Office for Nuclear Regulation

New Reactor Division – Generic Design Assessment

Step 2 Assessment of the External Hazards of UK HPR1000 Reactor

Assessment Report ONR-GDA-UKHPR1000-AR-18-004
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EXECUTIVE SUMMARY

This report presents the results of my external hazards assessment of the UK HPR1000 undertaken as part of Step 2 of the Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA).

The GDA process calls for a step-wise assessment of the Requesting Party's (RP) safety submission with the assessments increasing in detail as the project progresses. Step 2 of GDA is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including ONR's review of key nuclear safety and nuclear security claims (or assertions). The aim is to identify any fundamental safety or security shortfalls that could prevent ONR from permitting the construction of a power station based on the design.

During GDA Step 2 my work has focused on the assessment of the external hazards aspects within the UK HPR1000 Preliminary Safety Report (PSR), and a number of supporting references and supplementary documents submitted by the RP, focusing on design concepts and claims.

The standards I have used to judge the adequacy of the RP's submissions in the area of external hazards have been primarily ONR's Safety Assessment Principles (SAPs), in particular SAPs relating to external hazards in the EHA group, and ONR's Technical Assessment Guide External Hazards NS-TAST-GD-013 and Guidance to Requesting Parties.

My GDA Step 2 assessment work has involved continuous engagement with the RP in the form of technical exchange workshops and progress meetings, including meetings with the plant designers.

The UK HPR1000 PSR is primarily based on the Reference Design, Fangchenggang Unit 3 (FCG3), which is currently under construction in China. Key aspects of the UK HPR1000 preliminary safety case related to external hazards, as presented in the PSR, its supporting references and the supplementary documents submitted by the RP, can be summarised as follows:

- A preliminary Generic Site Envelope has been developed for the UK HPR1000 GDA, including external hazard values
- The external hazards scope of the UK HPR1000 GDA has been developed, including screening of hazards
- External hazard claims and methodologies have been developed for the major hazards in GDA scope

During my GDA Step 2 assessment of the UK HPR1000 aspects of the safety case related to external hazards I have identified the following areas of strength:

- Good progress has been made in the definition of GDA scope for external hazards
- The claims and outline approach towards the external hazards safety case are well developed
- An agreed resolution plan to the Regulatory Observation RO-UKHPR1000-0002 has been produced

During my GDA Step 2 assessment of the UK HPR1000 aspects of the safety case related to external hazards I have identified areas that require follow-up. These are detailed by topic in the report and will be included in my Assessment Plan for UK HPR1000 GDA Step 3. I have identified the following general areas that require follow up:

- For site licensing external hazards which have been screened out of GDA scope, the RP should provide confidence that the design will, in principle, be able to consider and mitigate them to provide an As Low As Reasonably Practicable (ALARP) design solution for these hazards. This may include protection concepts for the design.
- The suitability of the Generic Site Envelope and UK HPR1000 design should be addressed through the resolution of RO-UKHPR1000-0002. As further site characterisation information becomes available from Bradwell B the Generic Site Envelope values should be revisited to ensure a suitable GDA is achieved by the UK HPR1000 design basis bounding the site values.
- The approach to combinations of hazards including those which the RP deem to be site-specific will need to be clarified and justified in future generic safety case submissions.
- The RP's approach to beyond design basis hazards should be developed and applied to external hazards systematically.
- The aircraft crash safety case approach will need to be clarified in future Steps, including the hazard definition and Systems, Structures and Components (SSC) response.
- The RP's treatment of climate change in the meteorological external hazards should be clarified. The meteorological hazards which are subject to climate change should be clarified.
- Assessment of the Categorisation and Classification related to external hazards, including the seismic classification of SSCs should be undertaken when the Categorisation and Classification methodology is implemented on UK HPR1000.

During my GDA Step 2 assessment, I have not identified any fundamental safety shortfalls in the area of external hazards that might prevent the issue of a Design Acceptance Confirmation (DAC) for the UK HPR1000 design.

LIST OF ABBREVIATIONS

AIMDWG	Aircraft Impact Multi-disciplinary working group
ALARP	As Low As Reasonably Practicable
APC	Aeroplane Crash
BDA	Emergency Diesel generator Building A
BDB	Emergency Diesel generator Building B
BDC	Emergency Diesel generator Building C
BDU	SBO Diesel Generator Building
BDV	SBO Diesel Generator Building
BEJ	Extra Cooling System and Fire-fighting system building
BFX	Fuel Building
BMS	Business Management System
BNX	Nuclear Auxiliary Building
BRX	Reactor Building
BSA	Safeguards Building A
BSB	Safeguards Building B
BSC	Safeguards Building C
BWX	Radioactive Waste Treatment Building
CCI	Commercially confidential information
CGN	China General Nuclear Power Corporation
CR	Contact Record
DAC	Design Acceptance Confirmation
DBE	Design Basis Earthquake
DMGL	Delivery Management Group Lead
EA	Environment Agency
EDF	Électricité de France
EMI	Electromagnetic Interference
FCG3	Fangchenggang Nuclear Power Plant Unit 3
GDA	Generic Design Assessment
GNI	General Nuclear International
GNS	Generic Nuclear System Ltd
HPR1000	Hualong Pressurized Reactor
HVAC	Heating, Ventilation and Air Conditioning System
IAEA	International Atomic Energy Agency
LUHS	Loss of Ultimate Heat Sink
N/A	Not applicable
NRC	Nuclear Regulatory Commission
ONR	Office for Nuclear Regulation
PCSR	Pre-Construction Safety Report
PSA	Probabilistic Safety Analysis
PSR	Preliminary Safety Report (includes security and environment)
RGP	Relevant Good Practice

RO	Regulatory Observation
RP	Requesting Party
RQ	Regulatory Query
RRI	Component Cooling Water System[CCWS]
SAP(s)	Safety Assessment Principle(s)
SBO	Station Blackout
SEC	Essential Service Water System
SNI	Sensitive Nuclear Information
SSC	Systems Structures and Components
SSE1	Safe Shutdown Earthquake 1
SSE2	Safe Shutdown Earthquake 2
TAG	Technical Assessment Guide(s)
TSC	Technical Support Contractor
UK	United Kingdom of Great Britain and Northern Ireland
WENRA	Western European Nuclear Regulators' Association

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1 INTRODUCTION

1. The Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA) process calls for a step-wise assessment of the Requesting Party's (RP) safety submission with the assessments increasing in detail as the project progresses. General Nuclear System Ltd (GNS) has been established to act on behalf of the three joint requesting parties (China General Nuclear Power Corporation (CGN), Électricité de France (EDF) and General Nuclear International (GNI)) to implement the GDA of the UK HPR1000 reactor. For practical purposes GNS is referred to as the 'UK HPR1000 GDA Requesting Party'.

2. During Step 1 of GDA, which is the preparatory part of the design assessment process, the RP established its project management and technical teams and made arrangements for the GDA of the UK HPR1000 reactor. Also, during Step 1 the RP prepared submissions to be assessed by ONR and the Environment Agency (EA) during Step 2.

3. Step 2 commenced in November 2017. Step 2 of GDA is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including ONR's assessment of key nuclear safety and nuclear security claims (or assertions). The aim is to identify any fundamental safety or security shortfalls that could prevent ONR permitting the construction of a power station based on the design.

4. My assessment has followed my GDA Step 2 Assessment Plan for External Hazards (Ref. 1) prepared in October 2017 and shared with GNS to maximise openness and transparency.

5. This report presents the results of my External Hazards assessment of the UK HPR1000 as presented in the UK HPR1000 Preliminary Safety Report (PSR) (Ref. 2 chapters 3 and 18) and its supporting documentation.

2 ASSESSMENT STRATEGY

6. This section presents my strategy for the GDA Step 2 assessment of the External Hazards aspects of the UK HPR1000 (Ref 1). It also includes the scope of the assessment and the standards and criteria I have applied.

