GE Hitachi Nuclear Energy

NEDO-34186
Revision B
July 2025

US Protective Marking: Non-Proprietary Information UK Protective Marking: Not Protectively Marked

BWRX-300 UK Generic Design Assessment (GDA) Chapter 15.8 – Deterministic Safety Analyses – Analysis of External Hazards

NEDO-34186 Revision B

INFORMATION NOTICE

This document does not contain proprietary information and carries the notation "US Protective Marking: Non-Proprietary Information" and "UK Protective Marking: Not Protectively Marked."

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT
Please Read Carefully

The design, engineering, and other information contained in this document is furnished for the purpose of obtaining the applicable Nuclear Regulatory Authority review and determination of acceptability for use for the BWRX-300 design and licensing basis information contained herein. The only undertakings of GEH with respect to information in this document are contained in the contracts between GEH and its customers or participating utilities, and nothing contained in this document shall be construed as changing those contracts. The use of this information by anyone for any purpose other than that for which it is intended is not authorized; and with respect to any unauthorized use, no representation or warranty is provided, nor any assumption of liability is to be inferred as to the completeness, accuracy, or usefulness of the information contained in this document. Furnishing this document does not convey any license, express or implied, to use any patented invention or any proprietary information of GEH, its customers or other third parties disclosed herein or any right to publish the document without prior written permission of GEH, its customers or other third parties.

UK SENSITIVE NUCLEAR INFORMATION, UK EXPORT CONTROL AND US EXPORT CONTROL INFORMATION

This document does not contain any UK Sensitive Nuclear Information (SNI) subject to protection from public disclosure as described in the Nuclear Industries Security Regulations (NISR) 2003, does not contain UK Export Controlled Information (ECI), and does not contain US Export Controlled Information (ECI) subject to the export control laws and regulations of the United States, including 10 CFR Part 810.

EXECUTIVE SUMMARY

This report presents Chapter 15.8 of the BWRX-300 Preliminary Safety Report (PSR) for assessment by the Office for Nuclear Regulation within Step 2 of the Generic Design Assessment (GDA) process. The chapter summarises the deterministic assessment of external hazards.

A hazard identification and screening process has been performed within the context of GDA. For those hazards which can be generically characterised, they are included within a Generic Site Envelope (GSE) which defines a limiting value of the design basis hazard magnitude across the eight candidate United Kingdom (UK) coastal sites. Where possible, the GSE hazard magnitudes include allowances for climate change, based upon the RCP 6.0 scenario at the 90th percentile as defined in UKCP18 climate projections.

The safety strategy for external hazards is based upon the protection of equipment to minimise the likelihood of an event causing a Postulated Initiating Event (PIE), and to ensure the continued availability of defence line 3 functions to provide mitigation of PIEs if they do occur. For hazards such as seismic events in which structures cannot provide full protection of equipment from its effects, the SC1 equipment housed in the structure is assigned to the highest category or classification level for qualification to ensure continued functional performance during and after a design basis hazard event.

For each screened-in external hazard, the design basis event, insofar as this can be determined within GDA is given, and general methods for characterising site-specific hazards are discussed. Qualitative arguments are given to demonstrate deterministic protection strategies provided by the plant, to show that fundamental safety functions will be maintained following a design basis hazard event.

In GDA Step 2, formal quantitative deterministic external hazards assessments are not directly presented. The PSR primarily analyses external hazards within the probabilistic safety analysis, and whilst much of that analysis can be used to inform the deterministic external hazards assessment, additional work is required to meet UK regulatory expectations. These gaps in the presentation of the external hazards safety case are captured within the Forward Action Plan for external hazards.

ACRONYMS AND ABBREVIATIONS

Acronym	Explanation
ABWR	Advanced Boiling Water Reactor
AHU	Air Handling Unit
ALARP	As Low As Reasonably Practicable
ATWS	Anticipated Transient Without Scram
BDB	Beyond Design Basis
BL	Baseline
CB	Control Building
CME	Coronal Mass Ejection
CRE	Control Room Envelope
CREEFU	Control Room Envelope Emergency Filtration Unit
CWS	Circulating Water System
DB	Design Basis
DBE	Design Basis Earthquake
DG	Diesel Generator
D-in-D	Defence-in-Depth
DL	Defence Line
DL1	Defence Line 1
DL3	Defence Line 3
DP-SC	Diaphragm Plate Steel-Plate Composite
EFU	Emergency Filter Unit
EH	External Hazard
EHE	External Hazard Evaluation
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FAP	Forward Action Plan
FSF	Fundamental Safety Functions
FSP	Fundamental Safety Properties
FW	Feedwater
GDA	Generic Design Assessment
GEH	GE Hitachi Nuclear Energy
GIC	Geomagnetically-Induced Currents
GSE	Generic Site Envelope
GSR	General Safety Requirements
GSU	Generator Step Up Transformer
HEPA	High Efficiency Particulate Arresting
HGNE	Hitachi GE Nuclear Energy

Acronym	Explanation
HSE	Health and Safety Executive
HVAC	Heating, Ventilation, and Air Conditioning
HVS	Heating and Ventilation System
IAEA	International Atomic Energy Agency
ICS	Isolation Condenser System
LfE	Learning from Experience
LOOP	Loss of Offsite Power
LOPP	Loss of Preferred Power
MCE	Maximum Credible Event
MCR	Main Control Room
MS	Main Steam
NHS	Normal Heat Sink
NS	Non-Seismic
OBE	Operating Basis Earthquake
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
PB	Power Block
PCSR	Pre-Construction Safety Report
PCW	Plant Cooling Water
PIE	Postulated Initiating Event
PSA	Probabilistic Safety Analysis
PSR	Preliminary Safety Report
PSfR	Preliminary Safeguards Report
RAT	Reserve Auxiliary Transformer
RB	Reactor Building
RCP	Representative Concentration Pathways
RCPB	Reactor Coolant Pressure Boundary
RFI	Radio Frequency Interference
RGP	Relevant Good Practice
RW	Radwaste
RWB	Radioactive Waste Building
SC1	Safety Class 1
SC2	Safety Class 2
SC3	Safety Class 3
SCCV	Steel-Plate Composite Containment Vessel
SCN	Non-Safety Class
SCR	Secondary Control Room

Acronym	Explanation
SDG	Standby Diesel Generator
SDV	Screening Distance Value
SPD	Standard Plant Design
SPE	Solar Particle Events
SSCs	Structures, Systems and Components
SSG	Specific Safety Guide
SSR	Specific Safety Requirement
TB	Turbine Building
TGFU	Toxic Gas Filtration Unit
UAV	Unmanned Aerial Vehicles
UK	United Kingdom
UKCP	UK Climate Projections
U.S.	United States
USNRC	U.S. Nuclear Regulatory Commission

TABLE OF CONTENTS

EXECUTIVE SUMMARY iii

ACRONYMS AND ABBREVIATIONS iv

REVISION SUMMARY xi

15.8 ANALYSIS OF EXTERNAL HAZARDS 3

15.8.1 General Approach to External Hazards Protection 3

15.8.2 Assumptions and Conservatisms 4

15.8.3 Treatment of Cliff-Edge Effects 5

15.8.4 Identification, Screening and Grouping of External Hazards 6

15.8.5 Analysis of External Hazards 7

15.8.6 Meteorological Hazards 8

15.8.6.1 High Air Temperature 8

15.8.6.2 Low Air Temperature 9

15.8.6.3 Strong Winds 11

15.8.6.4 Humidity and Fog 12

15.8.6.5 Tornadoes 12

15.8.6.6 Extreme Rain 14

15.8.6.7 Extreme Snow and Hail 15

15.8.6.8 Frazil Ice 16

15.8.6.9 High Water Temperature 16

15.8.6.10 Low Water Temperature 17

15.8.6.11 Lightning 18

15.8.7 Hydrological Hazards 19

15.8.7.1 External Flooding 19

15.8.7.2 High Water Level 20

15.8.7.3 Low Water Level 21

15.8.7.4 Corrosion 21

15.8.8 Seismic and Geological Hazards 22

15.8.8.1 Earthquakes 22

15.8.9 Other Natural Hazards 23

15.8.9.1 Natural Airborne Hazards (birds, leaves, ash) 23

15.8.9.2 Water Borne Material 24

15.8.9.3 Solar Storms 25

15.8.10 Man-Made and Industrial Hazards 26

15.8.10.1 Externally Generated Missiles and Blasts 26

15.8.10.2 Releases from Industrial Facilities 27

15.8.10.3 Hazards from Adjacent Nuclear Sites 28
15.8.10.4 Transportation Accidents 29
15.8.10.5 Accidental Aircraft Crash 30
15.8.10.6 Electromagnetic Interference 32
15.8.11 Loss of Offsite Power 32
15.8.12 External Fires 33
15.8.13 Combinations of Hazards 34
15.8.14 References 40
APPENDIX A CLAIMS AND ARGUMENTS STRUCTURE AND ALARP DISCUSSION 42
APPENDIX B FORWARD ACTION PLAN 46
APPENDIX C EXTERNAL HAZARD INDENTIFICATION AND SCREENING 55
APPENDIX D UK Specific generic Site Envelope Discussion 62

LIST OF TABLES

Table 15.8-1: BWRX-300 GSE Tornado Missiles Spectrum and Maximum Horizontal Speed ... 36

Table 15.8–2: Tornado Missiles Spectrum and Maximum Horizontal Speed ... 37

Table A-1: External Hazards, Claims and Arguments ... 42

Table B-1: Chapter 15.8 Forward Actions ... 44

Table C-1: Summary of External Hazard Identification and Screening ... 51

Table D-1 Summary of GSE Design Basis Values ... 60

Table D-2: Comparison of UK GSE and BWRX-300 Standard Plant Parameters ... 61

Table D-3: UK Aircraft Classes ... 62

LIST OF FIGURES

None.

REVISION SUMMARY

Revision #	Section Modified	Revision Summary
A	All	Initial Issuance
B	All	Update for end of GDA Step 2 consolidation

INTRODUCTION

Purpose and Scope

This report presents Chapter 15.8 of the BWRX-300 Preliminary Safety Report (PSR) for assessment by the Office for Nuclear Regulation (ONR) within Step 2 of the Generic Design Assessment (GDA) process. The Chapter summarises the deterministic assessment of external hazards. The items which are included and excluded from the scope of GDA Step 2 are summarised below.

Generic Design Assessment

The following items are within the scope of the External Hazards GDA Step 2 assessment:

- Definition of buildings that will be in scope of the external hazards assessment
- Description of the approach to external hazards
- Comprehensive listing of external hazards
- Screening of external hazards for GDA and future work including site-specific analyses
- Suitable and sufficient Generic Site Envelope (GSE) values (bounding of United Kingdom (UK) National Policy Statement EN-6 candidate sites), including consideration of climate change
- Approach to the identification of combinations of hazards (consequential, correlated, and credible independent combinations)
- Illustrative analyses of external hazards, applicable to the GSE
- Seismic Analysis methodologies
- Definition of suitable external hazard arguments to support BWRX-300 Claims
- Inputs to fault schedule development, and future engineering substantiation
- Consideration of cross-cutting issues in safety case
- Consideration of interactions with the Environmental, Security and Safeguards Submissions

Site Specific and Future Work

The following items are explicitly excluded from the scope of GDA Step 2. These issues are discussed in detail in this Chapter and are the subject of actions raised in the Forward Action Plan (FAP), which is presented in APPENDIX B.

- Detailed evidential design substantiation against design basis hazards
- Comprehensive assessment of external hazard combinations
- Detailed discussion of hazards which cannot be characterised for a generic site within GDA
- Consideration of site-specific aspects of plant (i.e., heat sink design)
- Aircraft Impact Analysis (characterising impact loads for future design substantiation)

Document Route Map

Section 15.8.1 summarises the general approach to external hazards. It describes the generic external hazard protection strategy as reported in 006N5064, “BWRX-300 Safety Strategy,” (Reference 15.8-1). Section 15.8.2 describes the assumptions and conservatisms adopted during GDA, and Section 15.8.3 describes the general approach to the consideration of cliff-edge effects.

Section 15.8.4 describes the approach taken to address the external hazards identification, screening, and grouping, as performed in NEDC-34138P, “BWRX-300 UK GDA Generic Site Envelope and External Hazards Identification,” (Reference 15.8-2), referred to herein as “the GSE report”.

Section 15.8.5 outlines the approach taken to external hazards analysis in this chapter.

Sections 15.8.6 to 15.8.12 discuss each of the screened-in natural and man-made external hazards. A description of the physical phenomena causing the hazard is given, together with the effects that affect the plant and potentially challenge the Fundamental Safety Functions (FSF). For those hazards that can be generically characterised at GDA, the design basis hazard value is presented. For hazards which are location dependent, that cannot be meaningfully characterised at GDA, an approach to characterisation is given where practical. The general approach to protection against each hazard is discussed, and demonstration is provided, as far as possible at GDA, that FSFs will be maintained following a design basis hazard event.

APPENDIX A presents the safety claims and arguments for external hazards.

APPENDIX B lists the items identified in the FAP as requiring additional future work.

APPENDIX C tabulates the full list of external hazards and identifies whether each hazard is:

- Considered within the scope of GDA
- Site-specific, but with reassurance provided during GDA
- Only able to be considered in any detail for a site-specific design

APPENDIX D summarises the GSE, which defines the design basis for those external hazards that can be generically characterised within GDA, as derived in the GSE report (Reference 15.8-2).

Interfaces with Other Preliminary Safety Report Chapters

Chapter 15.8 has interfaces with the following PSR Chapters:

- Chapter 2 – NEDO-34164, “BWRX-300 UK GDA Chapter 2: Site Characteristics,” (Reference 15.8-3)
- Chapter 3 – NEDO-34165, “BWRX-300 UK GDA Chapter 3: Safety Objectives and Design Rules for SSCs,” (Reference 15.8-4)
- Chapter 8 – NEDO-34170, “BWRX-300 UK GDA Chapter 8: Electrical Power,” (Reference 15.8-5)
- Chapter 9B – NEDO-34172, “BWRX-300 UK GDA Chapter 9B: Civil Structures,” (Reference 15.8-6)
- Chapter 15 – NEDO-34178, “BWRX-300 UK GDA Chapter 15: Safety Analysis,” (Reference 15.8-7), including all subchapters.
- Chapter 22 – NEDO-34194, “BWRX-300 UK GDA Chapter 22: Structural Integrity,” (Reference 15.8-8)

15.8 ANALYSIS OF EXTERNAL HAZARDS

Subchapter 15.8 identifies external hazards that originate from sources that are outside of the control of the nuclear power plant license holder, (i.e., the hazard source is not a part of the licensed nuclear site). The External Hazard Evaluation (EHE) identifies both individual hazard sources, combinations of sources, and considers consequential indirect hazards (e.g., high wind is a hazard, and wind-generated missiles are a consequential indirect hazard).

External hazards include both natural and human-induced hazards. Examples of natural external hazards include earthquakes, droughts, floods, high winds, tornadoes, tsunamis, and extreme meteorological conditions, such as extreme cold or heat. Examples of human-induced external hazards include potential release of toxic gases from adjacent facilities, aircraft crashes and ship collisions. External hazard events are site-specific; however, for the purposes of the PSR, a generic EHE is undertaken. The technical basis for the EHE is:

- International Atomic Energy Agency (IAEA) Specific Safety Requirements (SSR) SSR-2/1, “Safety of Nuclear Power Plants: Design” (Reference 15.8-9)
- IAEA General Safety Requirements (GSR) Part 4, “Safety Assessment for Facilities and Activities” (Reference 15.8-10)
- IAEA Specific Safety Guide (SSG) SSG-67, “Seismic Design for Nuclear Installations” (Reference 15.8-11)
- IAEA SSG-68, “Design of Nuclear Installations Against External Events Excluding Earthquakes” (Reference 15.8-12)

15.8.1 General Approach to External Hazards Protection

The general approach to external hazard protection is presented in the Safety Strategy (Reference 15.8-1) and is summarised here. The approach and mitigation differ from that employed in the mitigation of specific Postulated Initiating Events (PIEs) (which establishes required functionality in each of the functional Defence Lines (DLs)). Specific PIEs are not deterministically postulated to result from external hazards. Instead, a more global Defence Line 1 (DL1) approach, itself layered in a Defence-in-Depth (D-in-D) manner, is employed.

The objectives of this layered DL1 approach are to:

- Reasonably protect plant equipment to minimise the likelihood of an external hazard causing a PIE
- Ensure continued availability of DL3 functions to provide mitigation of PIEs if they do result from an external hazard
- Ensure certain fail-safe features are included in DL3 function implementation so that protective actions are likely to be initiated for relevant equipment failure causes
- Ensure adequate provisions within the design to allow plant personnel to monitor FSF performance and physical barrier integrity, to support management of unforeseen conditions or complicating factors associated with impacts of an external hazard event
- Ensure that other equipment that does not support DL3 functions is appropriately protected and/or qualified as required to satisfy plant safety goals, with due consideration of its risk-significance for a given hazard

The following Fundamental Safety Properties (FSPs) reflect those DL1 measures which are key elements of the design approach for external hazards:

- Equipment that performs or supports DL3 functions during the first 72 hours of a Design Basis (DB) external hazard event is protected and/or qualified, to remain functional during and after the DB hazard event, as follows:
  - Structures containing such equipment are designed in accordance with nuclear-specific codes and standards applicable to Safety Class 1 (SC1) structures.
- For hazards in which structures cannot provide full protection of equipment from effects of the external hazard (e.g., for seismic events), the SC1 equipment housed in the structure is assigned to the highest category or classification level for qualification to ensure continued functional performance during and after the DB hazard event.
- Equipment performing DL3 functions is designed to be fail-safe for various conditions including loss of electrical power supply, and loss of control signals which could arise in case of physical damage to equipment. Structures housing radiological waste materials are designed for external hazard protection in accordance with regulatory guidance and industrial codes and standards having precedent for application to such structures in nuclear power facilities.
- Other structures are designed in accordance with external hazard provisions reflected in international building codes appropriate for a power generation facility. National, regional, and local codes are considered and addressed in the course of licensing each facility. The Main Control Room (MCR) and associated egress route(s) between the MCR and Secondary Control Room (SCR) are protected such that human inhabitants of those areas are not caused incapacitating physical harm as a result of any DB external hazard event.
- Equipment that is qualified and located to remain functional during and following DB external hazard events is provided to support display of a suitable inventory of indications that allow confirmation of FSF performance and status of physical barriers to release.
- Equipment determined to be risk-significant based on external hazard-specific Probabilistic Safety Analysis (PSA) modelling is provided with additional protection and/or designated for qualification to survive the hazard conditions.

