19.1.5.4.2. |
| Turbine Missile | Screened in Section 19.1.5.4.6. |
| Volcanic Activity | No volcanoes in vicinity |
| Waves | Screened in Section 19.1.5.4.2. |
| Other | None identified |

## 19.2 SEVERE ACCIDENT EVALUATIONS

This section of the U.S. EPR FSAR is incorporated by reference.

## 19.3 OPEN, CONFIRMATORY, AND COL ACTION ITEMS IDENTIFIED AS UNRESOLVED

This section of the U.S. EPR FSAR is incorporated by reference.