2.1 Scope of the Step 2 External Hazards Assessment

7. In accordance with the assessment plan, the objective of my GDA Step 2 assessment was to assess relevant design concepts and claims made by the RP related to External Hazards. In particular, my assessment has focussed on the following:

- Identification, screening and evaluation of external hazards and development of the design basis, including external hazard combinations.
- Definition of the Generic Site Envelope.
- Identification of safety requirements, categorisation and classification and seismic categorisation.
- Strategy for protection against each external hazard to protect safety functions.

8. During GDA Step 2 I have also evaluated whether the safety claims related to External Hazards are supported by a body of technical documentation sufficient to allow me to proceed with GDA work beyond Step 2.

9. Finally, during Step 2 I have undertaken to following preparatory work for my Step 3 assessment:

- Further familiarisation with aspects of the UK HPR1000 design.
- Engagement with the RP regarding the planned submissions for the remaining GDA Steps.
- Review of methodology reports for external hazards.
- A course review of an early version of the Pre-Construction Safety Report.

2.2 Standards and Criteria

10. For ONR, the primary goal of the GDA Step 2 assessment is to reach an independent and informed judgment on the adequacy of a preliminary nuclear safety and security case for the reactor technology being assessed. Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) guide NS-PER-GD-014 (Ref. 3).

11. In addition, the Safety Assessment Principles (SAPs) (Ref. 4) constitute the regulatory principles against which duty holders' and RP's safety cases are judged. Consequently the SAPs are the basis for ONR's nuclear safety assessment and have therefore been used for the GDA Step 2 assessment of the UK HPR1000. The SAPs 2014 Edition is aligned with International Atomic Energy Agency (IAEA) standards and guidance.

12. Furthermore, ONR is a member of the Western European Nuclear Regulators' Association (WENRA). WENRA has developed Reference Levels, which represent good practices for existing nuclear power plants, and Safety Objectives for new reactors.

13. The relevant SAPs, IAEA standards and WENRA reference levels are embodied and expanded on in the Technical Assessment Guides (TAGs) on External Hazards as TAG13 (Ref. 5). This provides the principal means for assessing the External Hazards aspects in practice.

2.2.1 Safety Assessment Principles

14. The key SAPs (Ref. 4) applied within my assessment are SAPs EHA.1, EHA.3, EHA.6, EHA.7, EHA.8, EHA.9, EHA.11, EHA.18, EHA.19 (see also Table 1 for further details).

2.2.2 Technical Assessment Guides

15. The following Technical Assessment Guides have been used as part of this assessment (Ref. 5):

- ONR-TAST-GD-013 External Hazards Revision 6

2.2.3 Guidance to Requesting Parties

16. ONR publishes Guidance to Requesting Parties (Ref. 6). This provides guidance on the structure and assessment of the GDA. This assessment has used the Guidance to Requesting Parties to assess the submissions relating to the generic site envelope where it relates to external hazards. This guidance is provided in Section 3 and Appendix 3 of Ref. 6.

2.2.4 National and International Standards and Guidance

- IAEA references (Ref.7):
  - IAEA Fundamental Safety Principles Series No. SF-1, 2006. ISBN:92-0-110706-4
  - IAEA Specific Safety Requirements Series No. SSR-2/1 Safety of Nuclear Power Plants: Design, 2012. ISBN:978-92-0-121510-9
  - IAEA Safety Guide Safety Standards Series No. NS-G-1.5- External Events Excluding Earthquakes in the Design of Nuclear Power Plants
  - IAEA Safety Guide Safety Standards Series No. NS-G-1.6 - Seismic Design and Qualification for Nuclear Power Plants Safety Guide
  - IAEA Safety Guide Safety Standards Series No. NS-G-3.1 - External Human Induced Events in Site Evaluation for Nuclear Power Plants
  - IAEA Safety Guide Safety Standards Series No. NS-G-3.3 - Evaluation of Seismic Hazards for Nuclear Power Plants Safety Guide
  - IAEA Safety Guide Safety Standards Series No. NS-G-3.4 - Meteorological Events in Site Evaluation for Nuclear Power Plants Safety Guide
  - IAEA Safety Guide Safety Standards Series No. NS-G-3.5 - Flood Hazard for Nuclear Power Plants on Coastal and River Sites Safety Guide

- WENRA references (Ref. 8):
  - Natural Hazards Guidance on Seismic Events (October 2016)
  - Natural Hazards Guidance on External Flooding (October 2016)
  - Natural Hazards Guidance on Extreme Weather Conditions (October 2016)
  - Reactor Safety Reference Levels (January 2008)
  - Safety Objectives for New Power Reactors (December 2009) and Statement on Safety Objectives for New Nuclear Power Plants (November 2010)
  - Statement on Safety Objectives for New Nuclear Power Plants (March 2013) and Safety of New NPP Designs (March 2013)

2.3 Use of Technical Support Contractors

17. During Step 2 I have not engaged Technical Support Contractors (TSCs) to support the assessment of External Hazards for the UK HPR1000.

2.4 Integration with Other Assessment Topics

18. Early in GDA, I recognised the importance of working closely with other inspectors (including Environment Agency's inspectors) as part of the External Hazards assessment process. Similarly, other inspectors sought input from my assessment of the External Hazards for the UK HPR1000. I consider these interactions are key to the success of the project in order to prevent or mitigate any gaps, duplications or inconsistencies in ONR's assessment. From the start of the project, I have endeavoured to identify potential interactions between the External Hazards and other technical areas, with the understanding that this position will evolve throughout the UK HPR1000 GDA project.

19. The key interactions I have identified are:

- Civil Engineering: provides input to the aircraft crash, seismic and some elements of the Generic Site Envelope aspects of the External Hazards assessment. This formal interaction has commenced during GDA Step 2. This work is being coordinated with the Civil Engineering Inspector, with External Hazards leading on the accidental aircraft crash and civil engineering leading on the malicious aircraft crash.
- Internal Hazards: provides input to the hazard screening and hazard combinations aspects of the External Hazards assessment. This formal interaction has commenced during GDA Step 2. This work is being undertaken jointly between myself and the Internal Hazards Inspector.
- Probabilistic Safety Assessment (PSA): I have provided input to the hazard screening aspects of the External Hazards PSA. This formal interaction has commenced during GDA Step 2. This work is being led by the PSA inspector with input from myself.
- Fault Studies: the plant response to external hazards and faults initiated by external hazards should be captured in the Fault Schedule, I am coordinating with the fault studies inspector to ensure consistency of approach.

3 REQUESTING PARTY'S SAFETY CASE

20. During Step 2 of GDA the RP submitted a PSR (Ref. 2) and other supporting references, which outline a preliminary nuclear safety case for the UK HPR1000. This section presents a summary of the RP's preliminary safety case in the area of External Hazards. It also identifies the documents submitted by the RP which have formed the basis of my External Hazards assessment of the UK HPR1000 during GDA Step 2. All documentation from the RP has been submitted in Step 2.

3.1 Summary of the RP's Preliminary Safety Case in the Area of External Hazards

21. The aspects covered by the UK HPR1000 preliminary safety case in the area of External Hazards can be broadly grouped under two headings which can be summarised as follows:

22. External Hazards: The RP's claims with regard to External Hazards are that:

- A design basis external hazard event will not prevent the delivery of the fundamental safety functions
- The likelihood and consequence of an off-site release is limited, and the safety assessment will demonstrate that the risk is ALARP
- There will be an absence of cliff-edge effects just beyond the design basis external hazards

23. Generic Site Envelope: The RP's claims with regard to the Generic Site Envelope are that:

- The generic site characteristics for suitable UK sites will be identified
- The design will be shown to be suited to the generic site characteristics

24. The RP has provided, through the PSR and supporting references, an outline of the external hazards case and a proposed Generic Site Envelope. The PSR is based upon the Reference Plant Fanchenggang 3 (FCG3), the reference design has not been amended to reflect UK requirements or conditions.