15.8.2 Assumptions and Conservatisms

The approach to External Hazards presented in this subchapter is based on the following assumptions. These are described in further detail in the GSE report (Reference 15.8-2):

- A single BWRX-300 unit operating in isolation is considered. Multi-unit considerations are outside the scope of the PSR. Some of the indicative hazard issues arising from adjacent nuclear sites are discussed in Section 15.8.10.3.
- The plant as discussed is based on the BWRX-300 Standard Plant Design (SPD)
- The buildings within the scope of PSR are those within the Power Block (PB) at Baseline (BL) BL1 level of maturity, which include:
  - Reactor Building (RB)
  - Turbine Building (TB)
  - Control Building (CB)

    - Radioactive Waste Building (RWB)
    - Service Building and Reactor Auxiliary Structures
- The generic site considered for the PSR is assumed to be coastal

The Normal Heat Sink (NHS) is assumed to use seawater as a once-through cooling water source from the sea to the Circulating Water System (CWS) and the Plant Cooling Water (PCW). Design of the heat sink is outside the scope of the PSR and work to address this will be performed at the site-specific stage. This requirement is covered by FAP Item PSR15.8-145 in APPENDIX B.

15.8.3 Treatment of Cliff-Edge Effects

The Safety Strategy (Reference 15.8-1) incorporates the concept of "cliff edge effect avoidance" consistent with IAEA SSR-2/1 (Reference 15.8-9) expectations. Supporting guidance in IAEA SSG-2, "Deterministic Safety Analysis for Nuclear Power Plants", (Reference 15.8-13) informs the BWRX-300 application of the concept.

A cliff edge effect is an instance of severely abnormal facility behaviour caused by an abrupt transition from one facility status to another following a small deviation in a facility parameter, and thus a sudden large variation in facility conditions in response to a small variation in an input. The term 'parameter' in this definition is interpreted in a broad sense as any plant physical variable or magnitude of an external hazard.

Sensitivity analyses and uncertainty quantifications are used to demonstrate that cliff edge effects leading to an early or large radioactive release are avoided (that the margin to a cliff-edge effect is adequate). Sensitivity analyses are performed on the best-estimate analyses of design extension condition event sequences in the extended deterministic safety analysis and the severe accident analysis. Dominant parameters in these analyses are examined to determine if small variations in the conservative direction introduce a cliff-edge effect. If a cliff edge effect is discovered, additional means of avoiding it are required to increase margin to the cliff edge.

Design basis events for natural hazards that can be characterised by a hazard curve are established at a 1.0 E-4/yr. frequency level including conservatisms. Design basis events for discrete or man-made external hazards are determined as a level consistent with plant faults at a frequency level of 1.0 E-5/yr. It is necessary to assess the hazard for events that are beyond the design basis level to demonstrate that the response of the plant does not result in disproportionately large risk consequences, and that there are no step changes or 'cliff-edges' close to the design basis return frequency and hazard load that would result in a gross increase in risk.

It is also necessary to determine the hazard loading at which FSFs could be lost, and to demonstrate that there are sufficient margins in the design and analysis assumptions between this point and the design basis.

Risk contributions from Beyond Design Basis (BDB) hazards are addressed in the hazards PSA NEDO-34184, "BWRX-300 UK GDA Chapter 15.6: Safety Analysis-Probabilistic Safety Assessment," (Reference 15.8-14). A complete assessment of cliff-edge effects is outside the scope of the PSR. Where appropriate, a discussion is provided for some hazards of the approach to cliff-edge considerations. This indicates, where possible, the absence of cliff-edge effects which would challenge the design. A detailed assessment of external hazards margins and cliff-edge effect will be undertaken in support of future work, and this is covered by FAP Item PSR 15.8-143 in APPENDIX B.

15.8.4 Identification, Screening and Grouping of External Hazards

A complete list of External Hazards (EHs) has been derived from Regulator guidance, publicly available documents, experience from previous nuclear plant External Hazard assessments, engineering judgment and international Relevant Good Practice (RGP). The process for deriving the list, together with the subsequent screening and grouping is described in detail in the GSE report (Reference 15.8-2). Where external hazard names identified are the same or similar, or have similar effects, these are grouped and considered together under a single hazard descriptor. The hazards are then examined to determine if they can be screened out from further consideration or if they are considered within PSR for assessment. Each external hazard is therefore considered to be either:

- Within scope of the PSR
- Site-specific but with provision of reassurance during PSR phase (i.e., partial inclusion in PSR scope)
- Site-specific and only able to be treated as such in any detail (i.e., excluded from the PSR scope)

Table C-1 in APPENDIX C lists and summarises the screening status of each external hazard for consideration.

EHs arising from malicious intent are not considered in this chapter.

The screening of EHs has been performed using the following screening criteria:

- Frequency of occurrence – 1.0 E-07 per reactor year is used as the cut-off frequency for assessment. Hazards with the potential to cause an initiating event that could lead to core damage and with frequencies greater than 1.0 E-07 per reactor year are screened in for deterministic assessment. Individual hazards with expected frequencies of less than 1.0 E-07 per reactor year are screened out. Those hazards that cannot be shown to be less frequent than 1.0 E-07 per reactor year with a high degree of confidence are not screened out:
  - The frequency of 1.0 E-05 per reactor year is used to determine the design basis for the discrete external hazards
  - For non-discrete hazards, a conservative estimate of hazard severity at the 1.0 E-04 per reactor year frequency of exceedance point on the hazard curve is used. Deterministic considerations are expected to include the region of the hazard curve down to the 1.0 E-04 point
  - Individual or combinations of independent external hazards with frequencies of lower than the design basis threshold frequency but greater than 1.0 E-7 per reactor year are considered to be BDB
- Bounded hazard – The failures induced by the hazard are bounded by another hazard of similar consequence and higher frequency.

The derivation of PIEs from screened-in external hazards has not currently been performed and is the subject of FAP Item PSR15.8-135.

For those hazards than cannot be screened out according to the above criteria, a design basis hazard event or loading is established. In some cases, this can be done on a generic basis based on consideration of potential sites at which BWRX-300 might be deployed. In other cases, characterisation of the hazards and establishment of a design basis can only be performed based on detailed considered of the site and its surrounding environment.

15.8.5 Analysis of External Hazards

This section discusses each of the screened-in external hazards. Subsections 15.8.6 to 15.8.9 discuss natural hazards and subsection 15.8.10 covers man-made hazards. Loss of Offsite Power (LOOP) and External Fire can arise from natural or man-made events; these are covered in subsections 15.8.11 and 15.8.12 respectively. External hazards which act in combination with other hazards are discussed in subsection 15.8.13.

A description of the physical phenomena causing the hazard is given, together with the effects that affect the plant and potentially challenge the FSFs. For those hazards that can be generically characterised at PSR, the design basis hazard loading is presented. For hazards which are location dependent, that cannot be meaningfully characterised at PSR, an approach to characterisation is given where practical.

Formal deterministic external hazards assessments are not directly presented. The general deterministic approach to protection against each hazard is provided here, and qualitative arguments are provided, as far as possible for the PSR, to show that FSFs will be maintained following a design basis hazard event.

The PSR primarily analyses external hazards within the PSA, and whilst much of that analysis can be used to inform the deterministic external hazards assessment, the following extra steps are identified as necessary future work:

- Derivation of the design basis loadings experienced by individual Structures, Systems and Components (SSCs) for all screened-in external hazards. In the case of some hazards, design basis loadings are derived within the GSE . For other hazards, a design basis cannot be established for the PSR. It may be possible to define a Maximum Credible Event (MCE) for some discrete hazards, and to argue that this will bound by consequence all events of a lesser magnitude.
- Comprehensive identification of all SSCs within each building for which:
  - Loss of function is assumed if a non-qualified building is challenged by a hazard
  - Continued function is assumed where the building is claimed to provide protection against the hazard
- The external hazards safety assessment does not currently identify PIEs which could occur as a result of an external hazard event. Future work would include identification of PIEs resulting from external hazards, evaluation of unmitigated radiological consequences, and identification of claimed DL3 Lines of Protection. This would support the development of the external hazard entries for future incorporation into a fault or hazard schedule. Development of the fault schedule is discussed in NEDO-34183, “BWRX-300 UK GDA Chapter 15.5 Safety Analysis – Deterministic Safety Analysis,” (Reference 15.8-15).
- Presentation of external hazards withstand functional requirements for those SSCs which are claimed to withstand and continue to function following a design basis external hazard event, and which are claimed to prevent demands on DL3 functions.
- Confirmation of qualification strategies for SSCs for which withstand and continued operation following a design basis hazard event is claimed. A notable instance is the RB structure, which protects all SC1 SSCs contained within from design basis hazards. Discussion of the integrity claims of the RB are provided within PSR Chapter 9B (Reference 15.8-6).

The outstanding work that is required to address these points is captured in FAP Item PSR15.8-135 in APPENDIX B.

Operational Experience (OPEX) arising from external hazard events which may have challenged nuclear facilities, or other infrastructure, and which may affect the design and safety case assumptions of the BWRX-300 plant, will be subject to review (FAP Item PSR15.8-151 in APPENDIX B refers).

15.8.6 Meteorological Hazards

15.8.6.1 High Air Temperature

Description of Hazard and Effects on Plant

Extreme high air temperature can affect the ability of the Heating, Ventilation, and Air Conditioning (HVAC) system to provide sufficient ventilation and prevent failure of temperature sensitive equipment. Failure of the HVAC system to provide cooling could lead to failure of SSCs to deliver their safety functions. Extremely high air temperature may induce thermal gradients in the structural components of the buildings (concrete, steel rebar, steel liners, tanks, etc.). These gradients can impose structural loads on SSCs that are important to safety and, in the extreme, could lead to the SSCs failing to deliver their safety functions.

Extremely high air temperatures can cause a loss of grid due to high demand on the transmission lines, which could potentially lead to a station blackout.

Extended periods of high air temp, with limited rainfall leading to drought can cause ground shrinkage leading to an impact on buried services.

The BWRX-300 Diesel Generators (DGs) are air-cooled, and thus operation may degrade or cease in extreme ambient temperature conditions, therefore potentially leading to a loss of back-up power.

It is assumed that BWRX-300 will use seawater as the NHS, which will not be directly affected by extreme high air temperatures.

Bounded Hazards

High Soil Temperature is assumed to be bounded by High Air Temperatures.

Design Basis Event

The design basis extreme high air temperature to be considered is specified in the GSE report (Reference 15.8-2). The maximum air temperature for a return frequency of 1.0 E-4 plus climate change adjustment factor for a coastal site is 45.6 °C (40.2 °C plus 5.4 °C) or for an inland site is 50.8 °C (45.4 °C plus 5.4 °C).

006N5991, “BWRX-300 Plant Architecture Definition,” (Reference 15.8-16) sets out the SPD parameters for high air temperature. SPD maximum dry bulb temperature is 39.7 °C. Safety Class 1 SSCs exposed to ambient environment conditions in MCR and SCR are designed for extreme temperatures of 47.2 °C. Safety Class 1 SSCs that are exposed to ambient environment conditions in RB and CB are designed for extreme temperatures of 37.8 °C. The SPD may not be bounding of the UK GSE value, FAP item PSR15.8-142 notes that the temperature hazards will be revisited at a future stage to ensure that the UK BWRX-300 design can accommodate the natural external hazard design basis values.

Protection Strategy

There is currently no deterministic assessment of high air temperature events available. This will be addressed in a future stage through FAP item PSR15.8-135. The PSA assumptions set out in 006N8341, “BWRX-300 External Hazards Screening” (Reference 15.8-17) encapsulate the safety philosophy for the high air temperature hazard, and provide claims and arguments that the safety functions of the plant are tolerant to beyond design basis air temperature events, which provides initial confidence that a deterministic case can be made in the future.

There are no BWRX-300 safety classified SSCs directly exposed to ambient environmental conditions. HVAC systems will maintain the environment in the PB buildings within appropriate parameters for temperature sensitive SSCs even if the outside air temperature is extreme.

The design of the HVAC system is intended to be customisable to accommodate customer requirements for different site-specific external air temperature and humidity ranges. It is envisaged that the heating and cooling functionality of the HVAC design for a UK BWRX-300 deployment will be modified according to the site-specific envelopes of these parameters. A site-specific system design description will be produced for the HVAC system, using temperature parameters derived for site conditions. FAP item PSR15.8-142 notes that the temperature hazards will be revisited at a future stage to ensure that the UK BWRX-300 design can accommodate the natural external hazard design basis values.

The integrity of the structural components of the building will not be challenged by the extreme air temperature postulated by the GSE temperatures. The civil structures which contain safety classified SSCs are designed to provide protection against external hazards and environmental conditions. Conservative safety margins are considered in the evaluations and design of SSCs to ensure their availability and efficiency under extreme temperature conditions.

Technical specification limiting conditions for operation are assumed to be in place to require plant shutdown in the event that environmental temperatures exceed a prescribed threshold. A plant shutdown will be achieved prior to a potential station blackout due to potential LOOP and loss of the DGs due to excessive temperature. Components that support Isolation Condenser System (ICS) operation are qualified for temperatures above credible high air temperatures.

Although the HVAC system efficiency is generally reduced due to extreme high air temperature conditions, the system is expected to provide sufficient cooling to maintain design limits for equipment rooms and to support control rooms habitability. For meteorological hazards, it is envisaged that Operating Procedures will be developed to obtain weather forecast information and outline appropriate measures following a forecast and detection of an extreme weather event. This is covered under FAP Item PSR15.8-146 in APPENDIX B.

Margins and Cliff-Edge Effects

Temperature performance margins will be incorporated into the design of SSCs, civil structures and HVAC systems to demonstrate their capability in postulated scenarios that are more severe (by a small amount) than those in the design basis without incurring cliff-edge effects. Conservative safety margins and sensitivity analyses will be applied in safety analyses to account for assumptions and uncertainties.

Conservative safety margins are considered in the evaluations and design of SSCs to ensure their availability and efficiency under extreme temperature and humidity conditions. The extreme ambient temperature hazard is slow to develop giving plant operators relatively long timescales to take responsive actions.

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.6.2 Low Air Temperature

Description of Hazard and Effects on Plant

Extremely low air temperature may induce thermal gradients in the structural components of the buildings (concrete, steel rebar, steel liners, tanks, etc.). These gradients can impose structural loads on SSCs that are important to safety and, in the extreme, could lead to the SSCs failing to deliver their safety functions.

Extreme air temperature and humidity variation can affect the ability of the HVAC system to provide sufficient ventilation and prevent failure of temperature sensitive equipment. Failure of the HVAC system to provide cooling could lead to failure of SSCs to deliver their safety function.

During periods of extreme cold, the potential exists for loss of grid due to high demand on the transmission lines and also failures of plant components due to low temperatures.

Bounded Hazards

Low Soil Temperature are assumed to be bounded by Low Air Temperatures.

Design Basis Event

The design basis extreme low temperature to be considered at PSR stage is specified in the GSE report (Reference 15.8-2). The minimum coastal temperature for a return frequency of 1.0 E-04 is -22.0°C and the minimum inland temperature for a return frequency of 1.0 E-04 is -38.4°C. The climate change adjustment factor for Low Air Temperature is conservatively assumed to be zero. The SPD temperature in the Plant Architecture Definition (Reference 15.8-16) for the BWRX-300 SSCs for low air temperature is -40 °C for a DB duration less than two hours, and -32.5 °C for 1 day.

Protection Strategy

There is no BWRX-300 safety classified SSCs directly exposed to ambient environmental conditions. SC1 equipment are located in the RB, and thus are not directly exposed to ambient environmental conditions.

Non-safety classified SSCs that are exposed to ambient environmental conditions and required to function in local extreme meteorological events, are assumed to be designed for 40 ºC.

During an extreme low air temperature event, LOOP is assumed to occur due to high energy demand and plant procedures are assumed to be in place to start the DGs when a low air temperature extreme is forecast. It is assumed that technical specification limiting conditions for operation exist which direct plant shutdown at an appropriate time interval if both or either DG fails to start and run. The DGs, which are air-cooled, are assumed to be unavailable given extreme temperatures at or below -40 ºC, which poses the potential for a station blackout.

Within GDA, the low air temperature hazard is assumed to bound the low soil temperature hazard. It is assumed that BWRX-300 building foundations are designed to address potential low soil temperatures and that pipes are buried below the frost line. In addition, this is a slow-developing event. If conditions exist that impact the ultimate heat sink, the plant is shut down prior to the loss of the heat sink.

For meteorological hazards, it is envisaged that Operating Procedures will be developed to obtain weather forecast information and outline appropriate measures following a forecast and detection of an extreme weather event (FAP Item PSR15.8-146 in APPENDIX B refers).

Margins and Cliff-Edge Effects

Temperature performance margins will be incorporated into the design of SSCs, civil structures and HVAC systems to demonstrate their capability in postulated scenarios that are more severe (by a small amount) than those in the design basis without incurring cliff-edge effects. Conservative safety margins and sensitivity analyses will be applied in safety analyses to account for assumptions and uncertainties.

Conservative safety margins are considered in the evaluations and design of SSCs to ensure their availability and efficiency under extreme temperature and humidity conditions. The extreme ambient temperature hazard is slow to develop giving plant operators relatively long timescales to take responsive actions.

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.6.3 Strong Winds

Description of Hazard and Effects on Plant

Extreme high winds can cause direct damage to plant structures, damage due to pressure differentials, and can cause the collapse of exposed structures. Damaged structures, such as building cladding, or untethered objects can also be carried by high winds and act as external missiles. High winds can also cause damage to grid connection infrastructure, resulting in LOOP.

Design Basis Event

The design basis strong winds hazard to be considered is specified in the GSE report (Reference 15.8-2). The mean wind velocity for a coastal site plus a climate change adjustment factor is 45.1 m/s (43.1 + 2 m/s), for a return frequency of 1.0 E-04.

