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BWRX-300 UK Generic Design Assessment (GDA) Chapter 2 - Site Characteristics

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EXECUTIVE SUMMARY

The BWRX-300 Generic Design Assessment (GDA) Preliminary Safety Report (PSR) Chapter 2 details the site characteristics and the future evaluation in support for the design, safety assessment and periodic safety review of the BWRX-300. This includes consideration of external hazards characterisation and generic site information.

For the purpose of GDA Step 2, PSR Chapter 2 does not describe the site-specific characterisation work including, for example, Foundation Interface Analysis, confirmatory site geological and seismic hazard investigations, and climate change effects for on-site hydrological and meteorological parameters.

Site characteristics for the environmental issues are presented separately within the Preliminary Environmental Report.

The United Kingdom (UK) GDA process is based upon a generic site, the characteristics of which will be defined in this chapter. These generic characteristics, which envelope expected UK conditions, form part of the overall GDA scope definition.

Site information are the features of the site that can be defined on a generic basis, including the heat sink, grid connections, density, and distribution of local population as well as the soil.

GDA will consider a single unit operating on a generic UK coastal site using a once through cooling system with seawater as the normal heat sink.

The purpose of this report is to develop the information provided in NEDC-34138P, “BWRX-300 UK Generic Design Assessment-Generic Site Envelope and External Hazards Identification” (Reference 2-4), to define the generic UK site characteristics to be used as the basis for the BWRX-300 UK GDA Preliminary Safety Report safety analysis.

Discussion of Claims, Arguments and Evidence is provided in APPENDIX A, and Forward Actions in APPENDIX B. It should be noted that this chapter does not directly support any claims and arguments, and does not directly support any forward actions.

Hazard screening is provided in APPENDIX C.

ACRONYMS AND ABBREVIATIONS

Acronym	Explanation
BL	Baseline
BL-AOO	Baseline Abnormal Operational Occurrences
BS	British Standard
CB	Control Building
CME	Coronal Mass Ejections
DB	Design Basis
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DEC	Design Extension Conditions
D-in-D	Defence in Depth
DSA	Deterministic Safety Analysis
EH	External Hazard
EMI	Electromagnetic Interference
EN	European Standard
ETI	Energy Technologies Institute
EUR	European Utility Requirement
GDA	Generic Design Assessment
GEH	GE-Hitachi Nuclear Energy
GIC	Geomagnetically Induced Current
GLE	Ground Level Event
GMSL	Global Mean Sea Level
GNSS	Global Navigation Satellite Systems
GSE	Generic Site Envelope
HF	High Frequency
IAEA	International Atomic Energy Agency
ICS	Isolation Condenser System
LLP	Limited Liability Partnership
LOCA	Loss Of Coolant Accident
LOOP	Loss of Offsite Power
LWR	Light Water Reactor
MCR	Main Control Room
NHS	Normal Heat Sink
NPS	National Policy Statement
OBE	Operating Basis Earthquake

Acronym	Explanation
ONR	Office for Nuclear Regulation
PGA	Peak Ground Acceleration
PMP	Probable Maximum Precipitation
PSA	Probabilistic Safety Analysis
PSR	Preliminary Safety Report
PSAR	Preliminary Safety Analysis Report
RB	Reactor Building
RCP	Representative Concentration Pathway
RG	Regulatory Guide
RGP	Relevant Good Practice
RPV	Reactor Pressure Vessel
RWB	Radwaste Building
SC1	Safety Class 1
SC2	Safety Class 2
SC3	Safety Class 3
SCCV	Steel-Plate Composite Containment Vessel
SCDS	Safety Case Development Strategy
SCR	Secondary Control Room
SEP	Solar Energetic Particles
SMR	Small Modular Reactor
SPD	Standard Plant Design
SSC	Structure, System, and Component
SSG	Specific Safety Guide
SSI	Soil-Structure Interaction
TAG	Technical Assessment Guide
TB	Turbine Building
TORRO	The Tornado and Storm Research Organisation
UK	United Kingdom
UKCP	United Kingdom Climate Projections
U.S.	United States
USNRC	U.S. Nuclear Regulatory Commission

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REVISION SUMMARY

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

2 SITE CHARACTERISTICS

Introduction

PSR Chapter 2 details the site characteristics and the future evaluation in support for the design, safety assessment and periodic safety review of the UK BWRX-300. Over the planned design life (stated in NEDO-34163, "BWRX-300 UK GDA Chapter 1: Introduction and Overview" (Reference 2-1)) of the BWRX-300 facility, the information in PSR Chapter 2 will periodically be updated to risk-inform the evaluation and implications of any such updates on safety.

The GSE for BWRX-300 for the UK GDA is defined via selecting envelope values of the characteristics of the candidate sites. The general approach to the GSE includes identification, screening, and value derivation that is obtained through a systematic methodology based on Relevant Good Practice (RGP) and requirements from the UK context. This chapter introduces the general approach as a whole.

Site characteristics are split into three groups:

- External Hazards:
  - External hazards are those natural or man-made hazards to a site and facilities that originate externally to both the site and its processes. The Design Basis (DB) and safety assessment of external hazards is presented in NEDO-34186, "BWRX-300 UK GDA Chapter 15.8: Safety Analysis - External Hazards" (Reference 2-2).
- Site Information:
  - Site information is the features of the site that can be defined on a generic basis, including the heat sink, grid connections, density, and distribution of local population as well as the soil.
- Site Characteristics for Environment:
  - Site characteristics for the environmental issues are presented separately within PSR Chapter 20: Environmental Aspects (Reference 2-3).

PSR Chapter 2 includes the following characteristics of the site and the surrounding region:

- Section 2.1 Hydrology
- Section 2.2 Meteorology
- Section 2.3 Geology, Seismology, and Geotechnical Engineering
- Section 2.4 Site Characteristics and Potential Effects of Nuclear Power Plants in the Region
- Section 2.5 Identification and screening of the Generic Site Envelope
- Section 2.6 Radiological Conditions due to External Sources
- Section 2.7 Site-related Issues in Emergency Preparedness and Response, and Accident Management
- Section 2.8 Monitoring of Site-related Parameters
- APPENDIX A Claims, Arguments Evidence
- APPENDIX B Forward Action Plan

- APPENDIX C Hazard Screening for Generic Design Assessment

A complete list of external hazards has been derived with reference to regulator guidance, publicly available documents, experience from previous nuclear plant EHs assessments and engineering judgment. The derivation of the external hazards list is provided in NEDC-34138P, “BWRX-300 UK Generic Design Assessment-Generic Site Envelope and External Hazards Identification” (Reference 2-4).

Interfaces with other chapters

- PSR Chapter 1 – NEDO-34163, “BWRX-300 UK GDA Chapter 1: Introduction and Overview” (Reference 2-1) describes the generic BWRX-300 design and how it could be constructed, operated, and decommissioned in the UK on a site bounded by the Generic Site Envelope (GSE) in a way that is safe, secure and that protects people and the environment.
- PSR Chapter 9B – NEDO-34172, “BWRX-300 UK GDA Chapter 9B: Civil Engineering Works and Structures” (Reference 2-5) describes general design requirement information is provided in Chapter 9B, on the integrated Reactor Building (RB), and on other structures including other buildings in the Power Block, the Pumphouse/Forebay as well as the intake and discharge tunnels.
- PSR Chapter 15 – NEDO-34183, “BWRX-300 UK GDA Chapter 15.5: Safety Analysis-Deterministic Safety Analysis” (Reference 2-6), NEDO-34187, “BWRX-300 UK GDA Chapter 15.9: Safety Analysis–Summary of Results of the Safety Analysis” (Reference 2-7) and NEDO-34184, “BWRX-300 UK GDA Chapter 15.6: Safety Analysis–Probabilistic Safety Assessment” (Reference 2-8) documents the Deterministic Safety Analysis (DSA) of bounding Baseline Abnormal Operational Occurrences (BL-AOOs) and evaluates the bounding BWRX-300 Design Basis Accidents (DBAs) involving Loss-of-Coolant Accidents (LOCA) and non-LOCA. Furthermore, the general approach to the Probabilistic Safety Analysis (PSA) is described and the chapter includes results of analysed DSA and PSA bounding events. Finally, it demonstrates that implementing Defence-in-Depth (D-in-D) provisions ensures protection against unacceptable radiation releases.
- PSR Chapter 20 – NEDO-34192, “BWRX-300 UK GDA Chapter 20: Environmental Aspects” (Reference 2-3) describes the Environmental Monitoring Program, Effluent Monitoring Program, and Groundwater Monitoring Program.