25. The assessment section of this report includes outline information on the topic being assessed to provide context for the conclusions reached.

3.2 Basis of Assessment: RP's Documentation

26. The RP's documentation that has formed the basis for my GDA Step 2 assessment of the safety claims related to the External Hazards aspects of the UK HPR1000 is presented in:

- Preliminary Safety Report Chapter 3 Generic Site Characteristics (Ref. 2)
- Preliminary Safety Report Chapter 18 External Hazards (Ref. 2)
- Generic Site Report (Ref. 9)
- The General Requirements Of Protection Design Against Internal And External Hazard (Ref. 10)
- The Identification And Screen Process Report Of Internal And External Hazard (Ref. 11)
- Methodology reports (Refs. 12)
  - Tornado Safety Evaluation Methodology Report
  - Explosion Safety Evaluation Methodology Report
  - Earthquake Safety Evaluation Methodology Report
  - Flood Safety Evaluation Methodology Report
  - Methodology of External Hazards PSA
  - Aircraft Crash Safety Evaluation Methodology Report

- RP responses to Regulatory Queries (RQs) (Ref. 13)
  - RQ-UKHPR1000-0008 Definition and applicability of the Generic Site Envelope (external hazards)
  - RQ-UKHPR1000-0009 Screening and treatment of specific external hazards in GDA step 2 (external hazards)
  - RQ-UKHPR1000-0087 Aircraft Impact Assessment Safety Case Strategy
  - RQ-UKHPR1000-0096 Ground Bearing Capacity
  - RQ-UKHPR1000-0112 Clarification from workshop
  - RQ-UKHPR1000-0126 Location of feed and steam systems (external hazards)
- Resolution plan for Regulatory Observation (RO) RO-UKHPR1000-0002 Demonstration that the UK HPR1000 Design is Suitably Aligned with the Generic Site Envelope (Ref. 14)

27. My assessment of the documentation has focussed on the following aspects, which align with the ONR SAPs relevant to the External Hazards topic in Step 2 of GDA:

- Identification and characterisation of external hazards
- Screening of external hazards
- Definition of generic site characteristics
- Analysis of external hazards that could affect safety, including combinations of hazards
- Beyond design basis events and cliff-edge effects
- Aircraft crash
- Earthquakes
- Electromagnetic interference
- Meteorological hazards
- Flooding
- Man-made hazards
- Biological hazards

28. In addition, during April 2018 GNS submitted to ONR, for information, an advance copy of the UK HPR1000 Pre-Construction Safety Report (PCSR). Chapters 3 and 18 (Ref. 15) which address generic site characteristics and external hazards respectively, this structure is consistent with that of the PSR. Having early visibility of the scope and content of these chapters has been useful in the planning and preparation of my GDA Step 3 assessment work. These advanced copies of the PCSR chapters have not been formally assessed during Step 2 of GDA and therefore do not form an input to my assessment.

4 ONR ASSESSMENT

29. This assessment has been carried out in accordance with HOW2 guide NS-PER-GD-014, “Purpose and Scope of Permissioning” (Ref.3).

30. My Step 2 assessment work has involved regular engagement with the RP’s External Hazards specialists, ie, two Technical Exchange Workshops (one in China and one in the UK (Ref. 16)) and four Level 4 routine progress meetings have been held (Refs.16). I have also conducted regular informal progress calls with the RP.

31. During my GDA Step 2 assessment, I have identified some gaps in the documentation formally submitted to ONR. Consistent with ONR’s Guidance to Requesting Parties (Ref. 6), these normally lead to Regulatory Queries (RQs) being issued. At the time of writing my assessment report, in External Hazards during Step 2, I have raised five RQs (Ref. 13) to facilitate my assessment.

32. Similarly, and again consistent with ONR’s Guidance to Requesting Parties (Ref. 6), more significant shortfalls against regulatory expectations in the generic safety case are captured by issuing Regulatory Observations (ROs). At the time of writing my assessment report in External Hazards topic, during Step 2, I have raised one RO comprising the following:

    - RO-UKHPR1000-002 – Demonstration that the UK HPR1000 Design is Suitably Aligned with the Generic Site Envelope (Ref. 17)

33. The complete list of ROs raised by ONR during Step 2 is recorded in Reference 18.

34. Details of my GDA Step 2 assessment of the UK HPR1000 preliminary safety case in the area of External Hazards, including the conclusions I have reached, are presented in the following sub-sections of the report. This includes the areas of strength I have identified, as well as the items that require follow-up during subsequent Steps of the GDA of UK HPR1000.

4.1 Identification And Characterisation Of External Hazards

4.1.1 Assessment

35. The RP has developed a hazard identification and screening methodology during Step 2, and applied it to produce a complete list of internal and external hazards which are to be considered in GDA. This methodology is described in the Identification and Screen process report of internal and external hazards (Ref.19). Due to the development of the methodology during Step 2, this report supplements and, in parts, supersedes the information provided in PSR Chapter 18 (Ref. 2), this is expected as the PSR describes Fanchenggang 3 without providing UK context.

36. I have assessed this information against SAP EHA.1 - Identification and Characterisation. The list of external hazards to be considered in the UK HPR1000 GDA before screening is derived from a comprehensive review of international guidance and previous GDAs. The RP has compiled a consolidated list of external hazards from IAEA, NRC, WENRA, ONR and previous GDA lists of external hazards. The external hazards identified have been further consolidated into hazard groups.

37. This has resulted in the scope of external hazards to be considered by the RP in GDA being extended from that considered for Fanchenggang 3 and originally presented in PSR chapter 18. This enhanced list has been adopted by the RP as the basis of the hazard screening.

38. I am content that a suitable external hazard identification process has been undertaken to provide the input for the screening of hazards for applicability to UK HPR1000 and for the definition of scope of GDA. The external hazards are defined in accordance with ONR definition and international practice. The definition of internal and external hazards is in accordance with ONR definition in the SAPs.

39. During my Step 2 assessment I have liaised closely with the ONR's Internal Hazards inspector in considering the identification and screening of external hazards as the process is common between the two topic areas. The outcome of the Step 2 assessment of Internal Hazards is captured in the corresponding assessment report (Ref. 20).

4.1.2 Strengths

40. During my GDA Step 2 assessment of the identification and characterisation of external hazards I have noted the following areas of strength:

- A comprehensive hazard identification exercise has been completed by the RP, based on international and UK sources of RGP. This has resulted in a robust and well underpinned set of external hazards being identified for the UK HPR1000 design.

4.1.3 Items that Require Follow-up*

41. During my GDA Step 2 assessment of the identification and characterisation of external hazards I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- As the detail of the external hazards within the generic safety reports develops, the RP must ensure that the definition, design bases and grouping of external hazards remains appropriate.

4.1.4 Conclusions

42. Based on the outcome of my Step 2 assessment of the identification and characterisation of external hazards, I have concluded that the RP has undertaken a comprehensive external hazard identification process by considering appropriate international and UK guidance. This identification is taken forward in to the hazard screening process. I am content that the external hazard identification process is appropriate for use in the future External Hazards safety reports for UK HPR1000.

4.2 Screening Of External Hazards

4.2.1 Assessment

43. The RP's external hazard identification and screening process is presented in Ref. 19. I have assessed this document and the output of the RP's external hazards screening. The final list of hazards to be taken forward to GDA and site-specific analysis for UK HPR1000 has been derived through the screening process and communicated to ONR (Ref.16 May workshop). The RP's proposal for those external hazards to be considered in GDA is contained in the GDA scope report (Ref. 21).