The design basis high wind event for the BWRX-300 SPD is 71.5 m/s (160mph, 257.5 km/h) for a return period of 3000 years (Reference 15.8-16). Although this return period is less than the 10,000-year return period used to derive the GSE value, the magnitude of the SPD design basis bounds that defined for the PSR.

Protection Strategy

The design wind speed for the BWRX-300 is defined as the (straight-line) 3-second gust wind speed based on NUREG-0800 ‘Regional Climatology’ Section 2.3.1 (Reference 15.8-18). Seismic Category I structures are designed for a basic wind speed value of 71.5 m/s (160 mph).

The design wind speed, its recurrence interval, the speed variation with height, and the applicable gust factors are used in defining the input parameters for the structural design criteria appropriate to account for wind loadings. The procedures that are utilised to transform the design wind speed into an effective pressure applied to structures will take into consideration the geometrical configuration and physical characteristics of the structures and the distribution of wind pressure on the structures.

Safety Class SC1 systems and components shall be protected within wind resistant SC1 structures. The remainder of plant structures and components not designed for SC1 structures severe wind loads shall be arranged or designed such that their failures do not adversely affect the ability of SC1 SSCs to perform their DL function(s). For example, a structural gap is maintained between the RB and RWB to prevent any physical contact between the buildings during an extreme wind event.

The CB is designed to maintain its structural integrity under an extreme wind event to prevent adverse interaction with the RB Seismic Category I SSCs, incapacitating injury to MCR occupants or their egress to the SCR in the RB. The MCR and MCR to SCR egress route in the CB are hardened by design against perforations by extreme wind missiles.

Site-specific evaluations will be required to ensure that there is no adverse interaction between the RWB, CB, TB and Reactor Auxiliary Bay and the RB under design basis wind loads applicable for the RB.

For meteorological hazards, it is envisaged that Operating Procedures will be developed to obtain weather forecast information and outline appropriate measures following a forecast and detection of an extreme weather event (FAP Item PSR15.8-146 in APPENDIX B refers).

Margins and Cliff-Edge Effects

The High Wind PSA as discussed in PSR Subchapter 15.6 (Reference 15.8-14) will consider BDB wind loadings, and will evaluate risk contributions from low frequency, higher magnitude wind events. A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.6.4 Humidity and Fog

Description of Hazard and Effects on Plant

Humidity is a measurement of water vapour in air. Relative humidity is the ratio of the amount of atmospheric moisture present relative to the amount that would be present if the air was completely saturated. The amount of water required to achieve saturation increases as the temperature increases. Humidity can challenge the performance of HVAC systems and other air coolers.

High humidity can lead to fog/mist, and freezing fog can occur when the air temperature is around 0°C which can lead to ice accumulation on cold surfaces. The fog hazard has potential widespread effects on infrastructure including visibility issues for air and land transportation. The presence of fog could affect plant operations which require on-site equipment movement. External transportation hazards are addressed separately in Section15.8.10.4.

Design Basis Event

Specified in the GSE report (Reference 15.8-2), the maximum relative humidity value of 100% is taken as a conservative value for the GSE. No climate change adjustment is therefore required for high humidity. The SPD considerations for humidity are based upon wet bulb temperature exceedance values. The Plant Architecture Definition (Reference 15.8-16) provides a Maximum High Humidity Average Wet Bulb Globe Temperature Index of 30.3 ºC.

Protection Strategy

It is anticipated that equipment will be qualified to withstand design basis humidity levels. For systems that are climate specific, such as the HVAC, the SPD can be adapted based on the site specific conditions. This will be considered at a future stage (FAP Item PSR15.8-142 in APPENDIX B refers). For meteorological hazards, it is envisaged that Operating Procedures will be developed to obtain weather forecast information and outline appropriate measures following a forecast and detection of an extreme weather event (FAP Item PSR15.8-146 in APPENDIX B refers).

Margins and Cliff-Edge Effects

Meteorological conditions which give rise to extreme humidity are forecastable and develop over relatively long timescales giving plant operators sufficient timescales to take responsive actions. The maximum relative humidity of 100% is specified as the GSE design basis value. A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.6.5 Tornadoes

Description of Hazard and Effects on Plant

A tornado is a violently rotating column of air, often associated with thunderstorms, and typically occurs in the form of a visible condensation funnel, whose narrow end touches the earth and is often encircled by a rotating cloud of debris and dust. The hazard is distinguished from other strong winds due to its special characteristics with respect to duration, wind speed, and frequency of occurrence.

Tornadoes can cause structural damage from structural loading via the impact of very high winds. The sudden pressure drop that accompanies the passage of the centre of a tornado could also lead to structural damage.

Tornado events can strike with relatively little advance warning.

Design Basis Event

The design basis tornado to be considered is specified in the GSE (Reference 15.8-2), and is based on the U.S. Nuclear Regulatory Commission (USNRC) RG 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," (Reference 15.8-19) Region II:

- Tornadic maximum wind speed is 89.4 m/s
- Tornado maximum pressure drop is 63 mbar
- Tornado pressure drop rate is 25 mbar/s
- The tornado missiles spectrum data is summarised in Table 15.8 – 1

Protection Strategy

Tornado loads are considered in the design of BWRX-300 building structures and components based on their pertinent Seismic Category. The design input tornado wind parameters and tornado missile spectrum applicable to the Seismic Category A RB structure are based on Region I values from USNRC RG 1.76 (Reference 15.8-19). These values bound the design basis Region II values.

The bounding tornado design parameters are:

- Tornado maximum wind speed is 103 m/s (371 km/hr)
- Tornado maximum pressure drop is 83 mbar (8.3 kPa)
- Tornado pressure drop rate 37 mbar/s (3.7 kPa/s)
- Tornado missile spectrum summarised in Table 15.8 – 2

The procedures for transforming tornado wind speed into pressure-induced forces to apply to structures and the distribution across the structures are based on Bechtel Power Corporation BC-TOP-3-A "Tornado and Extreme Wind Design Criteria for Nuclear Power Plants," (Reference 15.8-20) and follow the guidance of Reg Guide 1.76 (Reference 15.8-19) to determine the pressure drop and rate of pressure drop caused by the passage of a tornado.

The Seismic Category II PB structures surrounding the RB are designed to maintain their structural integrity during an extreme wind event such that they do not collapse on the Seismic Category I RB.

To ensure the habitability of the MCR and post-accident requirements, part or all of the CB shall be hardened by design for the extreme storm effect including tornado generated missiles. Structures of hardened areas shall be designed to remain functional before, during and after the design storm event.

The CB HVAC is provided tornado rated dampers as necessary to withstand high wind events. Tornado dampers are provided at each RB Heating and Ventilation System (HVS) penetration to protect the RB structure. Tornado dampers close automatically and mitigate the effect of external hazards, including missiles.

Missiles created as a result of components and cladding failing during a tornado wind event are considered enveloped by the design basis missile spectrum considered for the RB. The structural integrity of the CB is maintained in the event of a design basis tornado missile to allow egress of operators to the SCR in the RB and to ensure availability of SSCs providing post-disaster mitigation functions. The RB external doors are designed to resist tornado missiles unless shielded by external stair towers or elevator shafts. External stair towers or elevator shafts credited for shielding are evaluated for tornado missiles.

Operating procedures should be developed to obtain weather forecast information and outline appropriate measures following a forecast and detection of an extreme weather event (FAP Item PSR15.8-146).

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.6.6 Extreme Rain

Description of Hazard and Effects on Plant

The event is defined as damage to the plant due to rain load on structures following extreme rain.

Highly intense rainfall events can challenge the capacity of building roof drainage systems. In extreme cases this can result in the ingress of water into the building, or structural failure due to the static load of water on the roof.

Rainfall can contribute to pluvial flooding, in which the accumulation of groundwater during extreme rainfall events has the potential to enter buildings or structures at ground level. This is discussed within the External Flooding hazard in Section 15.8.7.1.

Design Basis Event

The design basis extreme rain to be considered is specified in the GSE report (Reference 15.8-2). The design basis rainfall values with climate change adjustment selected for the BWRX-300 GSE are 210.3 mm in 1-hour (163 mm plus 29 %) and 400 mm in 24-hours.

006N5991, “BWRX-300 Plant Architecture Definition,” (Reference 15.8-16) confirms that within the SPD, plant structures are designed to accommodate a maximum rainfall rate of 493mm/h, and maximum short-term rain fall rate of 157mm in 5 minutes.

Protection Strategy

Rain load is considered in the design of the BWRX-300 building structures. The PB roofs are designed to minimise or eliminate rain loading considering rain intensity and duration. The PB roofs are also designed to minimise and evaluate the potential of ponding. Roofs are usually provided with drains designed to discharge precipitation, along with additional design measures to prevent undesirable build-up of standing water on the roofs of safety classified buildings, in accordance with USNRC Regulatory Guide 1.102, “Flood Protection for Nuclear Power Plants,” (Reference 15.8-21). Routing of rainfall drainage pipework is considered in the civil plant design, where routing could be via the interior or exterior of the building. Drainage should be sized sufficiently with the capability to avoid flooding of buildings.

Operating procedures should be developed to obtain weather forecast information and outline appropriate measures following a forecast and detection of an extreme weather event (FAP Item PSR15.8-146 in APPENDIX B refers).

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.6.7 Extreme Snow and Hail

Description of Hazard and Effects on Plant

Snow or hail accumulation can lead to excessive loadings on roof structures and may lead to structural collapse and damage to heat sink pumphouses. Snow loading on trees and electrical cables can cause LOOP. Snow and hail can also lead to the blockage of air cooler intakes and impact the performance of HVAC systems. Melting of snow or hail can cause flooding effects, which will in general be bounded by those due to extreme rain.

Large hailstones have the potential to present a missile hazard and cause impact damage to incident structures. Extreme hail events have been known to cause widespread damage to infrastructure resulting in a LOOP to some nuclear sites. Hail can block drains, further contributing to the flooding effect. The potential for hail floating in water to clog cooling water intakes will in general be bounded by frazil ice.

Design Basis Event

The design basis extreme snow load to be considered is specified in the GSE report (Reference 15.8-2). The design basis snow load value is selected as 1.5 kN/m^2. A separate design basis for hail is not specified within the GSE and will be defined at the site-specific stage. A climate change adjustment factor has not currently been derived for the design basis snow load at PSR. This is addressed in FAP Item PSR15.8-144.

006N5991, “BWRX-300 Plant Architecture Definition,” (Reference 15.8-16) confirms that plant structures are designed to accommodate maximum ground snow load of 2.5kN/m^2 for normal winter precipitation events and 5kN/m^2 for extreme winter precipitation events, which bound the GSE values.

Protection Strategy

The RB structure is designed using ground snow loads for normal and extreme winter precipitation events of 2.5 kPa and 5.0 kPa, respectively. For the RB structure, ground snow loads are converted to roof snow loading in accordance with the methodology specified in ASCE/SEI 7, “Minimum Design Loads and Associated Criteria for Buildings and Other Structures,” (Reference 15.8-22) referenced in DC/COL-ISG-7, “Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures,” (Reference 15.8-23). For the RB structure, the normal roof snow load is considered as a normal live load for all normal operating load combinations considered in the design. The extreme roof snow load is considered as an extreme load for the extreme environmental combinations without concurrent seismic or tornado loads.

For the RWB design, snow load (including snow drifting conditions, as applicable) is computed in accordance with the methodology specified in Clause 6.3, CSA N291 “Requirements for Safety-Related Structures for Nuclear Power Plants,” (Reference 15.8-24) and “Canadian Commission on Building and Fire Codes,” (NBC) (Reference 15.8-25), and based on 100 years occurrence. For the design of other Non-Seismic (NS) Category PB structures, the design snow load is determined in accordance with the methodology specified in NBC considering 50 years recurrence.

Structures are assumed to be designed to withstand white frost and accumulations of hail stones.

Impact damage effects of hail, including wind-borne hailstones are captured in the High Wind PSA under the effects of tornado missiles.

It is assumed that building foundations are designed to address potential soil frost and that pipes are buried below the frost line.

Margins and Cliff-Edge Effects

It is assumed that if heavy snowfall is forecast for multiple days, action is taken by the site to perform a plant shutdown if the integrity of plant structures due to heavy loading is threatened. Extreme snow is a relatively slow-developing event over the course of hours. Operating procedures would be developed to obtain weather forecast information and outline appropriate measures following a forecast and detection of an extreme weather event including heavy snowfall or hail (FAP Item PSR15.8-146 in APPENDIX B refers). A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX Brefers).

15.8.6.8 Frazil Ice

Description of Hazard and Effects on Plant

Frazil ice consists of ice crystals which can sporadically form in open, turbulent, super-cooled water. It can form at sea (with a freezing temperature of approximately -1.8 °C) on clear nights during cold weather when air temperature reaches -6 °C or lower. Frazil ice is the first stage in the formation of sea ice. The formation of frazil ice can affect sea-based cooling water intakes and can potentially restrict flow rates in the NHS.

Design Basis Event

A frazil ice design basis event is not specified at PSR and will be defined at the site-specific design stage (FAP Item PSR15.8-144 in APPENDIX B refers).

Protection Strategy

For the PSR, it is envisaged that the NHS will be a once-through cooling water source from the sea to the CWS and the PCW. Detailed protection strategies to mitigate against Frazil Ice blockages of the NHS will depend upon site-specific design of the NHS system. However, the ICS consists of three high-pressure reactor isolation loops that passively remove heat from the reactor when the NHS system is unavailable.

Margins and Cliff-Edge Effects

Detailed consideration of margins and cliff-edge effects will be taken in the detailed site-specific design (FAP Item PSR15.8-143 in APPENDIX B refers). However, the ICS system will ensure that the heat removal FSF is delivered in the limiting event where NHS is completely lost due to an external hazard.

15.8.6.9 High Water Temperature

Description of Hazard and Effects on Plant

The NHS is a once-through cooling system using seawater. The amount of heat removed during the process depends on the flow rate and the temperature rise of the water passing through the condensers.

The cooling water temperature can impact on the operational performance of the NHS. High water surface temperatures could affect the cooling capacity of the water and thereby lead to a reduction in reactor cooling capability. Extreme water temperature could result in a loss of plant cooling efficiency, which in the most severe condition could lead to equipment failure. High water temperatures can also lead to the introduction of non-native marine biological species, which can increase the risk of biological fouling affecting the NHS (See also Section 15.8.9.2).

Bounded Hazards

The High and Low Water Temperature hazards is assumed to bound the 'Underwater temperature' hazard identified in the GSE report (Reference 15.8-2) and APPENDIX C.

Design Basis Event

The design basis high water temperature to be considered is specified in the GSE report (Reference 15.8-2). The maximum cooling water temperature for a return frequency of 1.0 E-04 plus climate change adjustment factor for the GSE is 32.2°C (30°C plus 2.2°C).

Protection Strategy

For the purpose of the PSR, it is envisaged that the NHS will be a once-through cooling water source from the sea to the CWS and the PCW. The choice of NHS is subject to future design option selection. The system will be designed to withstand extreme high-water temperatures (FAP Item PSR15.8-145 in APPENDIX B refers). Additionally, the plant power level can be adjusted to accommodate rises in cooling water temperature, if necessary. The ICS will passively remove heat from the reactor if the NHS system were to become inoperable due to extreme high-water temperatures.

Margins and Cliff-Edge Effects

Extreme high-water temperature is a slow developing hazard, allowing mitigative operator actions to be performed. Detailed consideration of margins and cliff-edge effects will be taken in the detailed site-specific design. However, the ICS system will ensure that the Heat Removal FSF is delivered in the limiting event where NHS is completely lost due to an external hazard. A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.6.10 Low Water Temperature

Description of Hazard and Effects on Plant

Low water temperatures can lead to the formation of frazil ice on the surface of shallow coastal water. Frazil ice can cause blockages or reduced flow at the cooling water intakes. Low water temperatures can also lead to the introduction of non-native marine biological species, which can increase the risk of biological fouling affecting the NHS (See also Section 15.8.9.2).

Bounded Hazards

The High and Low Water Temperature hazards is assumed to bound the 'Underwater temperature' hazard identified in the GSE report (Reference 15.8-2) and APPENDIX C.

Design Basis Event

The design basis low water temperature to be considered is specified in the GSE report (Reference 15.8-2). The low water temperature selected for GSE is -1.9 °C.

Protection Strategy

For the purpose of the PSR, it is envisaged that the NHS will be a once-through cooling water source from the sea to the CWS and the PCW. The choice of NHS is subject to future design option selection. The system will be designed to withstand extreme low water temperatures (FAP Item PSR15.8-145 in APPENDIX B refers). Additionally, PCW and circulating water flow can be adjusted to accommodate low cooling water temperature if necessary. The ICS will passively remove heat from the reactor if the NHS system were to become inoperable due to extreme low water temperatures.

Margins and Cliff-Edge Effects

Extreme low water temperature is a slow developing hazard, allowing mitigative operator actions to be performed. Detailed consideration of margins and cliff-edge effects will be taken in the detailed site-specific design. However, the ICS system will ensure that the Heat Removal FSF is delivered in the limiting event where NHS is completely lost due to an external hazard. A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.6.11 Lightning

Description of Hazard and Effects on Plant

The event is defined as plant damage due to lightning. The impact may be direct, causing structural damage or LOOP events, or indirect through the electromagnetic field or fire started by lightning. The consequences of lightning strike consist of lightning-induced fires, as well as voltage transients, which interfere with electrical systems functions.

Design Basis Event

The design basis for lightning is specified in the GSE report (Reference 15.8-2).

The lightning characteristics selected for BWRX-300 GSE are:

- The highest flash density is 1.4 flashes/km^2/year
- The upper limit for the lightning strike current is 300 kA
- Annual average days of thunder is 15 days

A climate change adjustment factor has not currently been derived for the design basis lightning event. This is addressed in FAP Item PSR15.8-149.

BWRX-300 SPD parameters relating to lightning are not available for GDA Step 2, FAP PSR15.8-142 will ensure that the UK BWRX-300 design can accommodate the UK GSE values at a future stage.

Protection Strategy

Grounding and lightning protection systems are used to protect structures, transformers, and equipment against lightning-induced surges.

BWRX-300 lightning and grounding protection systems are described in PSR Chapter 8 (Reference 15.8-5) and summarised as follows.