2.1 Hydrology

2.1.1 External Flooding

Site specific external flooding assessments will be required at the site-specific stage for the UK BWRX-300 site. However, some initial information can be provided based on the assessment described within the GSE report (Reference 2-4). The potential flood hazards identified include flooding due to:

- Probable Maximum Precipitation (PMP)
- Runoffs
- Rivers
- Waves
- Seiche
- Tsunami
- Ponds, Dams or Dikes

- Ice Jamming

The GSE report (Reference 2-4) describes generic mitigation measures for external flooding which may be appropriate for a potential UK BWRX-300 site including:

- Constructing barriers to stop floodwater from entering the structure/site areas
- Constructing retention and detention ponds to slow and/or stop floodwaters entering the site area
- Wet Flood Proofing whereby floodwaters are allowed to enter the structure/site area, but ensuring that there is no or minimal damage to the building structure/site or the content within
- Emergency management/flood forecasting
- Increase the size of specific culverts draining into specific sub-catchments
- Increase the storage capacity of one or more stormwater management ponds
- Route runoff from specific catchments into other specific catchments
- Ensure progressing designs have sufficient conveyance and detention capacity and the stormwater infrastructure is adequate

2.1.2 High Water Level

GEN-MCFH-EP-2021-1, "NS-TAST-GD-013 Annex 2 Reference Paper: Analysis of Meteorological Hazards for Nuclear Sites" (Reference 2-9) references the United Kingdom Climate Projections (UKCP) 18 Representative Concentration Pathway (RCP) 8.5 scenario for projected sea level rise along with other source references. It states that sea-level rise is projected to be 340 mm by 2050 and 1110 mm by 2100 above the Global Mean Sea Level (GMSL) observed in 2000. There is a possibility that the rise will be beyond two metres by 2100 in the high-emission scenario. This suggests a sea-level rise trend of around 9 mm/yr. for the next 30 years and over 111 mm/yr. by 2100. This worst-case scenario, which fits within the 95th percentile, predicts an average of well over 20 mm/yr over the next 80 years. It also notes that relative sea-level rise around coasts is variable and depends on a number of factors, therefore sea water level will require assessment at the site-specific stage. IAEA Specific Safety Guide SSG-18 "Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations" (Reference 2-10) states an estimated global average rise in mean sea level due to climate change of between 180 mm to 590 mm by 2099.

2.1.3 Low Water Level

Low water levels can result in exposure of sea water intake structures. Analysis of site-specific data relating to low tides and high air pressure will be required at the site-specific stage.

2.1.4 Corrosion

A particular issue at coastal sites is the presence of salt containing moisture that can promote corrosion of metalwork. Corrosion will occur on most exposed metal structures and components (such as electrical insulators) unless protected and maintained. Assurance will be provided that any Structure, System, and Component (SSC) potentially affected is identified and protected within the design.

2.2 Meteorology

2.2.1 High Air Temperature

Figure NA.2 of "National Annex - UK National Annex to Eurocode 1: Actions on Structures – Part 1-5: General Actions – Thermal Actions" (Reference 2-11) shows isotherms of maximum shade air temperature for the UK, derived from Meteorological Office Data. The maximum isotherm shown is 35 °C in the southeast of England and the maximum isotherm shown for the UK coastal area is 31 °C, both with the probability of being exceeded of 0.02 (1 in 50-year return period).

Section A.2 of "Eurocode 1: Actions on Structures, Part 1-5: General Actions – Thermal Actions" (Reference 2-12) provides a method to transpose the temperatures to a different return frequency. Therefore, the maximum UK temperature for a return frequency of 1.0 E-04 is 45.4 °C and the maximum UK coastal temperature for a return frequency of 1.0 E-04 is 40.2 °C, not accounting for climate change adjustment. At the site-specific stage, maximum air temperature durations will be considered in greater detail.

Air temperature is identified as a parameter affected by climate change, "UKCP18-Key-results-2022" (Reference 2-13) and IAEA SSG-18 (Reference 2-10) have been consulted to estimate an appropriate climate change adjustment factor. The UKCP18 RCP 6.0 probabilistic projections at 90th percentile for the year 2099, estimates a change of +5.4 °C on the mean summer temperatures (Reference 2-13). IAEA SSG-18 (Reference 2-10) Annex IV provides variations in globally averaged rise in air temperature for the year 2099 of up to 4 °C as a best estimate and up to 6.4 °C allowing for uncertainties in the climate model scenarios. Given the early stage of GDA, a factor of +5.4 °C has been selected which is considered to be conservative and can be refined as the GDA progresses, if considered appropriate.

The maximum air temperature for a return frequency of 1.0 E-04 plus climate change adjustment factor for a UK coastal site is 45.6 °C (40.2 °C plus 5.4 °C) or for a UK inland site is 50.8 °C (45.4 °C plus 5.4 °C).

006N5991, "BWRX-300 Plant Architecture Definition" (Reference 2-14) sets out the Standard Plant Design (SPD) parameters for high air temperature. The SPD maximum dry bulb temperature is 39.7 °C. Safety Class 1 (SC1) SSCs that are exposed to ambient environment conditions in Main Control Room (MCR) and Secondary Control Room (SCR) are designed for extreme temperatures of 47.2°C. SC1 SSCs that are exposed to ambient environment conditions in RB and Control Building (CB) are designed for extreme temperatures of 37.8°C (Reference 2-14).

The Met Office "National Meteorological Library and Archive Factsheet 9 – Weather Extremes" (Reference 2-15) shows the UK daily highest temperature recorded as 40.3 °C in July 2022, in Lincolnshire England UK. The ONR Expert Panel Paper on Meteorological Hazards (Reference 2-9) summarises three recent European heatwaves that occurred in 2003, 2018 and 2019. Although UK specific high temperatures are not quoted, maximum temperatures recorded in Europe during the 2003 and 2019 heatwaves were over 40°C.

2.2.2 Low Air Temperature

BS EN 1991-1-5 National Annex (Reference 2-11) Figure NA.1 shows isotherms of minimum shade air temperature for the UK, derived from Meteorological Office Data. The minimum isotherm shown is -21°C in central Scotland and the minimum isotherm shown for the UK coastal area is 12 °C, both with the probability of being exceeded of 0.02 (1 in 50-year return period).

BS EN 1991-1-5: 2003 Eurocode 1-5 (Reference 2-12) Section A.2 provides a method to transpose the temperatures to a different return frequency. Therefore, the minimum UK temperature for a return frequency of 1.0 E-04 is -38.4 °C and the minimum UK coastal temperature for a return frequency of 1.0 E-04 is -22.0 °C. At the site-specific stage, minimum air temperature durations will be considered. A climate change adjustment factor is not included for low air temperature to maintain a conservative value.

The SPD temperature in the Plant Architecture Definition (Reference 2-14) 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.

2.2.3 Strong Winds

The method outlined in BS EN 1991 1-4:2005+A1:2010, “Eurocode 1 – Actions on Structures, Part 1-4 General Actions – Wind Actions” (Reference 2-16) and BS EN 1991-1-4:2005+A1:2010, “UK National Annex to Eurocode 1 – Actions on Structures, Part 1-4 General Actions – Wind Actions” (Reference 2-17) has been used to calculate the UK basic wind velocity, defined as “a function of wind direction and time of year at 10 m above ground of terrain category II”.

The calculation set out in Eurocode 1 Wind Actions (Reference 2-16) requires the fundamental value of the basic wind velocity (defined as “the characteristic 10 minutes mean wind velocity, irrespective of wind direction and time of year, at 10 m above ground level in open country terrain with low vegetation such as grass and isolated obstacles with separations of at least 20 obstacle heights”), a directional factor and a seasonal factor. The directional factor and seasonal factor are recommended within BS EN 1991 1-4 (Reference 2-16) to be 1.0. The highest fundamental basic wind velocity value for the UK coastal area before altitude correction is 29 m/s (Reference 2-16) (which bounds inland locations), and the highest fundamental basic wind velocity value for the UK EN-6 site areas before altitude correction is 24.5 m/s (Reference 2-16). The highest UK coastal value is for northwest Scotland which is not considered to be a representative location for the potential BWRX-300 candidate site, therefore the highest fundamental basic wind velocity value for the UK coastal EN-6 site locations has been taken forward in the calculations.

The method requires altitude of site above sea level and building height, for a coastal site a conservative altitude of 10m has been used and the building height is taken to be 30 m. A probability factor of 1.26, calculated from BS EN 1991 1-4 (Reference 2-16), is then applied for a return frequency of 1.0 E-04. Therefore, the conservative 10-minute mean basic wind velocity for a UK coastal EN-6 site is 31.2 m/s.

The method builds on the basic wind velocity by applying a terrain roughness factor and orography factor to obtain the mean wind velocity. Figure NA.3 in the National Annex (Reference 2-17) has been used for the Country terrain category as the GDA Scope is for a single unit at a coastal site. For GDA scope the bounding UK mean wind velocity for a UK EN-6 site is 43.1 m/s. This will need to be revisited at the site-specific stage as the calculation is dependent on proximity and height of nearby buildings.