* *All the items identified in Step 2 as important to be followed up should be included in ONR's GDA Step 3 External Hazards Assessment Plan for the UK HPR1000*

44. During Step 2 the screening of external hazards for the UK HPR1000 GDA has been presented to ONR through level 4 interactions (Ref. 16) and response to an RQ (Ref. 13 RQ-UKHPR1000-0009). The screening results to be taken forward into the PCSR are contained in Table 2.

45. I have assessed the results of the screening against SAP EHA.19 – Screening. Two external hazards have been screened out of GDA and are proposed to be screened out of site licensing: meteorites and volcanic action (excluding volcanic ash). This is consistent with the approach taken by other Requesting Parties and duty holders (Ref. 22).

46. I have considered the results of the RP's screening for the division of external hazards between GDA and site licensing by considering the ONR Guidance to Requesting Parties (Ref. 6) and the suitability in delivering GDA. I am content that the external hazards identified and screened in to the scope of GDA are suitable for consideration in GDA and in accordance with the expectations of SAP EHA.1 and EHA.19.

47. For the hazards screened out of detailed consideration in GDA but required for consideration in site licensing, I am content that the result is reasonable as they are one of:

- The local source of a hazard which is considered in GDA (eg storm surge to flooding)
- A site-specific contributor to a fault which is considered in GDA (eg biological fouling leading to Loss of Ultimate Heat Sink (LUHS))
- The protection is provided by site-specific design (eg groundwater levels,)
- Dependant on the site-specific local environment (eg local industrial facilities and transport)

48. While it is suitable to screen out of detailed consideration the site-specific external hazards it is important during GDA that the RP provides confidence that the UK HPR1000 generic design is suitable for deployment in the UK. I will therefore expect that for site-specific external hazards, detailed analysis is not provided, but confidence is gained that the generic design has considered the external hazard and the risk associated with the external hazards will not be disproportionate, or suitable mitigation measures are available for consideration on an ALARP basis. This may include design options or protection concepts[†] which will be considered during site-specific design.

4.2.2 Strengths

49. During my GDA Step 2 assessment of screening of external hazards I have noted the following areas of strength:

- The development of a hazards screening methodology during Step 2 has been facilitated by good engagement between the RP and ONR.
- The derivation of the external hazards identification and screening during Step 2 has provided confidence that appropriate external hazards can be adequately considered in the UK HPR1000 generic design and provides clarity on the scope of GDA for subsequent Steps.

[†] *"Protection concept" is used in accordance with the WENRA definition "A protection concept, describes the overall strategy followed to cope with natural hazards. It shall encompass the protection against design basis events and events exceeding the design basis." (Ref. 8)*

4.2.3 Items that Require Follow-up

50. During my GDA Step 2 assessment of screening of external hazards I have identified the following additional potential shortfalls that I include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- For external hazards which have been screened out of GDA scope, to be considered in site licensing; the RP should include potential faults initiated by these external hazards in fault studies and specify in the fault schedule where appropriate. For example, while a detailed analysis of heat sink clogging is considered as required for site licensing[‡] the faults associated with Loss of Ultimate Heat Sink (LUHS) and the plant response should be included in GDA.
- For site licensing external hazards which have been screened out of GDA scope, the RP should provide confidence that the design will, in principle, be able to consider and mitigate them to provide an ALARP design solution for these hazards. This may include protection concepts for the design.

4.2.4 Conclusions

51. Based on the outcome of my Step 2 assessment of screening of external hazards , I judge the hazard identification and screening in GDA Step 2 to have derived an appropriate set of significant external hazards in a logical manner. I am content that the external hazards identified for the GDA scope reflect the areas of likely risk from external hazards and those which can reasonably be presented in a generic safety case.

52. For the site licensing external hazards that have been screened out from detailed consideration in GDA the RP should provide confidence that the UK HPR1000 generic design will, in principle, be able to mitigate these hazards to the point where associated risks are likely to be ALARP.

4.3 Definition Of Generic Site Characteristics

4.3.1 Assessment

53. The RP has defined a Generic Site Envelope for Step 2 in the Generic Site Report (Ref. 9). The definition of a Generic Site Envelope is required, as detailed in the ONR Guidance to Requesting Parties (Ref. 6). I have assessed the Generic Site Envelope against the relevant sections of the Guidance to Requesting Parties, and SAPs EHA.2 – Data sources and EHA.3 – Design basis events.

54. I have assessed the aspects of the Generic Site Report relevant to External Hazards. The screening aspects of the Generic Site Report has been superseded by later document The Identification and Screen Process of Internal and External Hazards (Ref. 19), I have not assessed the screening information in the Generic Site Report, see section 4.2 for assessment of the updated information.

55. The external hazards values defined in the Generic Site Report remain current and have been assessed accordingly. The RP has defined a set of external hazard magnitude values; these have been derived by a combination of; selecting a value from available data from Bradwell, Hinkley Point and Sizewell sites, calculating a value, or making a judgement. The values are presented as representative of the potential build site for UK HPR1000 at Bradwell B in Essex. The Generic Site Envelope values are reproduced in Table 4.

[‡] *As defined in Table 2*

Generic Site Envelope Values

56. The intent of the Generic Site Envelope is to define a suitable generic site to demonstrate that a design submitted for GDA will be suitable for construction on a variety of sites within Great Britain (Ref. 6). If a subsequent site licence application is made for a site which has characteristics bounded by the generic site envelope then the time taken for ONR's licensing assessment will be minimised.

57. The external hazards parameters presented in the Generic Site Envelope and the magnitude are reproduced in table 4.

58. During my assessment I have sought to gain confidence that the Generic Site Envelope is suitably defined by:

- Considering the appropriateness of the parameter list and the logic of its derivation
- Comparing the values selected to those of existing licensees and previous GDA Generic Site Envelopes

59. Due to the early stage of the External Hazards case it is not possible to make a formal judgment on the adequacy of the values selected. The values will be given greater context in future Steps as the External Hazards case develops and:

- the margin to safety between the Generic Site Envelope value and UK HPR1000 design is clearer
- site investigation studies for the Bradwell site are completed to support the bounding character of the Generic Site Envelope.

60. I have compared the Generic Site Envelope values to those of existing licensees and previous GDA Generic Site Envelopes (Ref. 22). Based on this benchmarking exercise I am content that most of the parameter values are within the range previously considered in GDA or bound the values previously considered in GDA, with two exceptions:

- The Rainfall (1 hour) value is the lowest used in a Generic Site Envelope, even with the climate change consideration. It is also lower than sites characterised for new nuclear build
- The Rainfall (24 hour) value is the lowest used in a Generic Site Envelope, even with the climate change consideration, it is also lower than sites characterised for new nuclear build

61. It is therefore not clear that the Generic Site Envelope values for rainfall will be bounding for a potential site. This is not critical for Step 2 as the response to rainfall depends largely on the site layout and drainage strategy, which are aspects of the site-specific design.

62. The RP should provide an adequate justification as to why the selection of Generic Site Envelope rainfall values less onerous than previous GDAs and new nuclear build sites is suitable for UK HPR1000. The RP should select the Generic Site Envelope to demonstrate that the UK HPR1000 generic design will be suitable for construction on a variety of sites within Great Britain.

63. An RQ (Ref. 13 RQ-UKHPR1000-0096) has been raised by the civil engineering inspector on the value and methodology for the Generic Site Envelope ground bearing capacity; this is discussed further in the civil engineering assessment report (Ref. 23). If changes to the ground bearing capacity are required to accurately reflect the potential sites then any consequential changes to the seismic response of the ground will be of interest to the External Hazards topic.