The overall grounding system consists of a plant ground grid and grounding system conductors with a low-resistance path to the plant ground grid. The BWRX-300 grounding grid includes a buried building grounding grid and a local switchyard grounding grid both with grounding electrodes. Ground grids are tied together to ensure equal potential and tied to the remote switchyard grounding grids when required. Grounding system conductors for equipment and instrument grounds are installed within buildings to provide a low-resistance path to the grounding grid. Lightning protection is installed on structures and select electrical equipment to protect against lightning strikes. Lightning protection devices are tied to the ground grid through low impedance paths.

The lightning protection system covers all major plant structures and is designed to prevent direct lightning strikes to the buildings, electric power equipment and instruments. It consists of air terminals, bare downcomers, and buried grounding electrodes. Lightning arresters are provided for each phase of all tie lines connecting the plant electrical systems to the switchyard and offsite lines. These arresters are connected to the high-voltage terminals of the Generator Step Up Transformer (GSU), and Reserve Auxiliary Transformer (RAT). Plant instrumentation located outdoors or connected to cabling running outdoors is provided with surge suppression devices to protect the equipment from lightning-induced surges if required.

The electrical grounding system is expected to perform its design functions in normal and abnormal conditions. These systems are completely passive and perform no active functions.

The BWRX-300 plant design is assumed to appropriately protect electrical systems functions from voltage transients though a LOOP may occur.

Operating procedures should be developed to obtain weather forecast information and outline appropriate measures following a forecast and detection of an extreme weather event (FAP Item PSR15.8-146 in APPENDIX Brefers).

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.7 Hydrological Hazards

15.8.7.1 External Flooding

Description of Hazard and Effects on Plant

External flooding hazards are extremely dependent on-site location and local hydrology. For coastal site locations considered for PSR, factors including sea water levels, storm surge, tides and tsunami can contribute to the flooding risk either individually or in combination. Storm surges are short-lived local increases in water level above that of the tide and are driven by wind and atmospheric pressure gradients.

Flood water can present a common failure cause of safety classified systems, resulting in the potential loss of the external connection to the electrical power grid, the decay heat removal system and other safety systems. Damage can also be caused to safety classified SSCs by the infiltration of water into internal areas of the plant, induced by high flood levels caused by the rise of the water table. Water pressure on walls and foundations may challenge their structural capacity. Deficiencies in the site drainage systems and in non-waterproof structures may also cause flooding of the site. The dynamic effect of the water can be damaging to the structure and the foundations of the plant as well as the many systems and components located outside the plant. Flooding may also affect the communication and transport networks around the plant site and can make the road network around the plant impassable.

Design Basis Event

The design basis flood height for a 1.0 E-4/yr. flooding event has not been established within the GSE for PSR and will be derived at the site-specific stage (FAP Item PSR15.8-144 in APPENDIX B refers). The effect of climate change on the design basis flood height will also be assessed. The maximum flood height for the BWRX-300 SPD is 0.341 meters below grade.

Protection Strategy

The maximum flood level and Local Intense Precipitation elevations do not exceed plant grade, and therefore a dry site concept is implemented. As a result, there are no external flooding protection features required in the BWRX-300 design, and no need for a permanent dewatering system. All exterior access openings and exterior penetrations for the Seismic Category I RB are above grade.

The BWRX-300 design considers the groundwater level at finished grade elevation. The hydrostatic pressure associated with the design flood level or with the design groundwater level is considered as a structural load on the base mat and basement walls for structural design. Uplift or floating of structures is considered and the total buoyancy force is based on the hydrostatic pressure due to the design flood level, excluding wave action, or the design groundwater level. The lateral, overturning and upward hydrostatic pressures acting on the side walls and on the foundation slab, respectively, are also considered in the structural design of these elements.

The BWRX-300 RB, which is embedded partially below grade, is analysed, and designed to withstand the effects of a maximum external flood defined at grade. Since the flood level is considered at the finished grade level, only hydrostatic effects are considered in the analysis and design of structures, while dynamic phenomena associated with a flooding event, such as currents, wind waves, and their hydrodynamic effects are not considered. Dynamic phenomena will be considered and developed as the site-specific flood level becomes available. The site-specific flood protection design requirements will also contain detailed flood protection design requirements including suitable water tightness measures.

The containment vessel and structures, the RB and the RWB are designed to include protective features to mitigate or eliminate the adverse consequences of flooding. Process piping penetrations through the exterior walls of the nuclear island below grade are embedded in the wall or are welded to a steel sleeve embedded in the wall. There are no access openings or tunnels penetrating the exterior walls of the nuclear island below grade. Suitable water tightness measures, including but not limited to use of waterproofing on exterior walls and under mat are provided below flood elevation. All exterior access openings and exterior penetrations for the RB are above grade. Walls below the design basis flood level are designed to withstand hydrostatic and hydrodynamic loads. Plant grade is above design flood level, so the PB structures remain accessible during postulated flood events. No emergency actions are required due to flooding to ensure the safe operation of the BWRX-300 plant.

The civil/structural design criteria for the BWRX-300 PB structures with respect to external flooding are addressed in PSR Chapter 3 (Reference 15.8-4).

The RWB is currently assessed against half of the Probable Maximum Flood height. Work is required to confirm if a design basis flood height for the RWB lower than the site design basis flood is appropriate, given the claimed low unmitigated radiological consequences of faults in this building. The requirement for this assessment is covered by FAP Item PSR15.8-136 in APPENDIX B. It is also included in NEDC-34357P, “BWRX-300 UK GDA Safety Case Manual Specification”, (Reference 15.8-30), which was produced during GDA Step 2 (in response to FAP item PSR15-3, see APPENDIX B). This specification outlines the requirements for a SCM for the deployment of the BWRX-300 baseline design in the UK, which the future phases of the project need to consider. Within this specification it highlights an approach to the development of information or methodologies to meet UK regulatory expectations and requirements within the PCSR and provides a level of confidence that identified differences shall be addressed.

Margins and Cliff-Edge Effects

Conditions that produce high water level are assumed to be gradual enough to permit achievement of plant shutdown and a safe stable state prior to flood damage of the TB and potential station blackout due to potential offsite power and loss of the DGs as a consequence of the flooding. Therefore, an external-flood-induced Anticipated Transient Without Scram (ATWS) is considered to be not credible. A station blackout is assumed to occur. However, ICS operation would allow the plant to maintain a safe stable state.

A full assessment of external flooding margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers)

15.8.7.2 High Water Level

Description of Hazard and Effects on Plant

The event is defined as plant impact due to abnormally high sea water levels. High sea water levels may be due to storm surges, waves, tides and seiches. Low pressure and high weather systems over the sea can cause local effects on sea level. The sea surface responds to the rise and fall in regional atmospheric pressure, with a decrease or increase in its surface height with reference to mean sea level. Effects on plant due to high sea water are bounded by those considered in the External Flooding hazards Section 15.8.7.1.

Design Basis Event

Sea water level will require assessment at the site-specific stage, noting that relative sea-level rise around coasts is variable and depends on a number of factors (FAP Item PSR15.8-144 in APPENDIX B refers). For the purpose of the PSR, sea level is expected to rise in the future due to climate change, a worst-case scenario predicts an average of well over 20 mm/yr. over the next 80 years as shown in the GSE report (Reference 15.8-2).

Protection Strategy

The protection strategy against the High Water Level Hazard is as described for the External Flooding Hazard in Section 15.8.7.1.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.7.3 Low Water Level

Description of Hazard and Effects on Plant

The event is defined as plant impact due to low sea water level. The low levels may be due to storm surges, waves, tides and seiches. Low pressure and high weather systems over the sea can cause local effects on sea level. The sea surface responds to the rise and fall in regional atmospheric pressure, with a decrease or increase in its surface height with reference to mean sea level. Low water levels can result in exposure of sea water intake structures and can therefore compromise the performance of the NHS. Severe geological shifting could accompany an earthquake and potential rapid loss of the NHS

Design Basis Event

Analysis of site-specific data relating to low tides and high air pressure, and characterisation of the Low Water Hazard will be required at the site-specific stage (FAP Item PSR15.8-143 in APPENDIX B refers).

Protection Strategy

Low water level is a slow developing event. It is assumed that the plant is shut down and to reach a safe stable state prior to the loss of circulating water or PCW. ICS operation is not impacted by the loss of the NHS and will therefore enable the plant to maintain a safe stable state.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.7.4 Corrosion

Description of Hazard and Effects on Plant

At a coastal site, exposed external surfaces are subject to corrosion due to the presence of salt containing moisture. Corrosion occurs when a surface is wetted by moisture formed due to rain, fog, and condensation. Atmospheric corrosion is a complex process involving a large number of interacting and constantly varying factors, such as weather conditions, air pollutants, material conditions, etc. Corrosion effects and accelerated ageing of steel structures exposed to the marine environment can be induced by sulphate-reducing bacteria. The combined effect of these factors results in great variations in corrosion rates. Corrosion will occur on most exposed metal structures and components (such as electrical insulators) unless protected and maintained. A salt covering of plant structures could impact the integrity of Non-Seismic Category I structures.

Design Basis Event

Characterisation of the corrosion hazard unavailable for PSR, and the hazard will be considered in detail during future work (FAP Item PSR15.8-144 in APPENDIX B refers).

Protection Strategy

Site-specific design measures will be adopted to mitigate or minimise the rates and consequences of corrosion for SSCs which will be exposed to corrosive salts. It is expected that inspection and maintenance programs for SSCs with potential to be affected by corrosion will be implemented to mitigate any effects which might lead to failure of safety function delivery (FAP Item PSR15.8-146 in APPENDIX B refers). It is assumed that the plant is shut down and in a safe, stable state prior to severe impact to plant structures from salt accumulation.

Margins and Cliff-Edge Effects

Corrosion is a slow developing hazard, and inspection and maintenance programmes will identify and mitigate any effects which might lead to loss of safety functions. A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.8 Seismic and Geological Hazards

15.8.8.1 Earthquakes

Description of Hazard and Effects on Plant

Seismic events are generally natural, due to movement of the Earth's tectonic plates but can also be caused by human action (induced seismicity), e.g., storing large amounts of water behind a dam, drilling, and injecting liquid into wells, and by coal mining or oil extraction. At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground (e.g., liquefaction, slope instability, subsidence, ground collapse).

The major effects from an earthquake are related to the vibrations induced through the structures of the plant. Vibrations can affect the plant safety functions directly or by indirect interaction mechanisms such as mechanical interaction between items, release of hazardous substances, fire or flooding induced by an earthquake, impairment of operator access and unavailability of evacuation routes or access routes. Earthquakes can also cause LOOP and affect communication and transport networks around the plant. Seismic events simultaneously affect all SSCs in the plant and can potentially challenge all FSFs.

Design Basis Event

For the PSR, a bounding peak ground acceleration of 0.3 g has been adopted as the Design Basis Earthquake (DBE) within the GSE report (Reference 15.8-2). An Operating Basis Earthquake (OBE) is not defined within the GSE for GDA Step 2 and will be defined during future work (FAP Item PSR15.8-144). Site-specific assessment of the seismic hazard will require detailed characterisation work to establish ground motion spectra and soil-structure interaction effects (FAP Item PSR15.8-144 in APPENDIX B refers). An output of seismic characterisation will be the derivation of a seismic hazard curve. This can be used to establish the 1.0 E-4/yr. DBE, and to provide input into seismic PSA to assess plant response and risk contributions from BDB events.

Protection Strategy

Details of the BWRX-300 seismic protection strategy and assessment methodology are presented in Section 3A.1.1 of PSR Chapter 3 (Reference 15.8-4). Subsections 3A.1.1.1 and 3A.1.1.2 describe the seismic design parameters used in the SPD, and the approach to site-specific design. Subsection 3A.1.1.3 presents the adopted seismic analysis methods. Subsection 3A.1.1.4 describes the seismic qualification by analysis of the BWRX-300 Seismic Category 1A and 1B subsystems. Subsection 3A.1.1.5 describes the instrumentation that is provided so that the seismic response of SSCs can be evaluated promptly after an earthquake. Subsection 3.2.3 of PSR Chapter 3 presents the seismic categorisation scheme. Subsection 3.9.2. of PSR Chapter 3 presents the equipment seismic qualification approach

Seismic Category RW is adopted for the radwaste building structure, and this is based on the definition of RW-IIa in USNRC RG 1.143 "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," (Reference 15.8-26). This requires that:

> *For a given structure housing radwaste processing systems or components, if the total design basis unmitigated radiological release (considering the maximum inventory) at the boundary of the unprotected area is greater than 500 millirem per year or the maximum unmitigated exposure to site personnel within the protected area is greater than 5 rem per year, the external structures are classified as RW-IIa.*

In the BWRX-300 SPD, SSCs seismically classified as RW are seismically qualified for one-half of the site-specific DBE, for which justification is claimed as it would bound the ground motion spectra for seismic categories identified in ASCE/SEI 43 "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," (Reference 15.8-27). Work is required to confirm the DBE for SSCs seismically classified as RW and if the assumed one-half of the site-specific DBE is appropriate. The requirement for this assessment is covered by FAP Item PSR15.8-137 in APPENDIX B. It is also included in NEDC-34357P, "BWRX-300 UK GDA Safety Case Manual Specification", (Reference 15.8-30), which was produced during GDA Step 2 (in response to FAP item PSR15-3, see APPENDIX B). This specification outlines the requirements for a SCM for the deployment of the BWRX-300 baseline design in the UK, which the future phases of the project need to consider. Within this specification it highlights an approach to the development of information or methodologies to meet UK regulatory expectations and requirements within the PCSR and provides a level of confidence that identified differences shall be addressed.

Margins and Cliff-Edge Effects

A full scope seismic PSA will assess the response of the plant to BDB seismic loads and will quantify the risk contributions from seismic events in excess of the DBE. This will demonstrate that there is no cliff-edge effect just beyond the DBE in which the radiological consequences would be disproportionately high. Fragility curves for seismically categorised SSCs will be derived in accordance with the methodology presented in PSR Chapter 3 (Reference 15.8-4) to determine seismic margin to failure and to provide determination of SSC functionality in BDB evaluations as part of the seismic risk evaluation. A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.9 Other Natural Hazards

15.8.9.1 Natural Airborne Hazards (birds, leaves, ash)

The event is defined as plant impact from airborne swarms or material including insects, birds, or leaves. Insect swarms can lead to restriction of air flow and limit operability of HVAC systems or back-up diesel plant. Similar consequences are likely to be seen from other naturally occurring hazards which have been screened as site specific, including:

- Salt storm
- Sandstorm
- Dust storm
- Volcanic activity, specifically volcanic ash

The following could be adversely affected by airborne swarms or material:

- Air filters (e.g., clogging of HVAC and High Efficiency Particulate Arresting (HEPA) filters)
- Power supplies (on-site and/or off-site), e.g., by creating short circuits in electrical equipment (e.g., leading to LOOP)
- Water supplies (via the deposition of particulates into the water, which could also affect water chemistry)
- Pumps and hydraulic systems may also be affected if lubricating oils become contaminated, although this is much less likely to occur due to the design of such systems
- Transport means, to and from site, including movement of staff
- Communications networks and transport networks around the site area of a nuclear installation
- Buildings (via ash loadings and contamination)
- Health of workers and support services
- Any air-cooled safety equipment could be directly affected by volcanic ash deposition as could any control centre facilities requiring a source of fresh filtered air for the personnel working within them
- Blockage or drains or gutters

Design Basis Event

Analysis will be required at the site-specific stage (FAP Item PSR15.8-144 in APPENDIX B refers).

Protection Strategy

Preventative measures will be considered in the design where appropriate, such as screens or equivalent engineered features, to prevent blockage of outside air intakes by non-human biota. Further mitigation measures and management procedures will be developed where required.

A comprehensive site ecology survey will be required at the site-specific stage.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.9.2 Water Borne Material

Description of Hazard and Effects on Plant

The event is defined as plant impact due to organic and non-organic material in intake water. The material may be algae, seaweed, fish, mussels, jellyfish, shellfish, shrimps, clams, shells, biological biofouling, biological flotsam (wood, foliage, grass), underwater debris, bottom flora, bottom deposit, trash, sediments, or similar materials.

Marine or water-borne hazards can cause blockages, obstructions, or damage to the intakes for sea water cooling systems leading to either a reduction in heat transfer capacity or total loss of cooling water to safety systems.

Design Basis Event

Determination of the design basis will be required for future work (FAP Item PSR15.8-145 in APPENDIX B refers).

Protection Strategy

The Pumphouse/forebay structure will be designed to prevent clogging by algae and exceptional quantities of fish and to stop them from entering the cooling systems. Measures considered to mitigate the effects of such clogging include locating the intake tunnel and intake structure at an adequate depth and the installation of traveling water screens to prevent intake of biofouling material.

To prevent the intake of biofouling material and mitigate the probability of clogging, design considerations regarding the intake tunnel and intake structure depths are employed. At the same time, traveling screens in the Pumphouse/Forebay may be used to mitigate clogging probability. If the intake structure screens are deemed insufficient for biofouling material intake prevention during the design phase, a fish return system, or slew, may be provided to safely return large fish.

There are no Safety Category 1 functions provided by the BWRX-300 water intake structures and associated systems and components. The PCW and CWS housed in the Pumphouse/Forebay are Safety Class 3 (SC3) systems. As a result, the Pumphouse/Forebay is categorised as a NS structure.

A comprehensive site ecology survey will be required at the site-specific stage.

Preventative measures will be considered in the design where appropriate, further mitigation measures and management procedures will be developed where required (FAP Item PSR15.8-146 in APPENDIX B refers).

In the Advanced Boiling Water Reactor (ABWR) GDA, Hitachi GE Nuclear Energy (HGNE) were advised to consider loss of heat sink due to hazards such as biological fouling as a frequent event in the generic design, even if design mitigations are site-specific and therefore out of scope of GDA. Therefore, this should also be considered for the BWRX-300, and this is captured in FAP Item PSR15.8-141 in APPENDIX B.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.9.3 Solar Storms

Description of Hazard and Effects on Plant

Solar storms can disrupt communication and cause blackouts by damaging power plants and electrical grid components.