As wind speed is identified as a parameter affected by climate change data, “UKCP18 Factsheet: Wind, Met Office” (Reference 2-18) has been consulted to estimate an appropriate climate change adjustment factor. The Met Office Factsheet presents an overview of global projections for the UK, using PPE-15 and CMIP5-13 datasets rather than scenarios. A factor of + 2 m/s has been conservatively selected as this is shown in the Met Office data to be the highest range in projected anomalies to the year 2100 (Reference 2-18).

For GDA scope the bounding UK mean wind velocity for a UK coastal EN-6 site plus a climate change adjustment factor for the GSE is 45.1 m/s (43.1 + 2 m/s). At the site-specific stage, where detailed meteorological data is available, consideration will also be given to gust speeds, which are usually recorded over a 3 s duration, and are typically around a factor of 2 greater than the 10 minute average value.

2.2.4 Humidity and Fog

"UK Climate Averages, Met Office" (Reference 2-19) have been used to determine the average annual relative humidity for the period 1991 to 2020. The average annual humidity for a UK coastal location range between 78% to 86% (Reference 2-19). The ONR Expert Panel Paper (Reference 2-9) discusses fog in relation to high humidity, fog occurs when the atmospheric humidity reaches 100%. Freezing fog occurs when the air temperature is around 0 °C which can lead to ice accumulation on cold surfaces. ONR Expert Panel Paper (Reference 2-9) notes that fog hazard is one of the hardest to predict, but of importance because of its potential widespread, if temporary, effects on infrastructure including transport. Air travel and road transport will be affected in such events, and this could present challenges in any emergency scenarios. Fog will not occur during large-scale storms but could present issues if it occurs at the same time as seismic events and could also obstruct remote sensing observations from aircraft and satellites. Fog hazard will be assessed at the site-specific stage with any credible hazard combination scenarios.

For GDA scope, the maximum relative humidity value of 100% is taken as a conservative value for the UK GSE.

A minimum humidity value is not provided within the GSE, as specific low-humidity design requirements are not identified within GDA.

2.2.5 Tornadoes

Tornadic Wind Speed

The ONR Expert Panel Paper (Reference 2-9) references a number of information sources for tornadoes and summarises a dataset from 1980 to 2012. It states that more than 95% of UK tornadoes, where wind speed could be measured or estimated, were on the F0 or F1 scale, with the remainder reaching F2, and no F3 tornadoes were recorded. The F (Fujita) Tornado Damage Scale is defined as:

- F0 Producing winds <73 mph (32.6 m/s)
- F1 Producing winds between 73-112 mph (32.6-50.1 m/s)
- F2 Producing winds between 113-157 mph (50.5-70.2 m/s)
- F3 Tornadoes producing winds between 158-206 mph (70.6-92.1 m/s)

The International Tornado and Storm Research Organisation (TORRO) Tornado Intensity Scale is described in "A Study of Tornadoes in Britain with Assessments of the General Tornado Risk Potential and Specific Risk Potential at Particular Regional Sites" (Reference 2-20). The intensity numbers on the scale, T0 to T10, represent wind speed bands in relation to the damage potential, summarised as:

- T0 Light Tornado, 39-54 mph (17-24 m/s)
- T1 Mild Tornado, 55-72 mph (25-32 m/s)
- T2 Moderate Tornado, 73-93 mph (33-41 m/s)
- T3 Strong Tornado, 93-114 mph (42-51 m/s)
- T4 Severe Tornado, 115-136 mph (52-61 m/s)
- T5 Intense Tornado, 137-160 mph (62-72 m/s)
- T6 Moderately Devastating Tornado, 161-186 mph (73-83 m/s)
- T7 Strongly Devastating Tornado, 187-212 mph (84-96 m/s)
- T8 Severely Devastating Tornado, 213-240 mph (96-107 m/s)

- T9 Intensely Devastating Tornado, 241-269 mph (108-120 m/s)
- T10 Super Tornado, 270-299 mph (121-134 m/s)

The wind speeds in the TORRO and Fujita scales are not directly comparable due to the bandings however the relationship between the scales is set out in Table 2-1.

The TORRO report (Reference 2-20, Table 5.2) presents data for tornado occurrence as a function of intensity for the British Isles and states that the data given for the time period 1950 to 1984 is preferable when considering mean annual frequency, therefore this data set has been summarized for this GSE report. Of classifiable tornado intensities from 1650 to 1984, 90.9 % were in categories T0 to T3 which roughly aligns with the above statistic of 95 % of UK tornadoes recorded in categories F0 or F1 on the Fujita scale. Categories T4 and T5 show 8.9 % of UK tornadoes within these intensity bands, which aligns roughly to F2. The remaining 0.2 % in T6 and T7 roughly aligns with F3.

The ONR Expert Panel paper (Reference 2-9) states that it is not clear whether tornadoes will become more frequent or more intense globally with climate change, therefore a climate change adjustment factor has not been considered at this stage. The “Meteorological Hazards” Annex to ONR, NS-TAST-GD-013, (Reference 2-21) suggests United States Nuclear Regulatory Commission (USNRC) Regulatory Guide (RG) 1.76 “Design Basis Tornado and Tornado Missiles for Nuclear Power Plants” (Reference 2-22) as a reference for design against the tornado hazard. USNRC RG 1.76 sets out the DB Tornado Characteristics by United States (U.S.) region, Region II is selected as the bounding case for the UK as this aligns with T7 and F3 wind speed bandings. The Region II maximum tornado wind speed is 89.4 m/s.

The SPD from the Plant Architecture Definition (Reference 2-14) states that the site characteristic associated with the DB tornado value for maximum wind speed is 230mph (103 m/s), based on USNRC RG 1.76 (Reference 2-22).

Tornado Maximum Pressure Drop

USNRC RG 1.76 states that the pressure drop for Region II is 63 mbar (Reference 2-22), this is selected as the UK GSE value.

Tornado Pressure Drop Rate

US NRC RG 1.76 states the rate of pressure drop for Region II is 25 mbar/s (Reference 2-22), this is selected as the UK GSE value.

Tornado Missiles

The tornado missiles spectrum data for Region II from USNRC RG 1.76 is selected for the UK GSE, summarised in Table 2-2.

2.2.6 Extreme Rain

Average 1-hourly and 24-hourly UK rainfall data are not available at this stage of the GDA as this is usually determined at the site-specific stage, therefore data presented in previous UK GDA submissions has been considered to determine a GSE value for this UK BWRX-300 GDA submission.

The UK Hualong Pressurised Water Reactor (HPR1000) GDA submission “Pre-Construction Safety Report, Chapter 3, Generic Site Characteristics” (Reference 2-23) has the bounding UK rainfall values accounting for climate change of 216 mm in 1-hour (163 mm plus 53 mm) and 302 mm in 24 hours (228 mm plus 74 mm). To determine GSE values for UK BWRX 300 GDA, the rainfall depths from HPR1000 before accounting for climate change have been selected and the climate change approach for this BWRX-300 submission has been applied. The 1-hour GSE design basis rainfall depth value selected for UK BWRX-300 is 163 mm

(Reference 2-14). The 24-hour GSE design basis rainfall depth value is 228 mm (Reference 2-14).

The UKCP18 RCP6.0 probabilistic projections at 90th percentile for the year 2099, estimates a change of +29 % on mean winter precipitation due to climate change, “UKCP18-Key-Results-2022” (Reference 2-13). Therefore, the UK rainfall values accounting for climate change are 210.3 mm in 1-hour and 294.1 mm in 24 hours.

The “European Utility Requirement (EUR) for LWR Nuclear Power Plants, Volume 2, Generic Nuclear Island Requirements, Chapter 4 Design Basis” (Reference 2-24) suggests that plant should be designed to withstand a DB rainfall depth of 100 mm in 1-hour and 400 mm in 24-hours. The EUR 24-hour value is assumed to implicitly include a climate change allowance, and bounds the GSE design basis value including climate change.

The Met Office Factsheet 9 (Reference 2-15) shows the UK most extreme rainfall event to be the highest 24-hour total of 341.1 mm in Cumbria in December 2015. The highest 1-hour total is 92 mm recorded in Berkshire in July 1901.

The rainfall values selected for the UK BWRX-300 GSE including climate change are 210.3 mm in 1-hour and 400 mm in 24-hours.

The BWRX-300 Plant Architecture Definition (Reference 2-14) shows that plant structures are designed to accommodate a maximum rainfall rate of 493 mm/h, and a maximum short-term rain fall rate of 157 mm in 5 minutes.

2.2.7 Extreme Snow

ONR TAG 13 Annex 2 Expert Panel Paper (Reference 2-9) sets out two recent examples of extreme snowfall in the UK. Snow accumulations were recorded on 2nd December 2009 at 580 mm in Balmoral, Aberdeenshire and 550 mm in County Durham. In February 2018, heavy snowfall of up to 500 mm was recorded over UK and Ireland.