Generic Site Envelope Parameters

64. In the Generic Site Report the RP has identified information gaps and their target resolution timescales as below:

- Determine shear wave velocity value for use in GDA – Step 2
- Determine generic parameters for values to allow conventional impact assessment to undertaken – Step 3
- Review climate change figures once guidance is updated – Step 2
- Further determine flooding requirements for GDA – Step 2
- Further determine accidental aircraft crash requirements for GDA – Step 2

65. The information gaps identified as being closed during Step 2 have not been closed by formal submissions. The RP has provided updates on progress in some areas informally. The gaps do not impact on my ability to complete this assessment but they will require closure by future submissions or document updates during Step 3.

66. I am content that, subject to the above gaps being closed, the Generic Site Envelope is defined in accordance with the GDA External Hazards scope presented by the RP for Step 2.

Comparison of Generic Site Envelope And Fanchenggang 3

67. In comparing the Generic Site Envelope and the UK HPR1000 External Hazards design as detailed in the PSR (Ref. 2 Chapter 18) during Step 2 I have raised a Regulatory Observation (RO) (Ref. 17) on the topic of External Hazards against the definition and applicability of the Generic Site Envelope. The RO identifies that the design parameters for Fanchenggang 3 (FCG3) contained in the PSR (Ref. 2 ch18) do not all bound the Generic Site Envelope values presented in the Generic Site Report (Ref. 9). Also some external hazards screened in to GDA have not been considered in Fanchenggang 3.

68. The information submitted meant that I had insufficient information to form a judgement on the likely impact on the UK HPR1000 design due to the differences in external hazards design basis assumed for FCG 3 and the Generic Site Envelope, and hence UK HPR1000's suitability for deployment in the UK.

69. The RP has produced a RO resolution plan (Ref. 13) which commits to provide:

- External hazards gap identification and evaluation report;
- External hazards gap resolution strategy report;
- Heating, Ventilation and Air Conditioning System (HVAC) systems analysis report;
- Structural analysis and design report;
- Seismic analysis for structure report;
- Control & Instrumentation System protection design against space weather report;
- Electrical Power System protection design against space weather report;
- Essential Service Water System (SEC) / Component Cooling Water System (RRI) system analysis report;
- Modification of UK HPR1000 design for external hazards summary report.

70. The RP has preliminarily identified the main gaps in table 3.

71. The RO resolution plan has been accepted by ONR and published on the ONR website (Ref.24). I am content that the RO resolution plan demonstrates RP's understanding of the RO and contains a credible plan to deliver resolution during GDA. As this topic is the subject of a RO which is being delivered against the agreed plan I have made no further assessment of this aspect of the design at this stage. The closure of the RO will require separate assessment during future GDA Steps.

4.3.2 Strengths

72. During my GDA Step 2 assessment of the definition of generic site characteristics I have noted the following areas of strength:

- The early scoping and definition of the Generic Site Envelope is welcomed and has enabled early identification of the discrepancy between the Generic Site Envelope and Fanchenggang 3. The agreement during Step 2 of a plan to close this discrepancy is positive and provides confidence that the RO can be addressed in a timely manner. Resolution of RO-UKHPR1000-0002 may include the requirement to modify the UK HPR1000 design.

4.3.3 Items that Require Follow-up

73. During my GDA Step 2 assessment of the definition of generic site characteristics I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- The RP has committed to updating the Generic Site Report to reflect the development of the hazard screening. This will be of value early in Step 3 and I will discuss with the RP through routine Level 4 interactions.
- Assessment of the adequacy of the RP's submissions to address the gaps identified in RO-UKHPR1000-0002. This will require multi-disciplinary assessment.
- Gaps requiring further work are identified by the RP in the Generic Site Report, these require closure and confidence in the timescale of closure:
  - Determine shear wave velocity value for use in GDA
  - Determine generic parameters for values to allow conventional impact assessment to undertaken
  - Review climate change figures once guidance is updated
  - Further determine flooding requirements for GDA
  - Further determine accidental aircraft crash requirements for GDA
- As further site characterisation information becomes available from Bradwell B the Generic Site Envelope values should be revisited to ensure a suitable GDA is achieved by the UK HPR1000 design basis bounding the site values. A detailed justification of the site characterisation will only be required for site licensing.
- The RP should provide justification as to why the Generic Site Envelope rainfall values are suitable, given that the values presented in Step 2 are less onerous than previous GDAs and new build sites.

4.3.4 Conclusions

74. The RP has provided a Generic Site Envelope which aligns with the defined GDA scope. I have raised RO-UKHPR1000-0002 in response to discrepancies between the Generic Site Envelope and Fanchenggang 3 reference design, the resolution plan for which has been agreed.

75. The values of the Generic Site Envelope parameters will require further justification as the External Hazards case develops. Information from site characterisation work on the Bradwell B site may be referenced in future GDA Steps.

4.4 Analysis of external hazards and combinations of hazards

76. This section covers various generic aspects of external hazards analysis followed by more detailed consideration of specific hazards or hazard groups.

4.4.1 Assessment

Analysis of External Hazards

77. The RP has not provided analysis of the effects of external hazards on Systems Structures and Components (SSCs) or plant safety. It is therefore not possible to perform as assessment against EHA.6 at this stage. Methodology reports (Ref. 12) have been submitted for:

- Tornado Safety Evaluation Methodology Report
- Explosion Safety Evaluation Methodology Report
- Earthquake Safety Evaluation Methodology Report
- Flood Safety Evaluation Methodology Report
- Methodology of External Hazards PSA May
- Aircraft Crash Safety Evaluation Methodology Report

78. These have been discussed with the RP (Ref. 16 Shenzhen workshop) but are not suitable for assessment at this time. The methodologies provide a commitment from the RP that the relevant external hazards will be assessed in GDA and that the design of UK HPR1000 may have to be modified to satisfy the analysis. The methodologies are not sufficiently detailed for me to be able to form an opinion on the adequacy of the analysis that will be performed. This does not affect the completeness of this assessment; the results of the analysis will be submitted and assessed in future steps of GDA.

Combinations of Hazards Methodology

79. The approach towards combinations of hazards has been presented by the RP in The General Requirements of Protection Design Against Internal and External Hazards (Ref. 10) and Identification and Screening Process of Internal and External Hazards (Ref. 19).

80. Combinations of hazards are considered as:

- consequential hazards
- correlated hazards
- independent hazards

81. The RP's document delivery schedule identifies a Combined Hazards Safety Evaluation Methodology Report which is due to be provided following the assessment of Step 2 but before entry to Step 3.

82. I consider that the RP's approach towards combinations of external hazards is suitable for Step 2 of GDA. The details of the external hazard combinations which require consideration in GDA can only be determined once the approach to external hazards and the margins to safety are further understood. It is therefore not possible to provide an assessment of the preliminary results of the external hazard combinations. I welcome the RP's early consideration of hazard combinations.

83. Detailed assessment of the combination of external hazards leading to internal hazards is also not yet possible due to the early stage of External Hazards safety case and the absence of a fixed scope for GDA on internal hazards. I welcome the early consideration of this topic by the RP and the high level claim that such combinations will be considered.

4.4.2 Strengths

84. During my GDA Step 2 assessment of analysis and combinations of hazards I have noted the following areas of strength:

- The RP beginning to consider hazard combinations during Step 2 is welcomed, providing confidence that it is within the scope of future GDA Steps.

4.4.3 Items that Require Follow-up

85. During my GDA Step 2 assessment of analysis and combinations of hazards I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- Analysis of external hazards and combinations of hazards will be required during GDA Step 3. This is expected to be included in the RP's programme of submissions to ONR for GDA Step 3.
- The approach to combinations of hazards including those which the RP deem to be site-specific will need to be clarified and justified in future generic safety case submissions.

4.4.4 Conclusions

86. The RP has provided high level claims that external hazards will be studied for the plant response and that combinations of hazards will be considered. For my Step 2 assessment I am satisfied with these claims and expect greater detail to be provided in future Steps.