A Coronal Mass Ejection (CME) is a significant ejection of magnetic field and accompanying plasma mass from the Sun's corona into the heliosphere. The CME's solar wind plasma connects with the Earth’s magnetosphere causing rapid changes in the configuration of Earth's magnetic field, a form of space weather called a geomagnetic storm. Solar flares can cause Geomagnetically-Induced Currents (GICs), which are a type of electrical current that flows along electrical power transmission systems and any other electrical equipment. This type of current is induced by a naturally induced geo-electric field during geomagnetic disturbances. Although the time, intensity, and areas of such an event cannot be precisely calculated, this current propagates along a route of least resistance such that certain conditions may be more prone. GICs have the potential to disrupt electrical transmission systems, giving rise to LOOP events.

In addition to GIC effects, fast CMEs can create shockwaves that accelerate coronal and solar wind ions (predominantly protons) to near light-speed velocities. These highly energised particles are able to reach the earth within a few minutes, producing Solar Particle Events (SPEs).

Design Basis Event

A design basis event is not defined for PSR stage. Analysis will be in future work (FAP Item PSR15.8-144 in APPENDIX B refers).

Protection Strategy

On-site monitoring to detect GIC currents in transformers as well as monitoring websites for issued warnings of the potential threat is recommended. Operating procedures should be developed with appropriate measures following forecast and detection of a solar storm event (FAP Item PSR15.8-146 in APPENDIX B refers).

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.10 Man-Made and Industrial Hazards

15.8.10.1 Externally Generated Missiles and Blasts

Description of Hazard and Effects on Plant

The event covers damage to the plants due to explosions (deflagration or detonation) of solid substances, gas clouds originating outside of the site, or damage to the plants due to explosions (deflagration or detonation) after a pipeline accident. The damage may be due to pressure impact or impact from missiles.

Shock waves produced by explosions pose the potential to damage site SSCs. In the worst case all structures could be lost, other than the RB, as well as a LOOP. The DGs could also be lost and electrical cables and control cables in the TB may be impacted.

Turbine disintegration events at adjacent nuclear sites can also generate external missiles which could affect the plant. Section 15.8.10.3 considers hazards from adjacent nuclear sites.

Design Basis Event

Industrial hazards will require site specific information for safety analysis in terms of location and distance of the hazard from the plant (FAP Item PSR15.8-144 in APPENDIX B refers). Characterisation of the effects of external missiles on the plant will typically be based on the Screening Distance Value (SDV) for each hazard effect. The SDV for a particular hazard is the distance from the site boundary beyond which the direct consequences of that hazard on safety classified SSCs on site are insignificant. Where potential hazard sources are identified within the SDV, these are then further assessed as to the likelihood of occurrence and impact on the site. IAEA give guidance on assessing the SDCs in IAEA Safety Standard SSG-79

"Hazards Associated with Human Induced External Events in Site Evaluation for Nuclear Installations," (Reference 15.8-28).

Protection Strategy

The RB shields the Steel-Plate Composite Containment Vessel (SCCV) structure and safety equipment from different external natural and human-induced hazards. The RB, CB and TB are qualified against design basis tornado missiles as discussed in Section 15.8.6.5. Impact loadings from design basis missiles are transmitted indirectly to the containment structure through the RB wingwalls and interconnecting floors. These may bound some of the effects of transportation hazards. This will be established at the site-specific design stage.

The missile hazard analysis would be required to evaluate missiles resulting from external hazards at the site-specific stage. Missile protection will be considered in the design of SSCs based on the pertinent safety class, seismic category, and special hardening requirements for extreme storms.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.10.2 Releases from Industrial Facilities

Description of Hazard and Effects on Plant

The event includes toxic impact due to chemical release outside the site. These releases may originate from process accidents outside the plant or from leakages of substances stored outside the plant. Industrial processes can release dust to the atmosphere due to component failure or human error. Hazardous materials have the potential to harm personnel and disable safety classified plant. The consequences of MCR staff exposure to high levels of dust can be similar to those from toxic chemical exposure.

Chemical releases pose the potential to contaminate process water and soil.

Design Basis Event

Industrial or military hazards will require site-specific information for safety analysis in terms of the types of hazardous material and their sources (FAP Item PSR15.8-144 in APPENDIX B refers). Characterisation of the effects of industrial hazards on the plant will typically be based on the SDV for each hazard effect. The SDV for a particular hazard is the distance from the site boundary beyond which the direct consequences of that hazard on safety classified SSCs on site are insignificant. Where potential hazard sources are identified within the SDV, these are then further assessed as to the likelihood of occurrence and impact on the site. IAEA give guidance on assessing the SDVs in SSG-79 (Reference 15.8-28).

Protection Strategy

The plant design includes two distinct and independent control rooms, a MCR and a SCR. The MCR and SCR are physically and electrically separated facilities such that at least one facility remains accessible and functional during and following a PIE. The MCR is located in the CB and has the capability to operate the plant during normal conditions as well as maintain the plant in a safe state and monitor critical parameters during an off-normal event. The SCR is located in the RB and provides the capability to initiate safe shutdown, maintain the plant in a safe state, and monitor critical parameters during an off-normal event.

The MCR is the assured operating location for a toxic gas release event. The HVAC system maintains the atmosphere in the MCR and SCR at the required temperature, humidity, pressurisation, radiation exposure, and toxic gases. Positive pressure is maintained in the CB by way of providing outside air through the normal supply Air Handling Unit (AHU), the Toxic

Gas Filtration Unit (TGFU), or the Control Room Envelope Emergency Filtration Unit (CREEFU).

In the event of a CB normal outside air intake toxic gas detection, the operating normal AHU normal outside air intake closes, and the same train TGFU automatically starts and its associated motor control dampers automatically open, providing an alternate source of filtered outside air for CB pressurisation.

The upper and lower RB supply AHU intakes are monitored for toxic gas (if applicable) and radiation. If toxic gas or radiation are detected, the upper and lower RB supply AHU turns off and the isolation dampers shut. Additionally, the SCR normal supply and exhaust isolation dampers shut, and the SCR pressurisation fans energise, supplying the SCR with filtered outside air.

Adequate provisions are provided within the design to allow plant personnel to monitor performance and physical barrier integrity, to support management of unforeseen conditions or complicating factors associated with impacts of an external hazard event.

In cases of loss of active cooling, the SCR is passively cooled, such that for 72 hours after the initiating event, the SCR temperature does not exceed 32.2 °C. It is a slow-developing event, and there are mitigating features, and enough time for operator to take proper action.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work activities (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.10.3 Hazards from Adjacent Nuclear Sites

Description of Hazard and Effects on Plant

Hazards from adjacent nuclear sites may include older pre-existing facilities, or from other BWRX-300 units on a multi-unit site. The PSR considers a single BWRX-300 unit; therefore, hazards from adjacent nuclear sites are considered out of the PSR scope. At the site-specific stage, consideration for any multi-unit site or construction on a site which already has an operational nuclear reactor or a facility undergoing decommissioning, will require assessment of such hazards.

Adjacent or nearby nuclear sites have the potential, under accident conditions, to release nuclear and other types of radioactive materials that could affect the site being assessed. This is in addition to the conventional industrial hazards such as hazardous gas release (e.g., carbon dioxide).

Design Basis Event

A design basis event is not defined for PSR. Analysis will be undertaken as part of future work activities (FAP Item PSR15.8-144 in APPENDIX B refers).

Protection Strategy

Protection against missiles and blasts from adjacent nuclear sites is similar to those from conventional industrial facilities and is addressed in Section 15.8.10.1.

With regard to offsite radioactive releases, the following protection strategy is provided.

In the event of a CB normal outside air intake radiation monitor alarm, the operating normal supply AHU outside air inlets isolate and the building goes into 100% recirculation mode. the associated TGFUs de-energize, and the associated train CREEFU automatically starts. The CRE isolation dampers close in conjunction with the start of the CREEFU. SDG backup power is provided to the building Air handler and CREEFU supply fans. The CREEFU heating coils are energized. Battery Room exhaust fans will continue to operate based off timers.

Adequate provisions are provided within the design to allow plant personnel to monitor performance and physical barrier integrity, to support management of unforeseen conditions or complicating factors associated with impacts of an external hazard event.

The upper and lower RB supply AHU intakes are monitored for toxic gas (if applicable) and radiation. If toxic gas or radiation are detected, the upper and lower RB supply AHU turns off and the isolation dampers shut. Additionally, the SCR normal supply and exhaust isolation dampers shut, and the SCR pressurisation fans energize, supplying the SCR with filtered outside air.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.10.4 Transportation Accidents

Description of Hazard and Effects on Plant

Accidents involving road, rail, or marine transportation onto or in the vicinity of the plant could challenge the safety and operation in several ways, including:

- Direct impact of a vehicle causing global structural damage of an impacted structures, including partial structural deformations which prevent the structure from performing its function or potentially structure collapse
- Localised structural damage due to the effects of direct and secondary missile impact, including penetration, perforation, scabbing and spalling, leading to failure of a structural element or of safety classified equipment
- Functional failure of SSCs due to induced vibrations in structural members and safety classified equipment, particularly when safety classified items are located close to the external perimeter of the structures
- The effects of fuel-initiated fires and possibly explosion on SSCs and personnel
- The effects of flammable, explosive, asphyxiant, corrosive, toxic or radioactive substances released on SSCs and personnel
- Damage to cooling water intakes due to shipping impacts
- Ingress of marine contamination into cooling water intakes

Aircraft impact accidents are addressed in Section 15.8.10.5 .

Design Basis Event

The characterisation of transportation hazards will require site-specific information for safety analysis in terms of location and distance of the hazard from the plant (FAP Item PSR15.8-144 in APPENDIX B refers). They would include locations of nearby roads, railways lines, and shipping lanes, together with any other transportation-related infrastructure.

Characterisation of the effects of transportation hazards on the plant will typically be based on the SDV for the hazard effect. The SDV for a particular hazard is the distance from the site boundary beyond which the direct consequences of that hazard on safety classified SSCs on site are insignificant. Where potential hazard sources are identified within the SDV these are then further assessed as to the likelihood of occurrence and impact on the site. IAEA give guidance on assessing the SDVs in SSG-79 (Reference 15.8-28).

Protection Strategy

The RB shields the SCCV and safety equipment from different external natural and human-induced hazards. The RB, CB and TB are qualified against design basis tornado missiles as discussed in Section 15.8.6.5. Impact loadings from design basis missiles are transmitted indirectly to the containment structure through the RB wingwalls and interconnecting floors. These may bound some of the effects of transportation hazards. This will be established at the site-specific design stage.

To protect against marine transportation accidents, a restricted zone surrounding the intake channel and diffuser can be implemented, to reduce the risk of commercial shipping approaching the site shoreline.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.10.5 Accidental Aircraft Crash

Description of Hazard and Effects on Plant

The Accidental Aircraft Crash hazard is due to failure of an aircraft in the airspace close to the locality of the BWRX-300 site, resulting in the aircraft crashing directly or in the immediate vicinity of buildings or structures on the site. Damage to the site can be caused by direct impact effects as well as fires and explosions due to aviation fuel, impact of secondary missiles and vibration effects.

Aircraft impact, with the BWRX-300 site as the target, due to malicious intent, terrorist acts or warfare are excluded from this assessment in the PSR.

Direct and indirect effects of an aircraft crash can include:

- Damage to impacted structures, including excessive deformations or displacements which prevent the structure from performing its function. Collapse or overturning of the structure is also possible.
- Localised structural damage due to the effects of direct and secondary missile impact, including penetration, perforation, scabbing and spalling, leading to failure of a structural element or of safety classified equipment.
- Functional failure of SSCs due to induced vibrations in structural members and safety classified equipment, particularly when safety classified items are located close to the external perimeter of the structures.
- The effects of fuel-initiated fires and possible explosions affecting SSCs resulting in thermal loads and blast loads on structures. Smoke ingress from aviation fuel pool fires is also possible.

As most of the RB containment structure is below grade, this is discounted from direct impact effects.

Bounded Hazards

The Accidental Aircraft Crash hazard is assumed to bound the ‘Meteorite’ and ‘Satellite crash’ hazards identified in the GSE report (Reference 15.8-2) and APPENDIX C.

Design Basis Event

The aircraft crash hazard is characterised by defining a discrete set of aircraft classes and deriving impact frequencies for each of these. Contributors to the crash frequencies will depend upon the proximity of the proposed site to airways and any military flight activity, together with local aviation features such as civilian and military airports in the area. All types of vehicles engaged in aerial activity could potentially contribute to the hazard. Light aircraft including helicopters, commercial airliners, transportation, and military aircraft all contribute to the hazard. These are summarised and defined in APPENDIX D. In addition, other vehicles such as hot-air balloons, gyrocopters, gliders, airships, and Unmanned Aerial Vehicles (UAV) should also be considered.

Classes of aircraft with site impact rates in excess of 1.0 E-5/yr. will be considered as design basis events, and those with impact rates below 1.0 E-5 but in excess of 1.0 E-7/yr. will undergo assessment as BDB events. For the purposes of PSR it is envisaged accidental aircraft impact of each class will be BDB. Protection measures against malicious aircraft impact will also afford protection against accidental events. Representative aircraft of each class will be selected for accidental impact evaluation studies.

The impact of UAVs or ‘drones’ striking the BWRX-300 SSCs is bounded by small aircraft crash. The USNRC has reviewed impact of drones on United States nuclear power plants in Office of Public Affairs “Drones and Nuclear Power Plant Security,” (Reference 15.8-31). Their assessment states “The technical analysis concluded that U.S. nuclear power plants do not have any risk-significant vulnerabilities that could be exploited by adversaries using commercially available drones to result in radiological sabotage, theft, or diversion of special nuclear material (essentially the reactor fuel)”. UAV impacts are therefore screened out.

Characterisation of accidental aircraft crash event frequencies is covered by FAP Item psr15.8-148 in APPENDIX B .

Protection Strategy

The RB is assumed to be designed to withstand large aircraft impact, which is bounding in terms of consequence of light aircraft impacts. The aircraft engines pose the most significant RB penetration hazard as these elements possess the greatest kinetic energy and effectively become missiles on impact. The RB utilises Diaphragm Plate Steel-Plate Composite (DP-SC) construction, and it is assumed that design parameters for the DP-SC, such as steel thickness, steel ductility, and concrete thickness, are selected to withstand perforation of the RB due to aircraft and aircraft engine impact. SC1 components inside the RB are assumed to remain intact and maintain their intended functions following the impact of a large commercial aircraft. The PSA assumes that a general transient occurs for all PB buildings, except the TB. For the TB, it is assumed that a Loss of Preferred Power (LOPP) event has occurred because of the electrical switchgear in the TB.

Jet fuel could potentially rain down the RB exterior or spill on grade. Energy from combustion of this fuel poses the potential to impact the integrity of non-concrete features of the RB. At grade level, these features consist of the doorway to the truck bay, and two single personnel access doors. If a jet fuel fire damages any of these doors, the products of combustion are assumed to enter Stair A, Stair B and/or the truck bay. There is no PSA-credited equipment in these locations. There are no propagation pathways from these locations for the fire to spread to the ICS pools, heat exchangers, and valves, which is the credited means of decay heat removal. There is an equipment access double door located at the refuelling deck, located approximately 16 m above grade at Level 16. The products of combustion from a jet fuel fire are postulated to not impact this doorway. The RB exterior penetrations are protected by robust structures designed to withstand the impact of an aircraft. Tornado louvers provide an additional layer of protection against missiles and jet fuel.

In the PSA, all structures other than the RB are assumed to be damaged and off-site power is assumed to be lost as a result of the impact and conflagration. The potential exists for a direct hit from an aircraft engine to one of the RB exterior doors. The conditional containment failure probability and resultant conditional core damage probability is conservatively assumed to be 1.0 for this case in the PSA.

The work required to analyse the response of the plant to accidental aircraft impact events is covered by FAP Item PSR15.8-147 (APPENDIX B refers). It is also included in NEDC-34357P, "BWRX-300 UK GDA Safety Case Manual Specification", (Reference 15.8-30), which was produced during GDA Step 2 (in response to FAP item PSR15-3, see APPENDIX B). This specification outlines the requirements for a SCM for the deployment of the BWRX-300 baseline design in the UK, which the future phases of the project need to consider. Within this specification it highlights an approach to the development of information or methodologies to meet UK regulatory expectations and requirements within the PCSR and provides a level of confidence that identified differences shall be addressed.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work activities (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.10.6 Electromagnetic Interference

Description of Hazard and Effects on Plant

The event includes impact from man-made magnetic or electric fields. The main examples of such fields are fields from radar, radio, or from mobile phones.

Electromagnetic Interference (EMI) is a disturbance that affects an electrical circuit due to electromagnetic radiation emitted from an external source. The source could be man-made such as an electrical circuit, radar, communication systems, civil activities, or military activities.

Bounded Hazards

For hazards screening purposes, EMI is also considered to include Radio Frequency Interference (RFI) and also Electromagnetic Compatibility (EMC) considerations. It is also assumed to bound the 'Eddy currents into ground' hazard identified in the GSE report (Reference 15.8-2) and APPENDIX C.

Design Basis Event

Due to the unavailability of specific electrical component specifications at PSR, the EMI hazard is not considered at this stage and will be assessed in future work.

Protection Strategy

BWRX-300 instrumentation and control systems are assumed to be designed to prevent electromagnetic disturbance from significantly impacting them.

Protection against EMI caused by lightning, high-voltage transmission lines and telecommunication towers is provided through the use of appropriate shielding and qualification of equipment. Safety Class SSCs are protected against EMI to enable them to perform their intended design functions and remain fit for purpose in the conditions under which they are expected to perform.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.11 Loss of Offsite Power

Description of Hazard and Effects on Plant

External Hazards may affect the surrounding off-site infrastructure through common-cause effects, for example there could be a LOOP as a consequence of a meteorological event. Climate change models predict an increase in the frequency and severity of meteorological events; therefore, climate change must be considered in terms of potential increase in the frequency and duration of the DB LOOP event.

The consideration of LOOP requires appropriate interface arrangements to manage potential secondary and consequential effects.

Design Basis Event

LOOP events are usually specified by duration and frequency. These will be established at the site-specific design stage. It is acknowledged that revised guidance on the approach to LOOP has recently been issued, and consideration of this will be addressed via FAP Item PSR15.8-140 (APPENDIX BAPPENDIX B refers) in order to assess any implications within External Hazards for the BWRX-300.