Snow Load

The EUR (Reference 2-24) suggests that plant should be designed to withstand a snow loading upper limit of 1.5 kN/m2. In line with European guidance, the UK BWRX-300 GSE value is selected as 1.5 kN/m2.

The BWRX-300 Plant Architecture Definition (Reference 2-14) shows that plant structures are designed to accommodate a maximum ground snow load of 2500 Pa (2.5kN/m2) for normal winter precipitation events and 5000 Pa (5 kN/m2) for extreme winter precipitation events.

An adjustment due to climate change is not required for snow load due to the UK projections for temperature increases to the year 2100.

2.2.8 Frazil Ice

The effects of frazil ice are considered by the low water temperature hazard, as defined in Section 2.2.10.

2.2.9 High Water Temperature

The Normal Heat Sink (NHS) for the BWRX-300 is described in Section 2.5.9.

The EUR (Reference 2-24) states the DB conditions for maximum cooling water temperature is 30°C for seawater and river water, which does not account for any effects of recirculation from the plant cooling water discharge to the intake. The effect of recirculation and the potential impact of several power plants on a particular site will be considered at the site-specific stage, as the GDA scope assumes a single unit.

As sea water temperature is identified as a parameter affected by climate change, UKCP18 data has been consulted to estimate an appropriate climate change adjustment factor. The

Met Office “UKCP18 Marine Report” (Reference 2-25) shows the global mean surface temperature change resulting from carbon dioxide and other climate forcings for the ensemble of CMIP5 climate models used in the UKCP18 time-mean sea level projections, relative to a 1981-2000 Baseline (BL). This report does “not include results for RCP6.0 because the scenario exhibits a similar GMSL rise at 2100 to RCP4.5” (Reference 2-25) which informs the global mean surface temperature change. Therefore, a value has been selected from climate change scenario RCP4.5, the median of the projection range given, as 2.2°C.

The maximum cooling water temperature for a return frequency of 1.0 E-04 plus climate change adjustment factor for the UK GSE is 32.2 °C (30 °C plus 2.2 °C).

2.2.10 Low Water Temperature

Low water temperatures can lead to the formation of frazil ice on the surface of shallow coastal water. The Met Office states that sea water with salinity of 3.5% will have a freezing point of around -1.8 °C, “Sea Ice: An Overview” (Reference 2-26). Frazil ice can cause blockages or reduced flow at the cooling water intakes. For the purposes of GDA, frazil ice is considered to be covered by low water temperature and water-borne material plugging water intakes.

The EUR (Reference 2-24) states the DB conditions for minimum cooling water temperature are -0.5 °C for seawater and 0 °C for river water.

The low water temperature selected for UK BWRX-300 GSE is -1.9 °C, this will be reviewed at the site-specific stage as the freezing temperature of sea water is dependent on salinity.

A climate change adjustment factor is not included for minimum sea water temperature to maintain a conservative value.

2.2.11 Lightning

The ONR TAG 13 Expert Panel Paper (Reference 2-9) states there are currently estimated to be about 300,000 lightning strikes annually in the UK, of which approximately 25% are of the critical cloud-to-ground strikes. Cloud-to-ground strikes can produce of the order of a billion joules of energy, and can cause significant damage to infrastructure, if not protected. It suggests that the incidence of lightning is projected to increase, assuming worst case scenario, there could be up to a 50% increase in lightning activity by 2099.

UKCP18 Factsheet: “Storms” (Reference 2-27) states that looking to the future climate, UKCP Local is at a spatial resolution that represents a step forward in how thunderstorms are simulated by climate models. For RCP8.5, UKCP Local shows that by 2060-2080 that lightning frequency is projected to increase in summer, increase slightly in spring, decrease in autumn, and shows little change in winter compared to 1980-2000. Noting that these changes vary regionally.

The lightning flash density map 2014, “PD 62305-2:2014, Flash Density Map 2014-Supplement to BS EN 62305-2:2012 – Protection Against Lightning, Part 2: Risk Management” (Reference 2-28) for the UK records the highest flash density for the UK as 1.4 flashes/km2/year for data collected between 2001 and 2012. This is further confirmed by Energy Technologies Institute (ETI), “Enabling Resilient UK Energy Infrastructure: Natural Hazard Characterization Technical Volumes and Case Studies, Volume 9: Lightning” (Reference 2-29) (as referenced in the ONR TAG 13 Expert Panel Paper (Reference 2-9)) for data recorded between 2008 and 2017. The ETI (Reference 2-29) suggests that the upper limit for the lightning strike current would be 300 kA, in temperate regions such as the UK. ETI (Reference 2-29) records Met Office data for the UK annual average days of thunder from 1971 to 2000, showing the highest average banded value to be >14 days. This reflects the information given in BS EN 62305-2:2012, “Protection Against Lightning, Part 2: Risk Management” (Reference 2-30) which shows a contour map for thunderstorm days per year throughout the world, with the UK shown between the 5-10 days/yr. contour and the 10-20 days/yr. contour.

2.2.12 Solar Storms

The increased reliance on technology driven systems globally means that infrastructure and electric grids are susceptible to the impacts of space weather events. Space weather events are briefly outlined in the following paragraphs using information from ONR Guidance Document, NS-TAST-GD-013-Annex 5, “Other External Hazards” (Reference 2-31), with regards to the potential hazards for the UK BWRX-300.

Solar flares are a sudden release of energy from the Sun in the form of X-rays, extreme UV rays and gamma-rays which take about 8 minutes to reach Earth (speed of light) and persist in a timeframe of minutes to hours. An eruption event will typically take one to four days to reach Earth and persist for one to two days:

- Solar Energetic Particles (SEPs) are highly energetic solar particles (protons and ions) travelling at relativistic speeds which may take the order of 15 minutes to 24 hrs to reach earth and persist for several days. A particle cascade can be composed of neutrons, protons, muons, pimesons, gamma rays and electrons. These particles are typically observed at high elevation in satellite and aviation systems but also have the potential to create ground-level particle fluxes of neutrons and muons; these events are referred to as Ground Level Events (GLEs).
- Coronal Mass Ejections (CMEs) are the ejection of electrical plasma and magnetic fields from the solar corona as a plasma ‘bubble’ into interplanetary space. CMEs interact with the Earth’s geomagnetic field; the event may result in a disturbance to the Earth's magnetic field and ionosphere.
- Geomagnetically Induced Current (GIC) is a consequence of the interaction between an appropriately magnetically aligned CME or fast stream of solar wind and the geomagnetic field induces a secondary magnetic field and a surface electric field in the Earth. A GIC can enter any ground-based network through the earthing points affecting electrical power transmission systems, pipelines, and railways.

Space weather affects man-made satellites and the aviation industry. The electronics within man-made satellites can be disrupted by the particle flux, giving the potential for reducing the reliability of signals and data. This includes man-made satellites providing Global Navigation Satellite Systems (GNSS). Where ground level infrastructure also relies on GNSS (position and/or timing), satellite communications, mobile or High Frequency (HF) communications, or contain electronic hardware sensitive to ionising radiation, then there are additional space weather risks. GLE are relevant to control and instrumentation systems.

2.2.13 Air Pressure

For the purposes of GDA, this hazard is covered by hydrological hazards high water level and low water level due to similar consequences.

2.3 Geology, Seismology, and Geotechnical Engineering

2.3.1 Geotechnical Description

The UK has a very varied geology and earth-surface processes that create some particular (non-seismic) hazards that will be considered at the site-specific stage, EN-6, "National Policy Statements for Energy Infrastructure" (Reference 2-32). The EN-6 sites have undergone review by UK Government for the National Policy Statement (NPS), they also either currently or historically had operational nuclear facilities located on these sites. Therefore, the geological conditions at the EN-6 sites are expected to be suitable for the BWRX-300 design, but this will be subject to confirmation through hazard analysis at the site-specific stage.

Basis of Design and Structural Design Method Statements for each in scope structure will be provided in GDA, including:

- Description of static analysis methods used and associated verification and validation studies (including Soil-Structure Interaction (SSI) methods)
- Description of seismic analysis methods used and associated verification and validation studies (including SSI and Structure-Soil-Structure Interaction methods); sensitivity studies; beyond DB (including ultimate capacity and reliability of the containment)

Detailed geotechnical assessment requires detailed site information; therefore, this will be considered at the site-specific stage and not for consideration in GDA.

2.3.2 Earthquake

It is noted that the UK soil type can range from 'soft' to 'hard' which can impact the selection of the spectra value, shape profile and response. Therefore, at the site-specific stage, the Peak Ground Acceleration (PGA) will be determined on which to anchor the response spectra. However bounding conditions will be assumed for the design.

The UK NPS EN-6 (Reference 2-32) considered seismic risk, it states that seismic risk is more appropriately assessed at site licensing stage when detailed site specific and reactor design information is available. It acknowledges that the reactor designs being considered under the GDA process are intended for worldwide application, with BL_seismic resistance designs in the area of 0.25 g to 0.5 g PGA. This does not therefore affect the potential suitability of the sites for the purposes of the EN-6 strategic siting assessment.