4.5 Beyond Design Basis Events And Cliff-Edge Effects

4.5.1 Assessment

87. During GDA Step 2, the RP has not presented detailed information on the approach towards considering beyond design basis external hazards. One high level claim is included in the RP's Principles Of Hazards Protection (Ref. 10 §5.1)

- The protection design measures should ensure that there is no cliff-edge effect.

88. Within the General Requirements Document (Ref. 10) some external hazards include a brief consideration of what a suitable beyond design basis external hazards approach may entail. There is, however, insufficient detail to enable a detailed assessment to be undertaken. The General Requirements Document provides confidence that the RP plans to address this important topic in the generic safety case.

89. The RP's specific external hazard evaluation methodology reports each include a section on cliff-edge effects (Ref.12). This is beneficial in gaining confidence in the UK HPR1000 response just beyond design basis but does not address the margin to failure or significantly beyond design basis events.

90. During my Level 4 interactions with the RP we have discussed the ONR expectations for beyond design basis events, including margins to failure and cliff-edge effects (Ref. 16 May 2018). Based on these discussions, I am reassured that the RP is actively considering its approach to this topic but no formal submission yet exists. This will form part of future GDA interactions and assessment.

91. Detailed assessment of beyond design basis external hazards and cliff-edge effects against SAPs EHA.18 and EHA.7 is not yet possible due to the early stage of External Hazards safety case.

92. The approach to beyond design basis and cliff-edge effects will need to be developed during future GDA Steps. The consideration of beyond design basis will also require consideration in the PSA.

4.5.2 Strengths

93. During my GDA Step 2 assessment of beyond design basis events and cliff-edge effects I have noted the following areas of strength:

- Early acknowledgement and engagement by the RP on the topic of beyond design basis external hazards.

4.5.3 Items that Require Follow-up

94. During my GDA Step 2 assessment of beyond design basis events and cliff-edge effects I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- The RP's approach to beyond design basis hazards should be developed and applied to external hazards systematically.
- Consideration of beyond design basis hazards should include both deterministic and probabilistic assessment.

4.5.4 Conclusions

95. No details have been provided on the approach to beyond design basis external hazards but discussions have demonstrated that the RP is preparing an approach.

4.6 Aircraft Impact

4.6.1 Assessment

96. The UK HPR1000 aircraft protection approach and results have not been presented in detail in the Step 2 submissions. The overall philosophy has been provided by the RP in response to an RQ (Ref. 13 RQ-UKHPR1000-0112). The UK HPR1000 is protected by two aircraft impact shells; Category I shell provides protection against design basis accidental aircraft loads, Category II shell provides protection against loads associated with malicious aircraft impact, which the RP defines as a beyond design basis hazards. The aircraft shells provide protection for all SSCs important to safety. The RP defines the aircraft impact design basis as the load from two defined light aircraft impact (Ref. 10 fig 5.3.3-1). Other aircraft types are considered as a beyond design basis threat.

97. Category I protection is provided to:

- Safeguards Building A (BSA)
- Safeguards Building B (BSB)
- Nuclear Auxiliary Building (BNX)
- Radioactive Waste Treatment Building (BWX)
- Emergency Diesel generator Buildings (BDA, BDB, BDC)
- Station blackout (SBO) Diesel Generator Buildings (BDU, BDV)
- Extra Cooling System and Fire-fighting system building (BEJ)

98. Category II protection is provided to;

- Reactor Building (BRX)
- Safeguards Building C (BSC)
- Fuel Building (BFX)

99. ONR wrote to the RP during Step 2 (Ref. 25) outlining expectations and raised RQ-UKHPR1000-0087 (Ref. 13) on the aircraft impact safety case strategy. For this external hazard, writing to duty holders is undertaken as a matter of course to provide openness and transparency with respect to regulatory expectations for aircraft crash.

100. The RP provided a partial response to the RQ and has formed a multi-disciplinary working group (Ref. 26) to consider aircraft impact. The partial response to RQ-UKHPR1000-0087 (Ref. 13):

- details a generic aircraft impact protection strategy,
- identifies an initial list of future deliverables and
- identifies work that the RP teams need to undertake.

101. Whilst the bulk of the work to produce a generic aircraft impact safety case has yet to be completed, the RP has a clear strategy in place. I am satisfied that the strategy, if implemented throughout GDA, will meet ONR expectations letter as defined in Ref. (25) and SAP EHA.8 paragraphs 251 and 252 in.

102. The provision of two levels of protection against aircraft impact may be novel and will require further assessment during GDA as greater detail is presented. In my assessment for Step 2 I am content that the approach is in accordance with SAP EHA.8. The definition of a design basis aircraft impact and the associated frequency has not been completed in the Step 2 submissions. The scope of GDA for UK HPR1000 should include accidental and malicious aircraft crash, including representative crash frequencies in the Generic Site Envelope.

103. In considering the UK HPR1000 response to aircraft crash I have emphasised to the RP that it must be considered as a generic hazard, while the aircraft crash frequency will be site-specific the hazard is present on all candidate sites for nuclear power stations in England and Wales (Ref. 16 Shenzhen workshop). The hazard is therefore suitable for consideration within the scope of GDA. No aircraft crash rate has been included in the Generic Site Envelope; this is an omission for both deterministic and probabilistic treatment of aircraft crash hazard.

4.6.2 Strengths

104. During my GDA Step 2 assessment of aircraft impact I have noted the following areas of strength:

- The definition of a light aircraft shell for all SSCs important to safety provides confidence that aircraft crash has been considered in the development of the UK HPR1000 design and reduces the reliance on crash shadow arguments to protect SSCs.
- The RP has established a multidisciplinary working group to consider aircraft impact (AIMDWG).

4.6.3 Items that Require Follow-up

105. During my GDA Step 2 assessment of aircraft impact I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- Category II aircraft impact shell should be shown to meet the requirements of Category I aircraft impact shell under the same conservative analysis, the entirety of the aircraft shell should be shown to meet the design basis requirements.
- The RP's definition of beyond design basis aircraft impact load case should be provided during GDA Step 3.

- The aircraft crash frequency should be provided for the Generic Site Envelope.
- The treatment of aircraft crash frequencies and definition of the hazard should be such that site-specific crash data can be derived from known data.
- In defining the design basis for aircraft impact the RP must demonstrate that it is not inappropriately dividing up the hazard by aircraft type, in a way that masks the true crash frequency and potential risk of consequential effects (sometimes referred to as “salami slicing”). While different levels of protection for different aircraft types may be appropriate the hazard frequency definition must reflect the overall aircraft crash frequency.

4.6.4 Conclusions

106. Based on the outcome of my Step 2 assessment of aircraft impact, I have concluded that the level of detail provided for the aircraft crash hazard for UK HPR1000 is appropriate for GDA Step 2. I am content that aircraft crash has been considered in the development of the generic design and that the approach defined can be developed to provide adequate demonstration of aircraft protection.

4.7 Earthquakes Hazards

4.7.1 Assessment

107. The RP has provided outline information on the approach to the seismic hazard in the PSR (Ref. 2) and (Ref. 10) and an Earthquake Safety Evaluation Methodology Report (Ref. 12). These provide reassurance that the hazard has been considered in the design of UK HPR1000 and that analysis will be undertaken during future Steps of GDA.

108. The claims made against SSCs classified against seismic loads, classified as SSE1 and SSE2 (SSE – Safe Shutdown Earthquake) align with the seismic classification systems considered Relevant Good Practice (RGP), noting that the Categorisation and Classification system has not yet been applied to UK HPR1000.

109. For UK HPR1000, the design of standard response spectrum adopts the standard response spectrum of NRC RG 1.60. The Design Basis Earthquake (DBE) seismic horizontal component and vertical component adopt 0.30g and 0.20g respectively.