Protection Strategy

The BWRX-300 electrical systems are designed to meet IAEA SSR-2/1, “Safety of Nuclear Power Plants: Design” (Reference 15.8-9). Although the BWRX-300 does not require any onsite or offsite AC power for safety, the permanently installed Standby Diesel Generators (SDG)s provide standby AC power and generally meet all requirements of IAEA SSR-2/1. Restoring power as soon as possible is desirable. Following a plant LOOP, the SDGs are expected (although not credited) to automatically start and achieve rated voltage and frequency within 30 seconds. The completion of automatic sequencing is expected (but not credited) to take no longer than two minutes. The permanently installed batteries provide the emergency power required for the SC1, SC2, and SC3 loads to meet plant needs for 72 hours. If offsite power is not restored, AC power is provided via the SDGs or via permanently installed external connections for use with portable generators.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work activities (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.12 External Fires

Description of Hazard and Effects on Plant

The event is defined as impact on the plant from fires originating from outside the site area. Sources of external fires include both naturally occurring and man-made fires including fireballs as a result of a rail transportation accident, forest fires, lightning.

Design Basis Event

A design basis external fire cannot be established for the PSR and will be developed during future work (FAP Item PSR15.8-144 in APPENDIX B refers).

Protection Strategy

External exposure hazards (e.g., flammable, and combustible liquid or gas storage, adjacent industrial facilities or transportation systems, natural vegetation, and adjacent plant support facilities) that could potentially expose SSCs important to safety to damage from the effects (e.g., heat, flame, smoke) of fires will be identified at the site-specific stage.

The land coverage surrounding the future site would likely be cleared of most vegetation.

The normal outside air intakes for the MCR will be monitored for toxic gases and smoke and isolates the outside air dampers if toxic gas or smoke is detected.

The SCR is provided with EFUs and pressurisation fans that supply ventilation air to the operators when automatically placed into service upon detection of smoke at the normal lower-level supply AHUs. A loss of power to both normal supply AHUs will also initiate operation of the SCR EFUs and pressurisation fans.

Margins and Cliff-Edge Effects

A full assessment of margins and cliff-edge effects will be undertaken in future work (FAP Item PSR15.8-143 in APPENDIX B refers).

15.8.13 Combinations of Hazards

The individual external hazards discussed in this section can potentially occur in combination. There are three distinct mechanisms of combined external hazard that should be considered:

- **Consequential Hazards:** An external natural or man-made physical event can directly present a primary external hazard to a nuclear plant. In some cases, this can directly cause one or more secondary events which act as secondary hazards to the plant. Similarly, the secondary hazards can in turn cause tertiary hazards. Combinations which arise due to this mechanism are generally termed Consequential Hazards. As an example, a seismic event which occurs under an ocean can result in a tsunami. In this case, the earthquake would present a primary hazard to the plant, and the flooding effect of the tsunami would be a secondary hazard. Primary external hazards can also cause secondary internal hazards. In the prior example, the seismic event could damage non-seismically qualified pipework within the plant, resulting in internal flooding and other pressure part failure related internal hazards.
- **Correlated Hazards:** Some external hazards can often occur together due to their having origins in common underlying physical conditions. This is often the case for meteorological hazards, where weather patterns can manifest a range of related hazardous phenomena. As an example, a winter storm can result in heavy rain, hail or snow, together with high winds and lightning. Groups of hazards occurring together in this way during certain scenarios are generally termed Correlated Hazards.
- **Independent Hazards:** Hazards or plant faults with no underlying causal link can sometimes randomly occur either simultaneously or in relatively close succession. In these cases, plant equipment could be damaged by the first hazard, which then compromises the ability of the plant to protect against the consequences of a second hazard or plant fault, before remedial action has been taken. As an example, a severe storm could occur several hours after a seismic event. Internal hazards could also occur randomly before or after a plant is challenged by an external hazard. These types of combinations can be assessed and potentially screened out based on occurrence frequencies and assumed recovery times.

Hazard combinations are currently addressed in the extant BWRX-300 PSA. The deterministic approach to the identification and assessment of external hazard combinations is not described in this Chapter. The planned approach to the treatment of internal and external hazards is addressed in a separate Topic Report (Reference 15.8-29). As there are many potential combinations involving both internal and external hazards, this combined hazards topic report present a single unified approach covering all hazards.

The current approach to the assessment of hazard combinations largely reflects the limited consideration of combined hazards within the PSA. It does not fully consider deterministic aspects in the approach; this is particularly relevant within the identification and screening of credible combinations. FAP item PSR15.7-72 is cross-cutting across internal and external hazards, and addresses the requirement to perform a deterministic assessment of hazards, including identification, screening, characterisation and assessment of consequences, including external combinations, external to internal combinations and internal combinations. This has been addressed for GDA Step 2 via the gap recorded in FAP Item PSR15-3, for which a Safety Case Manual (SCM) Specification, (Reference 15.8-30), has been produced.

CONCLUSION

A summary of the deterministic assessment of external hazards for BWRX-300 within GDA Step 2 has been presented in this chapter.

A hazard identification and screening process has been performed within the context of GDA to determine a complete list of external hazards. These have been categorised to determine if they can be considered within the scope of GDA or if they are site-specific. In the latter case, for some site-specific hazards, it is possible to provide some general reassurance within GDA. For those hazards which can be generically characterised, they are included within a GSE which defines a limiting value of the design basis hazard magnitude across the eight candidate UK coastal sites. This is presented in the GSE report (Reference 15.8-2). Where possible, the GSE hazard magnitudes include allowances for climate change, based upon the RCP 6.0 scenario at the 90th percentile as defined in United Kingdom Climate Projections (UKCP) UKCP18.

The safety strategy for external hazards is based upon the protection of equipment to minimise the likelihood of an event causing a PIE, and to ensure the continued availability of DL3 functions to provide mitigation of PIEs if they do occur. For hazards such as seismic events in which structures cannot provide full protection of equipment from its effects, the SC1 equipment housed in the structure is assigned to the highest category or classification level for qualification to ensure continued functional performance during and after a design basis hazard event.

For each screened-in external hazard, the design basis event, insofar as this can be determined within GDA is given, and general methods for characterising site-specific hazards are discussed. Qualitative arguments are given to demonstrate deterministic protection strategies provided by the plant, to show that FSFs will be maintained following a design basis hazard event. All SC1 SSCs are located within the RB, which provides the principal means of protection against many of the screened-in external hazards. A dry site concept is adopted as protection against external flooding, in which SSCs are located above the design basis flood level. The ICS provides passive heat removal against those external hazards which could result in loss of heat sink or LOOP.

In GDA Step 2, formal quantitative deterministic external hazards assessments are not directly presented. The PSRs for DNNP and TVA primarily analyse external hazards within the PSA, and whilst much of that analysis can be used to inform the deterministic external hazards assessment, additional work is required to meet UK regulatory expectations.

To support the full presentation of a deterministic external hazards safety case it will be necessary to derive the design basis loadings experienced by individual SSCs for all screened-in external hazards. It is also necessary to comprehensively identify all SSCs within each building for which loss of function is assumed, or for which continued function is claimed where, for instance, a housing building is claimed to provide protection against the hazard. Presentation of functional requirements for those SSCs which are claimed to withstand and continue to function following a design basis external hazard event, and which are claimed to prevent demands on DL3 functions will be required, together with qualification strategies to support these claims. Work is also required, where appropriate, to assign PIEs resulting from external hazards, and to evaluate of unmitigated radiological consequences and formally identify claimed DL3 Lines of Protection.

It is necessary to determine the hazard loading at which FSFs could be lost, and to demonstrate that there are sufficient margins in the design and analysis assumptions between this point and the design basis. It will also be necessary to assess the hazard for events that are beyond the design basis level to demonstrate that the response of the plant does not result in disproportionately large risk consequences, and that there are no step changes or 'cliff-edges' close to the design basis return frequency and hazard load that would result in a gross increase in risk. For each hazard, some initial discussion has been provided where possible to provide confidence in the availability of margins within the design, and to demonstrate its tolerance to cliff-edge effects.

These gaps in the presentation of the external hazards safety case are captured within the FAP for this topic, as given in APPENDIX B.

Table 15.8-1: BWRX-300 GSE (Region II) Tornado Missiles Spectrum and Maximum Horizontal Speed

Missile Type	Dimensions	Mass	Horizontal Velocity (V_{mhmax})	Vertical Velocity (0.67 of V_{mhmax})
Schedule 40 Pipe	0.168 m dia x 4.58 m long	130 kg	34 m/s	22.8 m/s
Automobile 5 m x 2 m x 1.3 m	5 m x 2 m x 1.3 m	1810 kg	34 m/s	22.8 m/s
Solid Steel Sphere	25.4 mm dia	0.0669 kg	7 m/s	4.7 m/s

Table 15.8–2: Region I Tornado Missiles Spectrum and Maximum Horizontal Speed

Missile Type	Dimensions	Mass	Horizontal Velocity (V_{mhmax})	Vertical Velocity (0.67 of V_{mhmax})
Schedule 40 Pipe	0.168 m dia x 4.58 m long	130 kg	41 m/s	27.5 m/s
Automobile 5 m x 2 m x 1.3 m	5 m x 2 m x 1.3 m	1810 kg	41 m/s	27.5 m/s
Solid Steel Sphere	25.4 mm dia	0.0669 kg	8 m/s	5.4 m/s

15.8.14 References

15.8-1 006N5064, "BWRX-300 Safety Strategy," Revision 6, GE-Hitachi Nuclear Energy, Americas, LLC, January 2024.

15.8-2 NEDC-34138P, "BWRX-300 UK GDA Generic Site Envelope and External Hazards Identification," Revision 1, GE-Hitachi Nuclear Energy, Americas, LLC., June 2024.

15.8-3 NEDO-34164, "BWRX-300 UK GDA Chapter 2: Site Characteristics," Rev B, GE-Hitachi Nuclear Energy, Americas, LLC.

15.8-4 NEDO-34165, "BWRX-300 UK GDA Chapter 3: Safety Objectives and Design Rules for SSCs," Rev B, GE-Hitachi Nuclear Energy, Americas, LLC.

15.8-5 NEDO-34170, "BWRX-300 UK GDA Chapter 8: Electrical Power," Rev B, GE-Hitachi Nuclear Energy, Americas, LLC.

15.8-6 NEDO-34172, "BWRX-300 UK GDA Chapter 9B: Civil Structures," Rev B, GE-Hitachi Nuclear Energy, Americas, LLC.

15.8-7 NEDO-34178, "BWRX-300 UK GDA Chapter 15: Safety Analysis – (including Fault Studies, PSA and Hazard Assessment)," Rev B, GE-Hitachi Nuclear Energy, Americas, LLC.

15.8-8 NEDO-34194, "BWRX-300 UK GDA Chapter 22: Structural Integrity," Rev B, GE-Hitachi Nuclear Energy, Americas, LLC.

15.8-9 IAEA Safety Standards, Specific Safety Requirements, No. SSR-2/1 (Rev. 1), "Safety of Nuclear Power Plants: Design," International Atomic Energy Agency, 2016.

15.8-10 IAEA Safety Standards, General Safety Requirements, No. GSR Part 4 (Rev. 1), "Safety Assessment for Facilities and Activities," International Atomic Energy Agency, 2016.

15.8-11 IAEA Safety Standards, Specific Safety Guide, No. SSG-67, "Seismic Design for Nuclear Installations," International Atomic Energy Agency, 2021.

15.8-12 IAEA Safety Standards, Specific Safety Guide, No. SSG-68, "Design of Nuclear Installations Against External Events Excluding Earthquakes," International Atomic Energy Agency, 2021.

15.8-13 IAEA Safety Standards, Specific Safety Guide, No. SSG-2 (Rev 1), "Deterministic Safety Analysis for Nuclear Power Plants," International Atomic Energy Agency, 2019.

15.8-14 NEDO-34184, "BWRX-300 UK GDA Chapter 15.6: Safety Analysis – Probabilistic Safety Assessment," Rev B, GE-Hitachi Nuclear Energy Americas LLC..

15.8-15 NEDO-34183, "BWRX-300 UK GDA Chapter 15.5: Safety Analysis – Deterministic Safety Analysis", Rev B, GE-Hitachi Nuclear Energy Americas LLC..

15.8-16 006N5991, "BWRX-300 Plant Architecture Definition," Rev 1, GE-Hitachi Nuclear Energy Americas LLC.

15.8-17 006N8341, "BWRX-300 External Hazards Screening," Rev A, GE-Hitachi Nuclear Energy Americas LLC., October 2021.

15.8-18 USNRC Standard Review Plan, NUREG-0800, "2.3.1 Regional Climatology", Revision 3, March 2007.

15.8-19 U.S. Nuclear Regulatory Commission, Regulatory Guide 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," March 2007.

15.8-20 BC-TOP-3-A, "Tornado and Extreme Wind Design Criteria for Nuclear Power Plants," Bechtel Power Corporation.

15.8-21 USNRC Regulatory Guide 1.102, "Flood Protection for Nuclear Power Plants," Rev 1, September 1976.

15.8-22 ASCE/SEI 7, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures," American Society of Civil Engineers.

15.8-23 USNRC DC/COL-ISG-7, "Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures."

15.8-24 CSA N291, "Requirements for Safety-Related Structures for Nuclear Power Plants," CSA Group.

15.8-25 Canadian Commission on Building and Fire Codes, National Building Code of Canada, Volume 1, 2020.

15.8-26 USNRC Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," Revision 2, November 2001.

15.8-27 ASCE/SEI 43, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," 2005.

15.8-28 IAEA Safety Standard SSG-79, "Hazards Associated with Human Induced External Events in Site Evaluation for Nuclear Installations".

15.8-29 NEDC-34271P, "BWRX-300 UK GDA Combined Hazards Topic Report", Rev B, GE-Hitachi Energy, Americas, LLC.

15.8-30 NEDC 34357P, "BWRX-300 UK GDA Safety Case Manual Specification", Rev 0, April 2025.

15.8-31 USNRC, Office of Public Affairs, Backgrounder, "Drones and Nuclear Power Plant Security," October 2020.

15.8-32 Met Office, UKCP18 Guidance: Representative Concentration Pathways, 2018.

15.8-33 "ONR Licence Condition Handbook," February 2017.

15.8-34 "The Calculation of Aircraft Crash Risk in the UK," Health and Safety Executive, 1997.

15.8-35 "Update of Aircraft Crash Rates used by HSE in Assessing Hazards from Chemical, Process and other Major Hazard Installations," HSE Research Report RR1140, 2019.

15.8-36 008N9751, "BWRX-300 UK Probabilistic Safety Assessment Summary Report", Revision B, GE-Hitachi Nuclear Energy, Americas, LLC.

APPENDIX A CLAIMS AND ARGUMENTS STRUCTURE AND ALARP DISCUSSION

Claims and Arguments Structure

The top-level claims relevant to this chapter of the BWRX-300 GDA PSR are:

Claim 2*: The safety risks to workers and the public during the construction, commissioning, operation and decommissioning of the BWRX-300 have been reduced as low as reasonably practicable.*

Claim 2.3*: A suitable and sufficient safety analysis has been undertaken which presents a comprehensive fault and hazard analysis that specifies the requirements on the safety measures and informs emergency arrangements.*

This top-level claim is supported by the following lower-level claims relevant to this chapter of the PSR:

Claim 2.3.1*: All initiating events with the potential to lead to significant radiation exposure or release of radioactive material, including the effects of internal and external hazards have been identified and appropriately assessed.*

Claim 2.3.1 is addressed by the following arguments:

> ***Argument 2.3.1.1****: National and international guidance has been used to derive a comprehensive list of external hazards for consideration. Screening and grouping has been applied to identity those which require safety assessment. (This is addressed in Section 15.8.4)*
>
> ***Argument 2.3.1.2****: Credible combinations of consequential, correlated, and independent external hazards have been identified. (This is addressed in Section 15.8.13)*
>
> ***Argument 2.3.1.3****: A Generic Site Envelope has been developed to characterise and provide bounding design basis hazard magnitudes for EN-6 UK coastal sites. Those hazards which are site-specific and cannot be generically characterised are also identified. These will be fully characterised when a site is selected. (This is addressed in APPENDIX D)*

Claim 2.3.2*: Design basis events have been appropriately assessed to specify requirements on safety functions and on safety measures and assess their effectiveness.*

Claim 2.3.2 is addressed by the following arguments:

> ***Argument 2.3.2.1****: All mechanisms by which each individual or combinations of external hazards could challenge Fundamental Safety Functions have been identified. (Preliminarily addressed in Section 15.8.5 and will be enhanced as PSR is developed).*
>
> ***Argument 2.3.2.2****: Protection measures which ensure delivery of Fundamental Safety Functions following a design basis external hazard event are identified and analysed using conservative assumptions. (Preliminarily addressed in Sections 15.8.6 to 15.8.12 and will be enhanced as PSR is developed).*
>
> ***Argument 2.3.2.3****: Operational or human actions to mitigate the effects of external hazards on the plant have been identified where relevant. (Preliminarily addressed in Sections 15.8.6 to 15.8.12 and will be enhanced as PSR is developed).*

Claim 2.3.3*: Beyond Design Basis and Severe Accidents have been appropriately assessed to identify further risk reducing measures and inform emergency arrangements.*

Claim 2.3.3 is addressed by the following arguments:

> ***Argument 2.3.3.1****: External Hazards with magnitudes just in excess of the Design Basis are analysed and do not result in disproportionate consequences.* (Preliminarily addressed in Sections 15.8.6 to 15.8.12 and is subject of FAP Item PSR15.8 143).
>
> ***Argument 2.3.3.2****: Radiological releases due to Beyond Design Basis External Hazards are shown to be As Low As Reasonably Practicable.* (Preliminarily addressed in APPENDIX A, ALARP Discussion).