EUR suggests that typical values for Operating Basis Earthquake (OBE) PGA could be in the range 0.05 to 0.1 g (Reference 2-24). EUR also defines the horizontal free field PGA for all site conditions as 0.25 g (Reference 2-24) but that this PGA has been selected for design purposes only and does not relate to the level of seismic hazard at any specific site.

The design of the standard plant will be carried out using conservative design procedures. There will be margins in the standard design arising from the adoption of a standard PGA of 0.25 g, three seismic input spectra and a wide range of soil properties, together with the margins inherent in the allowable limits of the codes. This procedure is expected to lead in practice to a standard design which has a capability to withstand SSE seismic events at a higher level than a 0.25 g ground motion (Reference 2-24).

A PGA value of 0.3 g, is selected for the UK BWRX-300 GSE value (Reference 2-14).

2.4 Site Characteristics and the Potential Effects of the Nuclear Power Plant in the Region

The GDA is being performed on a generic UK site.

No sites have been selected yet, but feasibility of emergency planning will be used as an exclusionary criterion in site selection. This will take into account, for example: population distribution and density around the site, evacuation routes and transport infrastructure (either existing or with necessary improvement), the presence of temporary or transient populations, any vulnerable groups for whom special arrangements would need to be included in the emergency plan, and the presence of any features such as physical barriers that would make implementing any emergency measures difficult.

2.5 Identification and Screening of Generic Site Envelope

The identification and screening process for external hazards is outlined within the Approach to Internal and External Hazards Report, NEDC-34143P "BWRX-300 GDA Internal and External Hazards Assessment Approach" (Reference 2-33). A description of the External Hazards Identification is provided within Section 4 of Reference 2-33. The approach is aligned to the Hazard Review Process described in Figure 2-1. The initial phase of this process includes consideration of sources of guidance and RGP literature.

This report derives a comprehensive set of external hazards and identifies the foreseeable external hazards that require assessment to support GDA Step 2 for the UK BWRX-300 design. Explanation is provided on the process by which DB External Hazards (EHs) are identified and by which other hazards can be screened out, using the screening process.

It should be noted that EHs that arise from malicious intent are not considered.

2.5.1 Description of Generic Site Envelope

The GSE in this chapter, consisting of external hazards, site characteristics and information, is based on consideration of the potential sites as described.

The EN-6 (Reference 2-32) sets out the potential locations within the UK which are suitable sites for a nuclear power plant. These sites have all previously accommodated nuclear power plants, namely the following candidate sites:

- Bradwell
- Hartlepool
- Heysham
- Hinkley Point
- Oldbury
- Sizewell
- Sellafield
- Wylfa

The generic site for UK BWRX-300 does not represent any particular location in the UK but represents the envelope of the potential UK site conditions. Additional description will be provided where appropriate for the individual characterisation of external hazards.

Table 2-3 presents the proposed GSE values for the UK BWRX-300 design, as determined in Sections 2.1, 2.2and 2.3 for the hydrological, meteorological, and seismic hazards, respectively. Where values are not available at this stage of the GDA, a comment is provided within the table and further description is provided within the relevant subsection of this report.

2.5.2 Site Layout

The scope of nuclear-safety significant buildings and related SSCs, is described in GDA NEDC-34148P, "Scope Definition Report" (Reference 2-34). This scope is predominantly focussed on the Power Block Buildings and includes all corresponding systems and components within these buildings. Where required, the EHs will consider the generic plant layout and remaining Balance of Plant.

The following section provide a basic description of the key Power Block Buildings and associated site infrastructure.

2.5.3 Reactor Building

The RB is a Safety Category 1 and Seismic Category A structure. It is a cylindrical shaped structure embedded in a vertical shaft to a depth of approximately 36 m below grade. The Reactor Pressure Vessel (RPV), Steel-Plate Composite Containment Vessel (SCCV) and other important systems and components are located in the deeply embedded RB vertical right-cylinder shaft to mitigate effects of external events, including aircraft impact, adverse weather, fires, and earthquakes.

Also within the RB are the SCR, reactor support and safety class systems, Safety Class 1 power supply and equipment; reactor cavity pool above the containment dome, three separate Isolation Condenser System (ICS) pools with one isolation condenser located in each pool, and the Fuel Pool.

2.5.4 Turbine Building

The Turbine Building (TB) houses the steam turbine generator, standby diesel generators, main condenser, condensate and feedwater systems, turbine-generator support systems, and parts of the Off-gas System (excluding the off-gas charcoal adsorbers).

The TB, CB, and Reactor Auxiliary Structures (summarised below) are Safety Class 2 (SC2) structures and categorized as non-Seismic. Additionally, they are evaluated for seismic interaction to ensure that the structural integrity and safety functions of the adjacent Seismic Category A RB are not compromised following a Design Basis Earthquake (DBE) or extreme Tornado wind conditions.

2.5.5 Control Building

The CB houses the MCR, Emergency Operations Centre (EOC), electrical, control, and instrumentation equipment. The CB serves as main entrance and exit for the Power Block unit during normal operations.

2.5.6 Radwaste Building

The Radwaste Building (RWB) houses rooms and equipment for handling, processing, and packaging liquid and solid radioactive wastes as well as the Off-gas System charcoal adsorbers that are used for processing radioactive gas. Some of these systems contain highly radioactive materials. The RWB is classified as a Safety Class 3 (SC3) building and categorized as RW-IIa. Additionally, it is also evaluated for seismic interaction to ensure that it will not compromise the structural integrity or safety functions of the adjacent Seismic Category A RB following a DBE or extreme Tornado wind conditions.

2.5.7 Service Building, and Reactor Auxiliary Structures

These buildings and structures contain facilities that support the routine operations of the BWRX-300.

2.5.8 Switchyard

The switchyard detailed design description is not included within the GDA scope. The BWRX-300 design will have a dedicated single grid connection.

2.5.9 Heat Sink

The standardised BWRX-300 design for the NHS includes several options, and the decision for the provision for the UK is undefined at this stage. The NHS design is considered to be at BL0 maturity level in GDA. As a BL0 system, the design sufficiently outlines the cooling water requirements for GDA.

GDA will consider a single unit operating on a generic UK coastal site using a once through cooling system with seawater as the NHS. This option is subject to change, based on any future design development for the standard design, and/or subject to any prospective licensee decision. This will provide the necessary detail to provide suitable and sufficient consideration of the heat sink aspects within GDA. The representative example design for the heat sink will be as follows.

Water withdrawn from sea will flow through the plant surface condensers to remove the excess energy of the turbine exhaust steam. The amount of heat removed during this process depends on the flow rate and the temperature rise of the water passing through the condensers. The plant heat is then rejected back to the sea.

The NHS includes, but is not limited to the following:

- Intake Tunnel, to decrease potential impacts to fish habitat and is sized to provide the required flow of cooling water to the plant. It is also constructed to minimize the intake velocity to prevent impingement and entrainment of fish and effect on local currents
- Discharge Tunnel
- Pumphouse/Forebay composed of the forebay, pump bays and superstructures to house the Circulating Water System (CWS) pumps and related equipment.

2.5.10 Security Building

A security building, known as the Protected Area Access Building, is provided on the protected area boundary to allow for ingress and egress to and from the protected area. Additionally, a sally port is provided adjacent to the security building to allow for vehicular traffic to enter the protected area. The switchyard detailed design description is not included within the GDA PSR scope but will be considered within the Security submission.

2.5.11 Additional On-Site Infrastructure

Infrastructure, including additional buildings, to support operations inside the Power Block include:

- An administration building with office spaces and a simulator training space
- A warehouse to provide long term storage space for Small Modular Reactor (SMR) components and equipment
- A car park near the administration building

2.5.12 General Layout

Figure 2-2 and Figure 2-3 below provides an overview of the Power Block layout, and representative example site layout respectively.

2.6 Radiological Conditions Due to External Sources

The list of EHs derived from the hazard's identification process are presented in NEDO-34186, "BWRX-300 UK GDA Chapter 15.8: Safety Analysis – External Hazards (Reference 2-2) where external hazard names identified are the same or similar, or have similar effects, these have been collated and are considered under one hazard 'descriptor.' These hazards are examined in the following sub-sections to determine whether they are within the DB or can be screened out of the DB. Where hazards cannot be screened out of the DB, they will be included in the assessment for GDA.