110. The safety requirements for UK HPR1000 seismic design are presented in (Ref. 10) and reproduced below:

- SSCs should be classified in terms of their importance to safety during and after an earthquake;
- Structures important to safety should be designed to exhibit non-linear behaviour to provide safety margin and to prevent potential cliff edge effects;
- For specific items for which general principles of seismic design cannot be observed owing to highly non-linear behaviour, sensitivity studies should be performed and appropriate strengthening measures should be taken to enhance safety margins;
- Seismic loads should be considered for all possible operational modes of the plant;
- For the seismic design of SSCs, external hazards such as floods or fires assumed to occur at the site as a consequence of an earthquake should be taken into account;
- The effects of the earthquake on other facilities or installations in the vicinity, and on the safety of any system or service at the facility, should also be taken into account. The effects of failure of non-nuclear SSCs important to safety should be taken into account if this could affect access for the control and/or repair of plant.

111. I have assessed the information provided against SAP EHA.9 - Earthquakes. The claims will require substantiation in future Steps of GDA. The claims made in the Step 2 documentation consider design basis events and beyond design basis events as cliff-edge effects and the requirement for non-linear behaviour to provide safety margin.

112. The seismic classification of SSCs will need to be considered in light of the UK Categorisation and Classification system once this is implemented. This will have to pay particular attention to the defence in depth systems provided in the design.

113. I am content that the UK HPR1000 Reference Plant FCG3 has been designed with seismic hazard in mind and that the claims made against the seismic hazard are appropriate for Step 2. The adequacy and application of the methodology will be assessed during future Steps of GDA as results become available.

4.7.2 Strengths

114. During my GDA Step 2 assessment of earthquakes I have noted the following areas of strength:

- The consideration of the seismic hazard includes beyond design basis response

4.7.3 Items that Require Follow-up

115. During my GDA Step 2 assessment of earthquake hazards I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- The seismic classification of SSCs will require confirmation when the UK HPR1000 Categorisation and Classification system is established and implemented.

4.7.4 Conclusions

116. Based on the outcome of my Step 2 assessment of earthquake hazards, I have concluded that the level of detail and approach provided for the seismic hazard for UK HPR1000 is appropriate for GDA Step 2. I am content that seismic hazard has been considered in the development of the design and that the approach defined can be developed as GDA progresses to provide adequate demonstration of seismic protection. The claims against UK HPR1000 seismic classification will require assessment once the Categorisation and Classification system is implemented.

4.8 Electromagnetic interference (EMI)

4.8.1 Assessment

117. I have assessed the information on the EMI external hazard against SAP EHA.10. Some information is provided in the PSR and General requirements document (Ref. 2, 10). The submissions do not contain sufficient information to form an opinion on the adequacy of protection. The high level claim for EMI is that EMI hazard will not prevent the delivery of the safety functions. EMI has been screened in for inclusion to the GDA scope.

118. No EMI methodology report has been provided.

119. I am content that the UK HPR1000 Reference Plant has been designed with EMI hazard in mind and that the claims made against the EMI hazard are appropriate for Step 2. Greater detail will be required for Step 3.

4.8.2 Strengths

120. During my GDA assessment of EMI I have not identified any specific strengths.

4.8.3 Items that Require Follow-up

121. During my GDA Step 2 assessment of EMI I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- No EMI methodology report has been produced, the means by which the external hazard will be analysed will need to be determined.
- The interaction between internally generated and externally generated EMI safety claims and analysis will need to be determined.

4.8.4 Conclusions

122. I am content that the UK HPR1000 Reference Plant has been designed with EMI hazard in mind and that the claims made against the EMI hazard are appropriate for Step 2.

4.9 Meteorological Hazards

4.9.1 Assessment

123. The RP has provided outline information on the approach to meteorological hazards in the PSR (Ref. 2) and (Ref. 10) and a Tornado Safety Evaluation Methodology Report (Ref. 12). I have undertaken my assessment against SAP EHA.11 – Weather Conditions.

Tornado

124. The tornado safety evaluation methodology selects the Nuclear Regulatory Commission (NRC) definitions of tornado and tornado missile (Ref. 12). This is recognised as RGP. The adequacy and application of the methodology will be assessed during future Steps of GDA as results become available.

Other Meteorological Hazards

125. The extreme meteorological hazards in the scope of the UK HPR1000 GDA are:

- Extreme wind
- Extreme temperature
- Extreme hail
- Sleet
- Snow
- Icing
- Rainfall
- Missile
- Lightning
- Drought
- Space weather

126. Other meteorological conditions will be considered at the site-specific stage.

127. Details of the plant response to meteorological hazards have not been submitted. The overall philosophy for UK HPR1000 is for the buildings containing safety classified SSCs to provide a shell which protects the contents from the external hazards. This is in accordance with the ONR hierarchy of safety with the building providing a passive protection measure.

128. I have raised an RQ (Ref. 13 RQ-UKHPR1000-0112) including questions on the response of building openings to the differential pressure associated with tornado, particularly the response of dampers which close to protect the HVAC system from blast and differential pressure. I have yet to receive detailed information on what claim is being made against the ability of the dampers to reopen, or the duration of their closure to avoid loss of function of the HVAC system; this will be further pursued during future Steps of GDA.

129. No information has been provided on the UK HPR1000 response to space weather, this is included in the scope of the RO-UKHPR1000-002 response.

130. The RP has provided information on the treatment of climate change for relevant meteorological external hazards. The external hazards which will be subject to climate change consideration are not consistently identified between the documents; this will need to be clarified in future submissions. The RP has suggested that climate change is treated as a margin assessment. It is ONR's expectation that where climate change effects are relevant, these effects will be accommodated in the definition of external hazard design bases. It is not clear that the proposed approach will deliver against this expectation.

4.9.2 Strengths

131. During my GDA Step 2 assessment of meteorological hazards I have noted the following areas of strength:

- The GDA scope for meteorological hazards has been defined.
- The RP has committed to including climate change in the meteorological hazard analysis

4.9.3 Items that Require Follow-up

132. During my GDA Step 2 assessment of meteorological hazards I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- The RP's treatment of climate change in the meteorological external hazards should be clarified
- The meteorological hazards which are subject to climate change should be clarified
- The RP should clarify if any claim is intended to be made on administrative measures taken in response to weather warnings for design basis meteorological external hazards.
- Meteorological hazards are included in the required response to RO-UKHPR1000-002
- The claim on the HVAC EPW dampers response to tornado pressure differentials and their reopening should be clearly expressed to confirm if the HVAC system can be compromised by their operation
- The treatment of tornadic missiles should be compared to that of external missiles and internal missiles from other sources

4.9.4 Conclusions

133. Based on the outcome of my Step 2 assessment of meteorological hazards, I have concluded that the level of detail provided for the meteorological hazards for UK HPR1000 is appropriate for GDA Step 2. The treatment of climate change requires more detail in future Steps of GDA. I am content that meteorological hazards have been considered in the development of the design and that the approach defined can be developed to provide adequate demonstration of meteorological hazard protection. The meteorological hazards will be affected by the response to RO-UKHPR1000-002.

4.10 Flooding

4.10.1 Assessment

134. The RP has provided outline information on the approach to the flooding hazard in the PSR (Ref. 2) and (Ref.10) and an External Flooding Safety Evaluation Methodology Report (Ref. 12). These provide reassurance that the hazard has been considered in the design of UK HPR1000 and that analysis will be undertaken during future Steps of GDA.

135. Details of the sources of flooding are site-specific but the RP has provided principles for flooding protection including:

- Protecting the platform from off-site flooding by adopting the dry site concept or providing permanent external barriers, the design of which may need to provide for flood levels beyond the design basis flooding event.
- Beyond design basis flooding will be taken into account.
- All buildings containing nuclear safety related SSCs to have a 0.3m sill between platform height and building ground floor.
- All doors, openings and penetrations on ground floor level to be qualified to 2m static water head.
- All doors, openings and penetrations below ground floor level to be qualified to 10m static water head.