ALARP Discussion

Demonstration that the risks to operators and the public from the effects of external hazards on the BWRX-300 are As Low As Reasonably Practicable (ALARP) is not addressed within the scope of GDA Step 2. It is envisaged that the following points will support the demonstration of ALARP for risks arising from External Hazards:

- External Hazards are identified and characterised based on RGP. A Design Basis magnitude for each hazard is derived, and the plant is assessed against this using conservative assumptions.
- All credible combinations of external hazards are identified and will be assessed.
- SSCs are designed and qualified with conservatisms and margins. In the case of external hazards, this particularly applies to SSCs which protect other SSCs from the effects of a hazard, such as the RB structure.
- Optioneering exercises are conducted for UK-specific design changes to ensure that alternate design solutions are considered, reviewed, and ranked prior to the selection of the chosen solution. This process is not limited to those aspects of the design that are modified for UK deployment.
- External Hazard considerations are included in the development of the generic plot plan within GDA and at the site-specific design stage. For example, the effects of building collapse on adjacent structures during a seismic event will inform the optimisation of the plot plan. Similarly, in the case of aircraft impact, an appropriate plot plan may support protection of redundant SSCs (such as the two SC3 Standby DGs) via separation, or SSCs afforded some protection due to their location in the “shadow” of another building.

Table A-1: External Hazards, Claims and Arguments

Level 15.8 Chapter Claim	Chapter 15.8 Argument	Subsections and/or reports that evidence the arguments
2.3 A suitable and sufficient safety analysis has been undertaken which presents a comprehensive fault and hazard analysis that specifies the requirements on the safety measures and informs emergency arrangements		
2.3.1 All initiating events with the potential to lead to significant radiation exposure or release of radioactive material, including the effects of internal and external hazards have been identified and appropriately assessed.	National and international guidance has been used to derive a comprehensive list of external hazards for consideration. Screening and grouping have been applied to identity those which require safety assessment.	Section 15.8.4
	Credible combinations of consequential, correlated, and independent external hazards have been identified.	Section 15.8.13
	A Generic Site Envelope has been developed to characterise and provide bounding design basis hazard magnitudes for EN-6 UK coastal sites. Those hazards which are site-specific and cannot be generically characterised are also identified. These will be fully characterised when a site is selected.	Section APPENDIX D
2.3.2 Design basis events have been appropriately assessed to specify requirements on safety functions and on safety measures and assess their effectiveness.	All mechanisms by which each individual or combinations of external hazards could challenge Fundamental Safety Functions have been identified.	Preliminarily addressed in Section 15.8.5 and will be enhanced as PSR is developed
	Protection measures which ensure delivery of Fundamental Safety Functions following a design basis external hazard event are identified and analysed using conservative assumptions.	Preliminarily addressed in Sections 15.8.6 to 15.8.12 and will be enhanced as PSR is developed
	Operational or human actions to mitigate the effects of external hazards on the plant have been identified where relevant.	Preliminarily addressed in Sections 15.8.6 to 15.8.12 and will be enhanced as PSR is developed

Level 15.8 Chapter Claim	Chapter 15.8 Argument	Subsections and/or reports that evidence the arguments
2.3.3 Beyond Design Basis and Severe Accidents have been appropriately assessed to identify further risk reducing measures and inform emergency arrangements.	External Hazards with magnitudes just in excess of the Design Basis are analysed and do not result in disproportionate consequences.	Preliminarily addressed in Sections 15.8.6 to 15.8.12 and is subject of FAP Item PSR15.8-143.
	Radiological releases due to Beyond Design Basis External Hazards are shown to be As Low As Reasonably Practicable.	Preliminarily addressed in APPENDIX A, ALARP Discussion

APPENDIX B FORWARD ACTION PLAN

Table B-1: Chapter 15.8 Forward Actions

FAP No	Finding	Forward Actions	Delivery Phase
PSR15-3	Whilst sufficient for the PSR, the underpinning Fault and Hazards Analysis methodologies are not consistent with RGP for use in support of a UK PCSR. The following methodologies will require revision / refinement for use in the PCSR: • Level 3 PSA • External hazards analysis of Radioactive Waste Structures • Deterministic analysis of hazards and combined hazards • Turbine generated missiles • Aircraft impact • Application of BEZs Consideration of moderate energy pipework	Agree the approaches to be adopted for the UK implementation of the BWRX-300 and document them in the specification for the SCM for implementation of the BWRX-300 in the UK. This action has been addressed during GDA Step 2 via the production of the SCM Specification, (Reference 15.8-30), which outlines the requirements for a SCM for the deployment of the BWRX-300 baseline design in the UK, which the future phases of the project will need to consider. Within this specification it highlights an approach to the development of information or methodologies (associated with the items listed in the Finding) to meet UK regulatory expectations and requirements within the PCSR and provides a level of confidence that identified differences will be addressed. Note: detailed methods development and performance of analysis will be in a later licensing phase.	Within Step 2

FAP No	Finding	Forward Actions	Delivery Phase
PSR15.8-135	The external hazards assessment for BWRX-300 is largely contained within the PSA at present. A formal presentation of the deterministic external hazards safety case is required. This should include: • DL1 protection claims, and external hazard withstand functional requirements placed on SSCs. • Identification of PIEs resulting from external hazards, evaluation of unmitigated radiological consequences, and identification of claimed DL3 Lines of Protection as input to the External Hazards elements of the Fault Schedule. • Hazard withstands qualification strategies for SSCs.	A programme of work is to be established to support the development of the deterministic external hazards safety case. This will include: • DL1 protection claims, and external hazard withstand functional requirements placed on SSCs. • Identification of PIEs resulting from external hazards, evaluation of unmitigated radiological consequences, and identification of claimed DL3 Lines of Protection as input to the External Hazards elements of the Fault Schedule. • Hazard withstands qualification strategies for SSCs.	For PCSR/PCER
PSR15.8-136	The RWB is currently assessed against half of the Probable Maximum Flood height. UK regulatory expectations allow design basis events for non-discrete natural hazards to be established for a higher frequency of exceedance if the facility (or the relevant parts of it) cannot give rise to significant unmitigated consequences. Work is required to confirm if a design basis flood height for the RWB lower than the site design basis flood is appropriate.	Work will be performed to confirm if a design basis flood height for the RWB lower than the site design basis flood is appropriate, given the claimed low unmitigated radiological consequences of faults in this building. This gap is recorded in PSR15-3, for which the SCM Specification (Reference 15.8-30) has been produced.	For PCSR/PCER

FAP No	Finding	Forward Actions	Delivery Phase
PSR15.8-137	The RWB is assessed against half of the Design Basis Earthquake magnitude. UK regulatory expectations allow design basis events for non-discrete natural hazards to be established for a higher frequency of exceedance if the facility (or the relevant parts of it) cannot give rise to significant unmitigated consequences. Work is required to confirm the UK DBE for SSCs seismically classified as RW and if the assumed one-half of the site-specific DBE is appropriate.	Work will be performed to confirm if a DBE for RW classified SSCs in the RWB of one-half of the site-specific DBE is appropriate, given the claimed low unmitigated radiological consequences of faults in this building. This gap is recorded in PSR15-3, for which the SCM Specification (Reference 15.8-30) has been produced.	For PCSR/PCER

FAP No	Finding	Forward Actions	Delivery Phase
PSR15.7-72	The current approach to the assessment of hazard combinations largely reflects the limited consideration of combined hazards within the PSA. It does not fully consider deterministic aspects in the approach; this is particularly relevant within the identification and screening of credible combinations. Much of the discussion on hazard combinations is taken from the BWRX-300 PSA Summary Report, (Reference 15.8-36). The approach that is outlined in the document does indicate the potential for DSA of combinations, but the shape of future DSA for hazard combinations is not known. Therefore, this is considered a gap. This action should focus on the deterministic assessment of hazards, including identification, screening, characterisation and assessment of consequences. In addition it should include external combinations, external to internal combinations and internal combinations. The probabilistic assessment of hazard combinations will be addressed separately within the UK PSR Subchapter 15.6 (PSA) (Reference 15.8-14).	The action should look to develop an approach regarding the deterministic assessment of credible hazard combinations, this has been addressed for GDA Step 2 via the gap recorded in PSR15-3, for which the SCM Specification, (Reference 15.8-30), has been produced. Beyond this, the action should develop detailed methodologies for PCSR/PCER in order to deterministically assess hazard combinations (external combinations, internal combinations, and external to internal combinations). This should take on board previous lessons learned and engage the right groups within GEH to enable a suitable and sufficient safety case to be developed that appropriately interacts with the PSA. It is acknowledged that some external hazards may only be determined at the site-specific stage and as such, combinations involving these hazards may only be assessed at this point.	For PCSR/PCER
PSR15.8-140	Following updated information from the National Grid and a review by EDF NGL, ONR’s Chief Nuclear Inspector wrote to all licensees asking them to reconsider their approach to LOOP. Therefore, this should be taken into consideration for BWRX-300.	Regulatory Guidance issued to UK licensees on the approach to LOOP will be reviewed to assess for implications within External Hazards for the BWRX-300.	For PCSR/PCER

FAP No	Finding	Forward Actions	Delivery Phase
PSR15.8-141	In the ABWR GDA, HGNE were advised to consider loss of heat sink due to e.g. biological fouling as a frequent event in the generic design, even if design mitigations are site-specific and therefore out of scope of GDA. Therefore, this should also be considered for BWRX-300.	Loss of heat sink due to external factors such as biological fouling should be assessed as a frequent event in the generic design, even if design mitigations are site-specific and therefore out of scope of GDA.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase
PSR15.8-142	Confirmation is required to demonstrate that the design basis values derived in the UK GSE for external natural hazards are bounded by the associated SPD parameters. There are also differences between US and UK conventions in which the design basis values are derived for some hazards. For examples different return frequencies are used, and different measuring conventions adopted.	Confidence to be provided that the UK BWRX-300 design can accommodate those natural external hazard design basis values, including climate change, derived in the GSE.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase
PSR15.8-143	UK regulatory guidance requires (SAP EHA.7) that: • The absence of cliff-edge effects which result in disproportionate consequences for hazards beyond the design basis is demonstrated. • For continuous natural hazards, the magnitudes at which FSFs could be lost are established. Therefore, analysis of this is required for the BWRX-300.	Analysis of continuous natural hazards will be required to demonstrate the absence of cliff-edge effects and to determine the return frequency at which FSFs will be lost, as recommended by SAP EHA.7. Interface with hazards PSA will be required to establish this.	For PCSR/PCER

FAP No	Finding	Forward Actions	Delivery Phase
PSR15.8-144	Some external hazards cannot be characterised for a generic site within GDA and as such are not covered within the GSE. Examples include, but are not limited to the following: • The seismic hazard will require detailed seismic characterisation work to establish ground motion spectra and soil-structure interaction effects. • A geological survey is required to assess selected site(s) for issues such as land rise or settlement, karst, landslide, subsidence, and water erosion/deposition. • A comprehensive site region hydrological survey will be required to fully characterise the site-specific flooding hazard. • A comprehensive assessment of nearby industrial and transportation features and facilities will be required to identify potential sources of external fire, explosion, missiles, hazardous substance release etc. • Ecological survey of biological agents which could present an external hazard will be required.	A comprehensive site characterisation programme will be developed to support the development of the site-specific external hazards safety case, including appropriate consideration of uncertainties. This will include a site-specific external hazard identification and screening exercise to capture hazards which could not be addressed within GDA. As an input to nuclear site licensing for a future selected site, a site justification report will be produced, which will incorporate the site-specific external hazards identification and characterisation.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase
PSR15.8-145	Some aspects of the design cannot be assessed during GDA, as they are site dependent. These include systems such as the NHS, which is assumed within GDA to be a once-through sea cooled system. The detailed site-specific plot plan also cannot be assessed within GDA.	Aspects of the plant which are site specific cannot be assessed during GDA and will be considered during the detailed design phase.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase

FAP No	Finding	Forward Actions	Delivery Phase
PSR15.8-146	Operating procedures are required to provide alerts for extreme meteorological, hydrological and space weather events that could challenge plant technical specifications, and which will mandate the implementation of operator actions to mitigate against the potential safety implications of such events. Similarly, maintenance procedures are required to inspect and maintain features of the plant which are vulnerable to biological fouling, and to salt corrosion.	External hazards considerations and safety case assumptions are to be captured within the development of plant operating procedures. These should require that external conditions are monitored, and mitigative actions defined for anticipated extreme events, to ensure compliance with plant technical specifications and safety case claims and assumptions. Monitoring should include, but is not limited to meteorological, hydrological and space weather events. Maintenance procedures should also capture the requirement to inspect and maintain features of the plant which are subject to external hazard actions including, but not limited to biological fouling and salt corrosion.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase

FAP No	Finding	Forward Actions	Delivery Phase
PSR15.8-147	Analysis of the effects of accidental aircraft impacts has been performed for the SPD against US regulatory requirements. However, UK-specific analysis using representative aircraft types is not currently available. Typical analyses would use appropriate force-time history functions to determine the local and global structural response of the RB. Analysis of aviation fuel fires and explosions, and of secondary effects such as missiles and vibration is also required. The analyses should demonstrate that FSFs are maintained for design basis impacts and should establish the consequences of BDB events. Additionally, site-specific aircraft crash frequencies should be derived for each class of aircraft, using recommended UK crash rates, and accounting for contributions from airways and other local aviation features.	Deterministic accidental aircraft crash analysis is currently underway within GEH. This will be reviewed and assessed against UK expectations, and requirements for additional work to meet UK expectations will be identified. Site-specific aircraft crash frequency characterisation will be performed using UK best practice techniques. The development of the methodologies required to undertake these activities are captured in the specification for a Safety Case Manual (FAP PSR15-3).	For PCSR/PCER
PSR15.8-149	UKCP18 does not provide climate change adjustment factors for all meteorological hazards that may be subject to climate change variations. Therefore, there is a need to derive those that are not provided in UKCP18 (i.e. snow, tornado, and lightning hazards).	Climate change adjustment factors will need to be derived for snow, tornado, and lightning hazards.	For PCSR/PCER

FAP No	Finding	Forward Actions	Delivery Phase
PSR15.8-151	OPEX arising from external hazard events which may have challenged UK or international nuclear facilities, or other infrastructure, and which may affect the design and safety case assumptions of a UK BWRX-300 plant, will be subject to ongoing review. For ABWR, ONR raised a Regulatory Observation for the Requesting Party to identify the relevant UK and IAEA learning from the Fukushima events and requested demonstration that this learning was fully incorporated into the design of the UK plant. This will also need to be demonstrated for the UK BWRX-300 design.	An OPEX survey will be undertaken to provide confidence that the assumptions of the BWRX-300 external hazards safety case are not challenged by occurrences of external natural or man-made events which may have affected operations of nuclear or other infrastructure assets. The survey will cover RGP developed by UK and International nuclear site licensees with respect to external hazards. A programme of work will be proposed to demonstrate that all Learning from Experience (LfE) from Fukushima events has been incorporate in UK BWRX-300 design.	For PCSR/PCER
PSR15.8-152	The licensee of a UK BWRX-300 site will undertake a periodic review of safety in accordance with ONR Site Licence Condition 15 and this should commit to reviews of ongoing climate science findings and recommendations throughout the planned lifetime of the plant. It should examine: • Whether climate change projections have the potential to undermine the external hazards design basis • Whether any of the external hazard safety case assumptions are challenged • Whether any mitigative actions are required to ensure that safety margins are maintained to support continued operation.	Commitments to Periodic Safety Reviews during site licensing should explicitly capture the need to maintain a watching brief on climate science findings and recommendations and their impact on the external hazards safety case.	Before Site License Application, Environmental Permit Applications and/or BL3 Design Phase

APPENDIX C EXTERNAL HAZARD INDENTIFICATION AND SCREENING

Table C-1: Summary of External Hazard Identification and Screening

Hazard Group	ID	Hazard	Screening Comments
Meteorological	1	Drought	Site-specific and only able to be treated as such in any detail.
	2	Extreme air pressure (high/low/gradient)	Site-specific and only able to be treated as such in any detail.
	3	Extreme rain	Within scope of GDA, Section 15.8.6.6
	4	Extreme snow	Within scope of GDA, Section 15.8.6.7
	5	Fog	Within scope of GDA, Section 15.8.6.4
	6	Frost (soil and white)	Site-specific and only able to be treated as such in any detail.
	7	Hail	Site-specific but reassurance can be provided during GDA, Section15.8.6.7
	8	High air temperature	Within scope of GDA, Section15.8.6.1
	9	High water temperature	Within scope of GDA, Section15.8.6.9
	10	Humidity	Within scope of GDA, Section15.8.6.4
	11	Tornadoes	Within scope of GDA, Section 15.8.6.5
	12	Ice cover (surface ice)	Site-specific and only able to be treated as such in any detail.
	13	Ice storm/freezing rain/sleet	Site-specific and only able to be treated as such in any detail.
	14	Lightning	Within scope of GDA, Section15.8.6.11

Hazard Group	ID	Hazard	Screening Comments
	15	Low air temperature	Within scope of GDA, Section 15.8.6.2
	16	Low water temperature	Within scope of GDA, Section 5.8.6.10
	17	Solar storms	Site-specific but reassurance can be provided during GDA, Section 15.8.9.3
	18	Strong winds	Within scope of GDA, Section 15.8.6.3
	19	Underwater temperature	Bounded by High water temperature (Hazard 9) and Low water temperature (Hazard 16) due to similar consequences.
	20	Meteorite	Bounded by Aircraft impacts (Hazard 77) due to similar consequences.
	21	Salt storm	Site-specific but reassurance can be provided during GDA, Section 15.8.9.1
	22	Sandstorm	Site-specific but reassurance can be provided during GDA, Section 15.8.9.1
	23	Volcanic activity	Site-specific but reassurance can be provided during GDA, Section 15.8.9.1
Hydrological	24	Coastal erosion	Site-specific and only able to be treated as such in any detail.
	25	Corrosion	Site-specific but reassurance can be provided during GDA, Section 15.8.7.4
	26	External flooding	Site-specific but reassurance can be provided during GDA, Section 15.8.7.1
	27	Frazil ice	Site-specific but reassurance can be provided during GDA, Section15.8.6.8

Hazard Group	ID	Hazard	Screening Comments
	28	Groundwater (too much or too little)	Site-specific and only able to be treated as such in any detail.
	29	High water level	Site-specific but reassurance can be provided during GDA, Section 15.8.7.2
	30	High tide	Site-specific but reassurance can be provided during GDA, Section 15.8.7.2
	31	Ice barriers	Site-specific and only able to be treated as such in any detail.
	32	Low water level	Site-specific but reassurance can be provided during GDA, Section15.8.7.3
	33	Other extraordinary waves	Site-specific and only able to be treated as such in any detail.
	34	River diversion	Site-specific and only able to be treated as such in any detail.
	35	Seiche	Site-specific but reassurance can be provided during GDA, Section 15.8.7.2
	36	Storm surge	Site-specific but reassurance can be provided during GDA, Section 15.8.7.2
	37	Strong currents (under-water erosion)	Site-specific and only able to be treated as such in any detail.
	38	Tsunami	Site-specific and only able to be treated as such in any detail.
	39	Underwater landslide (impact on soil, i.e., not tsunami)	Site-specific and only able to be treated as such in any detail.
	40	Water surface variation	Site-specific and only able to be treated as such in any detail.