The DB hazards that are included or excluded from GDA scope will differ depending on the design-specific context. These are divided into the following categories:

- Within scope of GDA
- Site-specific but reassurance can be provided during GDA (i.e., partial inclusion in GDA scope)
- Site-specific and only able to be treated as such in any detail (i.e., excluded from GDA scope)

The screening of EHs has been performed using the following screening criteria presented in ONR "Safety Assessment Principles for Nuclear Facilities" (Reference 2-35):

- 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 provided to the Fault Evaluation for disposition. Those hazards that cannot be shown to be more infrequent than 1.0 E-07 per reactor year with a high degree of confidence is also provided to the Fault Evaluation. Individual hazards with expected frequencies of less than 1.0 E07 per reactor year are screened from consideration in the Fault Evaluation.
    - The frequency of 1.0 E-05 per reactor year is used to determine the DB for the discrete internal hazards and external hazards.
    - For non-discrete hazards, a conservative estimate of hazard severity at the1.0 E04 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.
    - The frequency of combination of independent external hazards between 1.0 E-07 per reactor year and ~1.0 E-05 per reactor year is considered in the cliff edge analysis.
    - Bounded hazard – The failures induced by the hazard are bounded by another hazard of similar consequence and higher frequency.
    - The EHs screening presented in the following sub-sections discusses each external hazard identified and categorises those hazards that require further assessment from those that can be screened out or incorporated. A summary of the EHs screening is presented in Appendix C.

2.7 Site Related Issues in Emergency Preparedness and Response and Accident Management

The design provisions of the BWRX-300 that support effective emergency response will be described, however the detailed emergency response planning and the organizational capability to respond to an emergency are outside of the scope of this GDA.

2.8 Monitoring of Site Related Parameters

Where available, bounding values have been derived for the EH, that forms the GSE (see Table 2-3). Where values have not been determined at this stage of the GDA, a description is provided. As the GDA Safety Analysis progresses, bounding values will be included and updated where appropriate.

To inform the estimated values for the UK BWRX-300 GSE, for each of the EH parameters within the GDA scope, a number of data sources have been reviewed including RGP documents, reference documents relating to the UK EN-6 (Reference 2-32) candidate sites.

The UK RGP reference documents that have been consulted during derivation of the EH values include:

- ONR Technical Assessment Guide (TAG) NS-TAST-GD-013, “External Hazards” (Reference 2-36) including:
  - Annexes (NS-TAST-GD-013 - Annex 1, “Seismic Hazards,” (Reference 2-37), Annex 2 Meteorological Hazards (Reference 2-21), NS-TAST-GD-013 - Annex 3, “Coastal Flood Hazards,” (Reference 2-38), NS-TAST-GD-013 - Annex 4, “Accidental Aircraft Crash Hazard,” (Reference 2-39), and Annex 5 Other External Hazards (Reference 2-31))
  - Associated Expert Panel Papers (GEN-SH-EP-2016-1, “NS-TAST-GD-013 Annex 1 Reference Paper: Analysis of Seismic Hazards for Nuclear Sites,” (Reference 2-40), Annex 2 Reference Paper: Analysis of Meteorological Hazards for Nuclear Sites (Reference 2-9), and GEN-MCFH-EP-2021-2, “NS-TAST-GD-013 Annex 3 Reference Paper: Analysis of coastal Flood Hazards for Nuclear Sites,” (Reference 2-41))
- Met Office data, including UKCP from “UKCP18 Guidance: Representative Concentration Pathways” (Reference 2-42)
- British Standards (BS) European Standards (EN) BS EN Eurocodes (References 2-11, 2-12, 2-16 and 2-17)
- USNRC RG 1.76 (Reference 2-22)
- European Utility Requirements (EUR) for Light Water Reactor (LWR) Nuclear Power Plants (Reference 2-24)
- Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations, IAEA SSG-18 (Reference 2-10)
- TORRO report – A Study of Tornadoes in Britain (Reference 2-20)
- Energy Technologies Institute (ETI) Limited Liability Partnership (LLP), Enabling Resilient UK Energy Infrastructure: Natural Hazard Characterisation Technical Volumes and Case Studies (Reference 2-29)
- UK National Policy Statement (NPS) EN-6 (Reference 2-32)

It should be noted that the NPS for Energy Infrastructure EN-6 (Reference 2-32) has been withdrawn as of 23rd January 2024. For GDA this policy statement is still considered to be suitable for supporting the development of the GSE and external hazards considerations and has been used to inform the characterisation of the generic site. GDA will consider a single unit operating on a generic UK coastal site using a once through cooling system with seawater as the ultimate heat sink.

The GDA Scope specification of a coastal site will be used to characterise the external hazards that are representative of the EN-6 (Reference 2-32) coastal sites.

Furthermore, population data for the Heysham site would present a likely bounding case for the UK BWRX-300 GDA with respect to Local Population considerations.

Table 2-1: Relationship Between the Tornado and Storm Research Organisation and Fujita Scales

T	F
0	0.1
1	0.6
2	1.1
3	1.6
4	2.2
5	2.7
6	3.2
7	3.7
8	4.2
9	4.8
10	5.3

F	T
0	-0.15
1	1.8
2	3.7
3	5.6
4	7.5
5	9.4

Table 2-2: UK BWRX-300 Generic Site Envelope (Region II) Tornado Missiles Spectrum for 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	2.54 cm dia	0.0669 kg	7 m/s	4.7 m/s

Table 2-3: Summary of External Hazard Values

EH Group	External Hazard Parameter	UK BWRX-300 GSE Design Basis Value	UK BWRX-300 Climate Change adjustment
Meteorological	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%	To be considered during assessment.
	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 report for dimensions and velocities.	Not assessed.
	Extreme rain	210.3 mm in 1-hour	+29 %
		400 mm in 24-hours	Climate change assumed to be implicitly included in the DB value
	Extreme snow	1.5 kN/m^2 Snow depths not defined within GSE	To be considered during assessment.
	Frazil Ice	Considered in Low Water Temperature.	n/a
	High water temperature	30 °C	+2.2 °C
	Low water temperature	-1.9 °C	Not required.
	Lightning	Lightning flash density 1.4 flashes/km2/year Lightning Strike Current 300 kA Average days of thunder 15 days/year	Frequency projected to increase in summer and spring.
	Space Weather	Value not available at this stage.	n/a

EH Group	External Hazard Parameter	UK BWRX-300 GSE Design Basis Value	UK BWRX-300 Climate Change adjustment
	Air pressure	Value not available at this stage.	To be considered during assessment.
Hydrology	External Flooding	Value not available at this stage.	To be considered during assessment.
	High Water Level	Site specific, some data provided within this report.	To be considered during assessment.
	Low Water Level	Site specific.	To be considered during assessment.
	Corrosion	Value not available at this stage.	Not applicable.
Seismic	Earthquake	0.3 g	Not applicable.
Other Natural Hazards	Geological	Site specific.	Not applicable.
	Biological	Site specific.	Not applicable.
Industrial and Man-Made Hazards	Externally generated missiles	Site specific.	Not applicable.
	Industrial or military facility accident	Site specific.	Not applicable.
	Collapsed structures and falling objects	Site specific.	Not applicable.
	Hazards from adjacent nuclear sites	Site specific.	Not applicable.
	Electromagnetic Interference (EMI)	Site specific.	Not applicable.
Fire	Natural and man-made fires	Site specific.	To be considered during assessment.
Aircraft Impact	Accidental Aircraft Impact	Indicative assessment approach to be provided in GDA.	Not applicable.
Loss of Offsite Power (LOOP)	LOOP	LOOP frequencies and durations not currently assessed.	Not applicable.

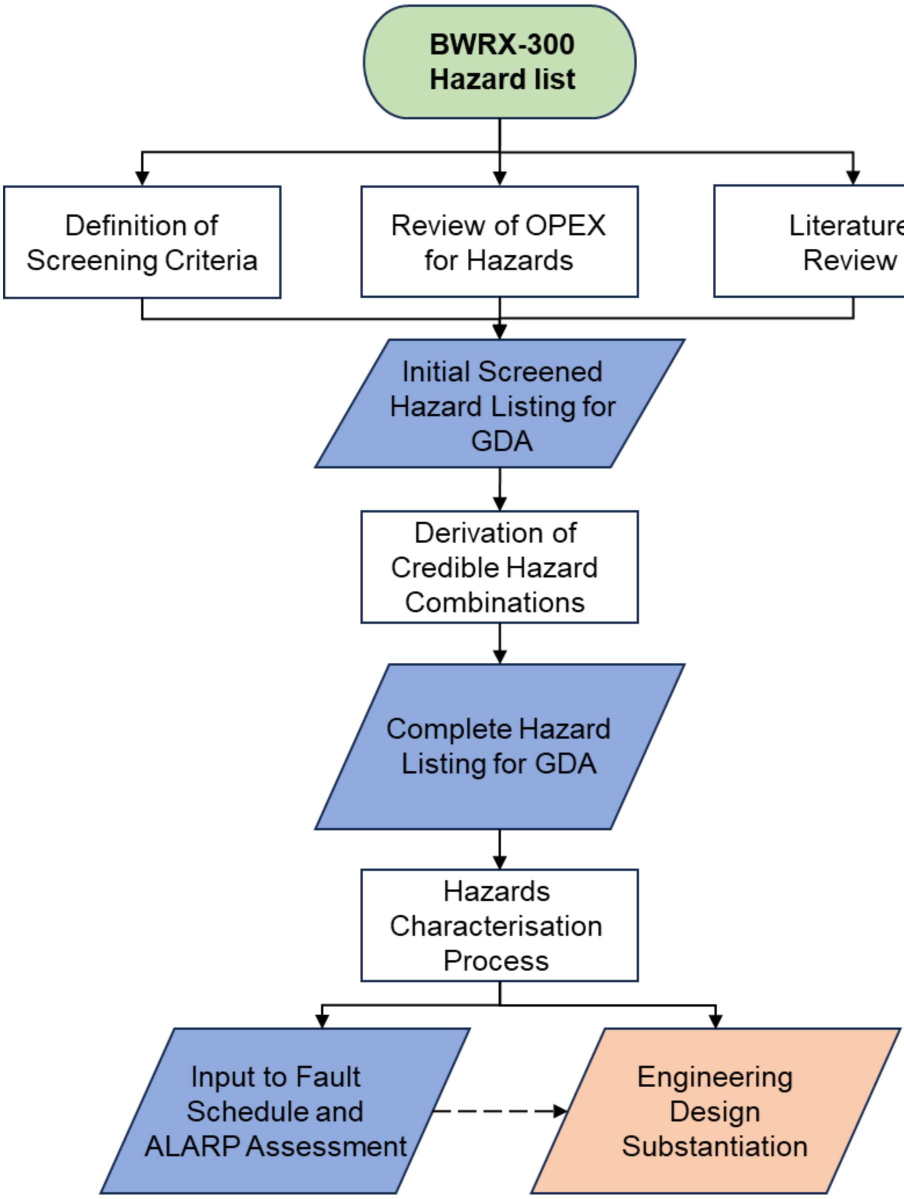

Figure 2-1: Overview of Hazards Review Process for BWRX-300 Generic Design Assessment

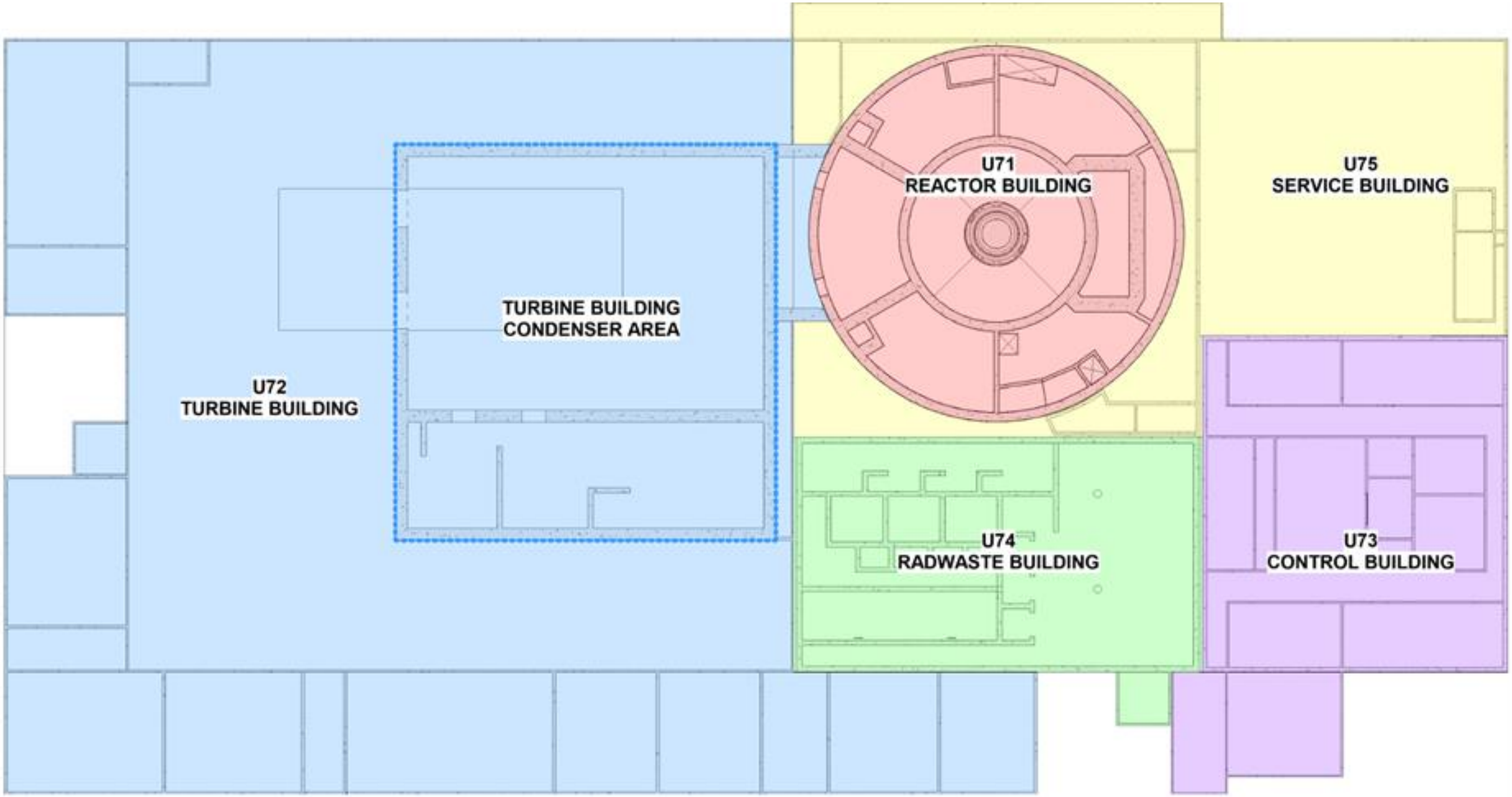

Figure 2-2: Representation of BWRX-300 Standard Power Block

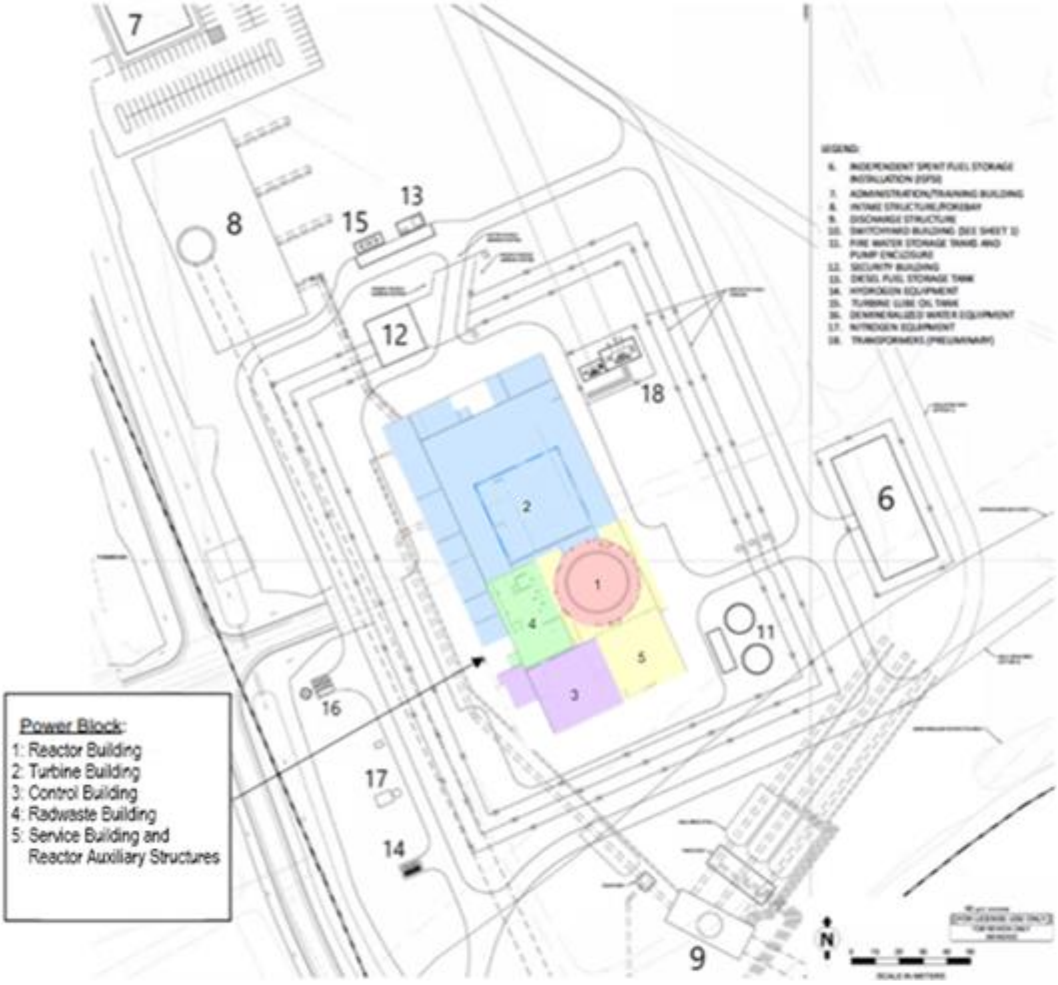

Figure 2-3: Representative BWRX-300 Generic Design Assessment Site Layout

2.9 References

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APPENDIX A Claims, Arguments and Evidence