Hazard Group	ID	Hazard	Screening Comments
	41	Waves	Site-specific but reassurance can be provided during GDA, Section15.8.7.2
Seismic	42	Earthquakes	Site-specific but reassurance can be provided during GDA, Section 15.8.8.1
Geological	43	Above-water landslide	Site-specific and only able to be treated as such in any detail.
	44	Avalanche	Site-specific and only able to be treated as such in any detail.
	45	Erosion	Site-specific and only able to be treated as such in any detail.
	46	Excavation work	Site-specific and only able to be treated as such in any detail.
	47	Ground collapse	Site-specific and only able to be treated as such in any detail.
	48	Ground vibration (e.g., due to nearby explosions)	Site-specific and only able to be treated as such in any detail.
	49	Land rise	Site-specific and only able to be treated as such in any detail.
	50	Landslide	Site-specific and only able to be treated as such in any detail.
	51	Soil shrink-swell	Site-specific and only able to be treated as such in any detail.
Industrial and Man Made	52	Blockage or damage to cooling water intakes	Bounded by Water borne material plugging water intakes/organic material in water (Hazard 80) due to similar consequences.
	53	Chemical release after pipeline accident	Site-specific and only able to be treated as such in any detail.
	54	Chemical release after transportation accident	Site-specific but reassurance can be provided during GDA, Section 15.8.10.4

Hazard Group	ID	Hazard	Screening Comments
	55	Chemical release and contamination from chemicals	Site-specific and only able to be treated as such in any detail.
	56	Chemical release outside or inside site	Site-specific and only able to be treated as such in any detail.
	57	Chemical releases into water	Site-specific and only able to be treated as such in any detail.
	58	Collapsed structures/falling objects	Site-specific and only able to be treated as such in any detail.
	59	Contamination from chemicals	Site-specific and only able to be treated as such in any detail.
	60	Eddy currents into ground	Bounded by EMI (Hazard 61) due to similar consequences.
	61	EMI	Site-specific but reassurance can be provided during GDA, Section 15.8.10.6
	62	Explosion after pipeline accident	Site-specific and only able to be treated as such in any detail.
	63	Explosion after transportation accident	Site-specific but reassurance can be provided during GDA, Section 15.8.10.4
	64	Explosion outside plant	Site-specific and only able to be treated as such in any detail.
	65	Externally generated missiles and blasts	Site-specific but reassurance can be provided during GDA, Section 15.8.10.1
	66	Ground contamination (e.g., from chemicals)	Site-specific and only able to be treated as such in any detail.
	67	High air pollution	Site-specific and only able to be treated as such in any detail.

Hazard Group	ID	Hazard	Screening Comments
	68	Impurities in water from ship release (solids and liquids)	Site-specific and only able to be treated as such in any detail.
	69	Releases from industrial facilities	Site-specific but reassurance can be provided during GDA, Section 15.8.10.2
	70	Man-made explosion (deflagration and detonation)	Site-specific and only able to be treated as such in any detail.
	71	Missiles (from military activity or other plant)	Site-specific and only able to be treated as such in any detail.
	72	Satellite crash (orbital debris)	Bounded by Aircraft impacts (Hazard 77) due to similar consequences.
	73	Ship accidents	Site-specific and only able to be treated as such in any detail.
	74	Adjacent Nuclear Sites	Site-specific but reassurance can be provided during GDA, Section 15.8.10.3
	75	Train crash	Site-specific and only able to be treated as such in any detail.
	76	Vehicle impacts with plant SSCs	Site-specific and only able to be treated as such in any detail.
Aircraft Impact	77	Accidental aircraft impacts	Site-specific but reassurance can be provided during GDA, Section 15.8.10.5
Biological	78	Natural airborne hazards (birds, leaves, ash etc)	Site-specific but reassurance can be provided during GDA, Section 15.8.9.1
	79	Biological events (microbial corrosion)	Site-specific and only able to be treated as such in any detail.
	80	Water borne material plugging water intakes/organic material in water	Site-specific but reassurance can be provided during GDA, Section 15.8.9.2

Hazard Group	ID	Hazard	Screening Comments
LOOP	81	LOOP	Site-specific but reassurance can be provided during GDA, Section 15.8.11
Fire	82	External Fires	Site-specific but reassurance can be provided during GDA, Section 15.8.12

APPENDIX D UK SPECIFIC GENERIC SITE ENVELOPE DISCUSSION

D.1 UK Specific Generic Site Envelope Content

A GSE has been established which defines a limiting value of the design basis hazard loading across all of the candidate UK coastal sites for those hazards which can be generically characterised. This is presented in detail in the GSE report (Reference 15.8-2). A summary of the GSE is provided in Chapter 2 – NEDO-34164, "BWRX-300 UK GDA Chapter 2: Site Characteristics," (Reference 15.8-3).

Natural external hazards can usually be characterised by a hazard curve, which presents the magnitude of the hazard loading as a function of frequency of exceedance. The design basis value is taken to be that which has a frequency of exceedance of 1 in 10,000 years (i.e., 1.0 E-04/yr.). Man-made external hazards are evaluated up to events with a frequency of exceedance of 1 in 100,000 years (i.e. 1.0 E-05/yr.).

Best Practice requires that a confidence level is usually applied to the derivation of the design basis value, and a 1σ confidence limit is usually applied, which corresponds to an 84% percentile confidence level. For individual sites, this can be readily performed using site-specific datasets and uncertainty analyses. GSE values, as derived in the GSE report (Reference 15.8-2), are based on a variety of data sources, and as such, the inherent uncertainties have not been quantified within the context of the PSR; this will be covered under FAP item PSR15.8-144 in APPENDIX B. The GSE design basis hazard loadings are summarised in Table D-1, noting that only those hazards where a generic design basis value has been derived are included within the table. Table D-1 also summarises adjustment factors derived to account for climate change by 2100.

D.2 Effects of Climate Change

The reasonably foreseeable effects of climate change over the lifetime of the facility have been considered.

The plant is expected to be commercially operational by 2030, with a design life of 60 years followed by 10 years of decommissioning; therefore, the lifecycle of the plant is expected to end around 2100.

The UK Climate Projections (UKCP) is a climate analysis tool, forming part of the Met Office Hadley Centre Climate Programme, that shows how the UK climate may change in the future. Where appropriate, climate change values have been calculated for the UK using the UK Climate Projections 2018 (UKCP18) "Representative Concentration Pathways," (Reference 15.8-32). UKCP18 uses Representative Concentration Pathways (RCPs) to model and predict the future climate based on assumptions and scenarios. RCPs specify concentrations of greenhouse gases that will result in total radiative forcing increasing by a target amount by 2100, relative to pre-industrial levels (Reference 15.8-32). There are four radiative forcing scenarios RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5. Each RCP scenario is defined by its radiative forcing target measured in Watts per square metre (W/m2), for example RCP 6.0 is equivalent to a radiative forcing target of 6.0 W/m2 for the year 2100.

RCP 6.0 scenario uses a high greenhouse gas emission rate where total radiative forcing is stabilised after 2100 by employment of a range of technologies and strategies for reducing greenhouse gas emissions. The lifetime expectancy of the plant is to be around 2100 and this appears to be a reasonable emission scenario due to Government initiatives on climate change being enacted. Therefore, a value of RCP 6.0 at 90th percentile has been selected to examine climate change adjustment values for this report. Where alternative RCP scenarios have been used this is explained within the relevant hazard subsection. It is noted that climate change projection work within the UK is on-going and is subject to change in the future.

The following list outlines the parameters that are affected by climate change:

- Air temperature
- Rainfall intensity
- Sea water temperature
- Wind speed
- Storm frequency and lightning
- Snow loading and drifting
- Humidity

It is noted that while the above meteorological aspects are judged to be impacted by climate change, several of these parameters are not covered by UKCP18. Where this is the case, the best available data has been used.

Following licensing, construction, and commissioning of BWRX-300 units in the UK, the site licensee will undertake a periodic review of safety in accordance with ONR Licence Condition 15 from "Site Licence Condition Handbook" (Reference 15.8-33). It is advised that this includes reviews of ongoing climate science findings and recommendations throughout the planned lifetime of the plant (FAP Item PSR15.8-152 in APPENDIX B refers). It should examine whether climate change projections, as applied to the vicinity of the nuclear site, have the potential to undermine the design basis, or to affect any of the external hazard safety case assumptions. It should identify whether any managed adaptation actions are required to ensure that safety margins are maintained to support continued operation allowing for climate change.

D.3 Comparison Between UK Design Basis Values and BWRX-300 Standard Plant Parameters

The GSE report (Reference 15.8-2) identifies and discusses several hazards where further work is required to confirm whether the standard plant parameters derived for the BWRX-300 SPD are suitably bounding of UK conditions. For some hazards, plant parameters are not available for comparison to the UK GSE value. Additionally, in some cases these values have been derived for return periods less than the 10,000 per year value which is adopted as best practice in the UK for continuous natural hazards. A FAP item (FAP item PSR15.8-142 in APPENDIX B) has been raised to further assess BWRX-300 natural hazard design values against the GSE, to provide confidence at a future stage that the UK design can accommodate the GSE values.

Table D-2 provides an indicative comparison of UK GSE design basis values against BWRX-300 standard plant parameters where available in 006N5991, "BWRX-300 Plant Architecture Definition," (Reference 15.8-16).

Table D-1 Summary of GSE Design Basis Values

External Hazard	BWRX-300 UK GSE Design Basis Value	BWRX-300 UK Climate Change adjustment (2100)
Meteorological Hazards		
High Air Temperature	40.2 °C (coastal) 45.4 °C (inland)	+5.4 °C
Low Air Temperature	-22.0 °C (coastal) -38.4 °C (inland)	Conservatively assumed to be zero.
Strong Winds	43.1 m/s	+2 m/s
High Humidity	100%	Not required as DB is 100 %.
Tornadoes	Maximum tornado wind speed 89.4 m/s Tornado maximum pressure drop 63 mbar. Tornado pressure drop rate 25 mbar/s Tornado missiles, see Table 15.8 – 1 for dimensions and velocities.	Not assessed.
Extreme rain	163 mm in 1-hour 400 mm in 24-hours	+29 %
Extreme snow	1.5 kN/m^2 Snow depths not defined within GSE	To be considered during site specific assessment.
High water temperature	30 °C	+2.2 °C
Low water temperature	-1.9 °C	Not required.
Lightning	Lightning flash density 1.4 flashes/km^2/year Lightning Strike Current 300 kA Average days of thunder 15 days/year	Frequency projected to increase in summer and spring. To be considered during site specific assessment.
Seismic and Geological Hazards		
Earthquake	Design Basis Earthquake (DBE): 0.3 g OBE not defined within GDA GSE and will be defined during site specific stage.	Not applicable.

Table D-2: Comparison of UK GSE and BWRX-300 Standard Plant Parameters

External Hazard Parameter	UK GSE Design Basis Value (incl CC)	BWRX-300 Standard Plant Design (SPD) parameter (Reference 15.8-16)	Notes/Comments
High Air Temperature	45.6 °C (coastal) 50.8 °C (inland)	Standard Plant maximum dry bulb temperature designed to 39.7 °C. Safety Class 1 SSCs exposed to ambient environment conditions in MCR and SCR designed to 47.2 °C. Safety Class 1 SSCs exposed to ambient environment conditions in RB and CB designed for 37.8 °C.	SPD may not be bounding of UK GSE values.
Low Air Temperature	-22.0 °C (coastal) -38.4 °C (inland)	-40 °C for less than two hours -32.5 °C for 1 day.	SPD is bounding of the coastal UK GSE regardless of durations.
Strong Winds	43.1 m/s (mean wind velocity)	Severe Wind: 71.5 m/s (160 mph) for return period of 3000 years. Extreme Wind: 89.4 m/s (200 mph) Severe wind speed for Seismic Category A & B structures is defined as the (straight-line) 3-second gust wind speed based appropriate standards, with suitable corrections for local conditions per NUREG-0800 Section 2.3.1. Value of 71.5 m/s (160 mph) is based on ASCE 7-16 Risk Category IV basic wind speed maps (3-sec gust), which correspond to a Mean Recurrence Interval of 3,000 years.	SPD is bounding of UK GSE regardless of durations and return frequency.
High Humidity	100 %	The design accommodates a Maximum High Humidity Average Wet Bulb Globe Temperature Index of 30.3 ºC for 0% Exceedance Maximum Wet Bulb Temperature Day.	SPD design considerations for humidity are based upon wet bulb temperature exceedance values and are therefore not directly comparable with UK GSE.

<table>
<tr><th>External Hazard Parameter</th><th>UK GSE Design Basis Value (incl CC)</th><th>BWRX-300 Standard Plant Design (SPD) parameter (Reference 15.8-16)</th><th>Notes/Comments</th></tr>
<tr><td>Tornadoes</td><td>Maximum tornado wind speed 89.4 m/s
Tornado maximum pressure drop 63 mbar.
Tornado pressure drop rate 25 mbar/s
Tornado missiles, see Table 15.8–1 for dimensions and velocities.</td><td>
<table>
<tr><th>Parameter</th><th>Value</th></tr>
<tr><td>Maximum wind speed</td><td>103 m/s (230 mph)</td></tr>
<tr><td>Maximum rotational speed</td><td>82 m/s (184 mph)</td></tr>
<tr><td>Translational speed</td><td>21 m/s (46 mph)</td></tr>
<tr><td>Radius</td><td>45.7 m (150 ft)</td></tr>
<tr><td>Maximum pressure drop</td><td>8.3 kPa (1.2 psi)</td></tr>
<tr><td>Rate of pressure drop</td><td>3.7 kPa/s (0.5 psi/s)</td></tr>
</table>
<table>
<tr><th>Missile Type</th><th>Dimensions</th><th>Mass</th><th>Horizontal Velocity</th><th>Vertical Velocity</th></tr>
<tr><td>Schedule 40 Pipe</td><td>0.168 m diameter x 4.58 m length</td><td>130 kg</td><td>41 m/s</td><td>27.5 m/s</td></tr>
<tr><td>Automobile</td><td>5.0 m x 2.0 m x 1.3 m</td><td>1810 kg</td><td>41 m/s</td><td>27.5 m/s</td></tr>
<tr><td>Solid Steel Sphere</td><td>2.54 cm diameter</td><td>0.0669 kg</td><td>8 m/s</td><td>5.4 m/s</td></tr>
</table>
</td><td>SPD is bounding of UK GSE.</td></tr>
<tr><td>Extreme rain</td><td>210.3 mm in 1 hr
400 mm in 24-hrs</td><td>Plant structures designed to accommodate maximum rainfall rate of 493mm/h, and maximum short-term rain fall rate of 157mm in 5 minutes.</td><td>SPD is bounding of UK GSE.</td></tr>
<tr><td>Extreme snow</td><td>1.5 kN/m2</td><td>Plant structures designed to accommodate maximum ground snow load of 2.5kN/m2 for normal winter precipitation events and 5kN/m2 for extreme winter precipitation events.</td><td>SPD is bounding of UK GSE.</td></tr>
<tr><td>High water temperature</td><td>32.2 °C</td><td>Site specific parameter not defined within SPD.</td><td>Comparison between SPD and UK GSE cannot be made for GDA Step 2.</td></tr>
<tr><td>Low water temperature</td><td>-1.9 °C</td><td>Site specific parameter not defined within SPD.</td><td>Comparison between SPD and UK GSE</td></tr>
</table>

External Hazard Parameter	UK GSE Design Basis Value (incl CC)	BWRX-300 Standard Plant Design (SPD) parameter (Reference 15.8-16)	Notes/Comments
			cannot be made for GDA Step 2.
Lightning	Lightning flash density 1.4 flashes/km2/year Lightning Strike Current 300 kA Average days of thunder 15 days/year	Not available.	Comparison between SPD and UK GSE cannot be made for GDA Step 2.
Earthquake	Design Basis Earthquake (DBE): 0.3 g	Horizontal GDRS are anchored at 0.3 g PGA. Vertical GDRS are developed by multiplying horizontal GDRS by a frequency-dependent vertical-to-horizontal (V/H) spectral ratio (Reference 15.8-4).	SPD and UK GSE values align.

D.4 UK Specific Aircraft Impact Content

The frequency of an aircraft impact on the BWRX-300 PB will be evaluated using the accepted Health and Safety Executive (HSE) “Calculation of Aircraft Crash Risk in the UK,” (Reference 15.8-34) and “Update of Aircraft Crash Rates used by HSE in assessing hazards from chemical, process and other major hazard installations’ (Reference 15.8-35) for each of the five classes of aircraft. This requires PB dimensions and relative locations and will be performed as the detailed plant civil design becomes established. The evaluation will consider aspects such as the wingspan of the incident aircraft and the potential for skidding. Site-specific factors which can contribute to the crash rate include proximity to airfields and airways. These cannot be evaluated within GDA and will be deferred to the site-specific characterisation of external hazards.

Table D-3: UK Aircraft Classes

	Aircraft Class	Definition
1	Light civilian aircraft	Fixed wing aircraft generally falling into the Civil Aviation Authority (CAA) classification of less than2.3 te maximum take-off weight authorised (MTWA)
2	Helicopters	All civilian and military helicopters
3	Small transport	Fixed wing aircraft covering the mass range 2.3 - 20.0 te MTWA, including civilian and military transport aircraft
4	Large transport	Any other fixed wing aircraft, civilian or military, not covered in the light aircraft, small transport or military combat and jet trainer categories
5	Military combat and jet trainers	All military fixed-wing aircraft with MTWA up to 50 te used for, or capable of, aerobatic style flying.