The ONR "Safety Assessment Principles for Nuclear Facilities" 2014 (Reference 2-35) identify ONR's expectation that a safety case should clearly set out the trail from safety claims, through arguments to evidence. The Claims, Arguments, and Evidence (CAE) approach can be explained as follows:

- Claims (assertions) are statements that indicate why a facility is safe
- Arguments (reasoning) explain the approaches to satisfying the claims
- Evidence (facts) supports and forms the basis (justification) of the arguments

The GDA CAE structure is defined within BWRX-300 UK GDA NEDC-34140P, "Safety Case Development Strategy (SCDS)" (Reference 2-43) and is a logical breakdown of an overall claim that:

> *"The BWRX-300 is capable of being constructed, operated and decommissioned in accordance with the standards of environmental, safety, security and safeguard protection required in the UK".*

This overall claim is broken down into Level 1 claims relating to environment, safety, security, and safeguards, which are then broken down again into Level 2 area related sub-claims and then finally into Level 3 (chapter level) sub-claims.

This chapter does not directly demonstrate compliance against the Level 3 sub-claims that are identified within the SCDS (Reference 2-43).

It is not the intention to generate a comprehensive suite of evidence to support the derived arguments, as this is beyond the scope of GDA Step 2. However, where evidence sources are available, examples are provided.

Risk Reduction as Low As Reasonably Practicable

It is important to note that nuclear safety risks cannot be demonstrated to have been reduced As Low As Reasonably Practicable (ALARP) within the scope of a 2-Step GDA. It is considered that the most that can be realistically achieved is to provide a reasoned justification that the BWRX-300 SMR design aspects will effectively contribute to the development of a future ALARP statement. In this respect, this chapter contributes to the overall future ALARP case by demonstrating that:

- The chapter-specific arguments derived may be supported by existing and future planned evidence sources covering the following topics:
  - RGP has demonstrably been followed
  - Operational Experience has been taken into account within the design process
  - All reasonably practicable options to reduce risk have been incorporated within the design
- It supports its applicable level 3 sub-claims, defined within the SCDS (Reference 2-43)

Probabilistic safety aspects of the ALARP argument are addressed within PSR Chapter 15.

APPENDIX B Forward Action Plan

This chapter does not directly support any forward actions, as defined within the Forward Action Plan.

APPENDIX C Hazard Screening for Generic Design Assessment

Hazard Group	ID	Hazard	In Scope for GDA (Y/N)	Screening Comments
Meteorological	1	Drought	N	Site-specific and only able to be treated as such in any detail.
	2	Extreme air pressure (high/low/gradient)	N	Site-specific and only able to be treated as such in any detail.
	3	Extreme rain	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	4	Extreme snow	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	5	Fog	N	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	6	Frost (soil and white)	N	Site-specific and only able to be treated as such in any detail.
	7	Hail	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	8	High air temperature	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	9	High water temperature	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	10	Humidity	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	11	Tornadoes	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	12	Ice cover (surface ice)	N	Site-specific and only able to be treated as such in any detail.
	13	Ice storm/freezing rain/sleet	N	Site-specific and only able to be treated as such in any detail.
	14	Lightning	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)

Hazard Group	ID	Hazard	In Scope for GDA (Y/N)	Screening Comments
	15	Low air temperature	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	16	Low water temperature	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	17	Solar storms	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	18	Strong winds	Y	Within scope of GDA, Subchapter 15.8 (Reference 2-2)
	19	Underwater temperature	N	Bounded by High water temperature (Hazard 9) and Low water temperature (Hazard 16) due to similar consequences.
	20	Meteorite	N	Bounded by Aircraft impacts (Hazard 77) due to similar consequences.
	21	Salt storm	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	22	Sandstorm	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	23	Volcanic activity	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
Hydrological	24	Coastal erosion	N	Site-specific and only able to be treated as such in any detail.
	25	Corrosion	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	26	External flooding	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	27	Frazil ice	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)

Hazard Group	ID	Hazard	In Scope for GDA (Y/N)	Screening Comments
	28	Groundwater (too much or too little)	N	Site-specific and only able to be treated as such in any detail.
	29	High water level	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	30	High tide	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	31	Ice barriers	N	Site-specific and only able to be treated as such in any detail.
	32	Low water level	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	33	Other extraordinary waves	N	Site-specific and only able to be treated as such in any detail.
	34	River diversion	N	Site-specific and only able to be treated as such in any detail.
	35	Seiche	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	36	Storm surge	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	37	Strong currents (under-water erosion)	N	Site-specific and only able to be treated as such in any detail.
	38	Tsunami	N	Site-specific and only able to be treated as such in any detail.
	39	Underwater landslide (impact on soil, i.e., not tsunami)	N	Site-specific and only able to be treated as such in any detail.
	40	Water surface variation	N	Site-specific and only able to be treated as such in any detail.
	41	Waves	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)

Hazard Group	ID	Hazard	In Scope for GDA (Y/N)	Screening Comments
Seismic	42	Earthquake	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
Geological	43	Above-water landslide	N	Site-specific and only able to be treated as such in any detail.
	44	Avalanche	N	Site-specific and only able to be treated as such in any detail.
	45	Erosion	N	Site-specific and only able to be treated as such in any detail.
	46	Excavation work	N	Site-specific and only able to be treated as such in any detail.
	47	Ground collapse	Y	Site-specific and only able to be treated as such in any detail.
	48	Ground vibration (e.g., due to nearby explosions)	N	Site-specific and only able to be treated as such in any detail.
	49	Land rise	N	Site-specific and only able to be treated as such in any detail.
	50	Landslide	N	Site-specific and only able to be treated as such in any detail.
	51	Soil shrink-swell	N	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	N	Bounded by Water borne material plugging water intakes/organic material in water (Hazard 80) due to similar consequences.
	53	Chemical release after pipeline accident	N	Site-specific and only able to be treated as such in any detail.
	54	Chemical release after transportation accident	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	55	Chemical release and contamination from chemicals	N	Site-specific and only able to be treated as such in any detail.
	56	Chemical release outside or inside site	N	Site-specific and only able to be treated as such in any detail.
	57	Chemical releases into water	N	Site-specific and only able to be treated as such in any detail.
	58	Collapsed structures/falling objects	Y	Site-specific and only able to be treated as such in any detail.
	59	Contamination from chemicals	N	Site-specific and only able to be treated as such in any detail.
	60	Eddy currents into ground	N	Bounded by EMI (Hazard 61) due to similar consequences.

Hazard Group	ID	Hazard	In Scope for GDA (Y/N)	Screening Comments
	61	EMI	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	62	Explosion after pipeline accident	N	Site-specific and only able to be treated as such in any detail.
	63	Explosion after transportation accident	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	64	Explosion outside plant	N	Site-specific and only able to be treated as such in any detail.
	65	Externally generated missiles	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	66	Ground contamination (e.g., from chemicals)	N	Site-specific and only able to be treated as such in any detail.
	67	High air pollution	N	Site-specific and only able to be treated as such in any detail.
	68	Impurities in water from ship release (solids and liquids)	N	Site-specific and only able to be treated as such in any detail.
	69	Releases from industrial facilities	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	70	Man-made explosion (deflagration and detonation)	N	Site-specific and only able to be treated as such in any detail.
	71	Missiles (from military activity or other plant)	N	Site-specific and only able to be treated as such in any detail.
	72	Satellite crash (orbital debris)	N	Bounded by Aircraft impacts (Hazard 77) due to similar consequences.
	73	Ship accidents	N	Site-specific and only able to be treated as such in any detail.
	74	Adjacent Nuclear Sites	N	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	75	Train crash	N	Site-specific and only able to be treated as such in any detail.

Hazard Group	ID	Hazard	In Scope for GDA (Y/N)	Screening Comments
	76	Vehicle impacts with plant SSCs	N	Site-specific and only able to be treated as such in any detail.
Aircraft Impact	77	Accidental aircraft impacts	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
Biological	78	Natural airborne hazards (birds, leaves, ash etc)	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
	79	Biological events	N	Site-specific and only able to be treated as such in any detail.
	80	Water borne material plugging water intakes/organic material in water	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
LOOP	81	LOOP	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)
Fire	82	External Fires	Y	Site-specific but reassurance can be provided during GDA, Subchapter 15.8 (Reference 2-2)