136. I have assessed the information provided against SAP EHA.12 – Flooding. The claims will require substantiation in future Steps of GDA. The claims made in the Step 2 documentation consider both design basis and beyond design basis flooding events.

137. No information has yet been provided on the duration of flooding events or the operability of the plant with a flooded platform, this should be considered as part of the beyond design basis flooding case.

138. I am content that the UK HPR1000 Reference Plant has been designed with external flooding hazard in mind and that the claims made against the flooding hazard are appropriate for Step 2. The adequacy and application of the methodology will be assessed during future Steps of GDA as results become available.

4.10.2 Strengths

139. During my GDA Step 2 assessment of flooding I have noted the following areas of strength:

- Claims are made against the beyond design basis flooding hazard.

4.10.3 Items that Require Follow-up

140. During my GDA Step 2 assessment of flooding I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- As discussed in section 4.3.1 the Generic Site Envelope extreme rainfall values require justification.
- The claim which is being made against the building and site drainage systems should be clarified in future GDA Steps.
- Information should be provided on the duration of flooding events and the operability of the plant with a flooded platform in the beyond design basis case.

4.10.4 Conclusions

141. Based on the outcome of my Step 2 assessment of flooding, I have concluded that the level of detail provided for the flooding hazard for UK HPR1000 is appropriate for GDA Step 2. I am content that external flooding has been considered in the development of the design and that the approach defined can be developed to provide adequate demonstration of flooding protection.

4.11 Man-made hazards

4.11.1 Assessment

142. The RP has provided outline information on the approach to man-made hazards in the PSR (Ref. 2) and (Ref. 10).

143. Aircraft crash and Electromagnetic Interference (EMI) are screened in for consideration in GDA. Other man-made hazards have been screened out for detailed consideration in site licensing. The RP has committed to present general protection measures for external explosion and provided an External Explosion Safety Evaluation Methodology Report (Ref. 12). A standard load-time function is used as a design basis (Ref. 10 §5.3.3).

144. I have assessed the aircraft impact and EMI hazards separately in this report (Sections 4.6, 4.8).

145. I am content that the UK HPR1000 Reference Plant has been designed with external explosion hazard in mind and that the claims made against the external explosion hazard are appropriate for Step 2. The adequacy and application of the methodology will be assessed during future Steps of GDA as results become available.

146. Other man-made external hazards have been screened out of scope for GDA, to be considered in site-licensing. While the details of the external hazards are site specific I will be seeking reassurance that the screened out external hazards have been considered in the UK HPR1000 design such that site licensing is practicable.

4.11.2 Strengths

147. None identified for external explosion.

4.11.3 Items that Require Follow-up

148. During my GDA Step 2 assessment of man-made hazards I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- For man-made external hazards which have been screened out of GDA scope, but are likely to be screened in at the site-specific design stage, reassurance should be provided that they are considered in the design of UK HPR1000 such that site licensing will be practicable.
- The status of external explosion hazard should be clarified against the scope of GDA.

4.11.4 Conclusions

149. Man-made hazards are largely screened out of GDA scope. Aircraft impact and EMI are presented separately, external explosion is ambiguously defined within the scope of GDA.

150. Based on the outcome of my Step 2 assessment of External Hazards, I have concluded that the level of detail provided for the man-made hazards for UK HPR1000 is appropriate for GDA Step 2. I am content that man-made hazards have been considered in the development of the design and that the approach defined can be developed to provide adequate demonstration of external explosion protection.

4.12 Biological hazards

4.12.1 Assessment

151. Biological hazards have been screened out of scope of the UK HPR1000 GDA, to be addressed in the site-specific design phase. I am content that this is an appropriate approach, providing that the consequences of biological hazards is included in the fault schedule; this is primarily the loss of ultimate heat sink (LUHS) for water-borne biological hazards.

4.12.2 Strengths

152. None identified

4.12.3 Items that Require Follow-up

153. During my GDA Step 2 assessment of biological hazards I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- As biological hazards are deferred to site licensing, the LUHS faults should be included in the fault schedule in GDA.

4.12.4 Conclusions

154. Based on the outcome of my Step 2 assessment of biological hazards, I have concluded that the level of detail provided for the biological hazards for UK HPR1000 is appropriate for GDA Step 2. The screening out of scope for GDA of biological hazards to site licensing is appropriate.

4.13 Classification and Categorisation of Systems, Structures and Components

4.13.1 Assessment

155. The seismic Categorisation and Classification system will follow from the implementation of the UK-specific Categorisation and Classification system. This has not yet been implemented in the UK HPR1000 safety documentation. I will assess the seismic classification of SSCs when the Categorisation and Classification methodology is established.

4.13.2 Strengths

156. None identified

4.13.3 Items that Require Follow-up

157. During my GDA Step 2 assessment I have identified the following additional potential shortfalls that I will include in assessment planning for Step 3 and will follow-up during future Steps of GDA:

- Assessment of the Categorisation and Classification related to external hazards, including the seismic classification of SSCs should be undertaken when the Categorisation and Classification methodology is implemented on UK HPR1000.

4.13.4 Conclusions

158. No assessment has been possible for the external hazards Categorisation and Classification as the methodology is still in development.

4.14 ALARP Considerations

4.14.1 Assessment

159. I have not made any specific reference to ALARP considerations in my assessment. The RP has not made any ALARP arguments in its treatment of external hazards in the PSR or supporting references. The approach to ALARP will be considered in the Step 2 Summary Report (Ref. 27).

160. When the ALARP approach is implemented in the UK HPR1000 safety case I will assess the appropriateness of its implementation for external hazards. This may be relevant when considering the response to RO-UKHPR1000-002 (Ref. 17).

4.15 Out of Scope Items

161. My assessment has been conducted against the RP's PSR, its supporting references and other relevant documentation submitted during Step 2, up to the assessment cut-off point.

162. The scope of my assessment is in accordance with my assessment plan (Ref. 1).

163. The following items have been left outside the scope of my GDA Step 2 assessment of the UK HPR1000 external hazards.

- Implementation of UK HPR1000 categorisation and classification methodology due to the lack of detail on its use for external hazards.
- Assessment of the ALARP approach for UK HPR1000, due to the absence of its application for UK HPR1000 Step 2 in the topic of External Hazards.

164. It should be noted that the above omissions do not invalidate the conclusions of my GDA Step 2 assessment. During my GDA Step 3 assessment I will follow-up the above out-of-scope items as appropriate; I will capture this within my GDA Step 3 Assessment Plan.

4.16 Comparison with Standards, Guidance and Relevant Good Practice

165. In Section 2.2, above, I have listed the standards and criteria I have used during my GDA Step 2 assessment of the UK UKHPR1000 External Hazards topic, to judge the adequacy of the preliminary safety case. In this regard, my overall conclusions can be summarised as follows:

- SAPs: sufficient progress is being made against the SAPs relevant to External Hazards. The claims contained in the Step 2 submissions are consistent with the expectations of the SAPs. The assessment in Section 4 and Table 1 provide further details.
- TAGs: the claims contained in the Step 2 submissions are in accordance with the expectations of the External Hazards TAG (Ref. 5). The approach to hazard identification and screening has identified a suitable scope for the UK HPR1000 GDA.
- ONR Guidance to Requesting Parties: For the External Hazards topic the definition of a UK HPR1000 Generic Site Envelope is in accordance with the ONR Guidance to Requesting Parties.

4.17 Interactions with Other Regulators

166. I have consulted with members of the Environment Agency GDA team in considering the Generic Site Envelope. These interactions will continue through future Steps of GDA.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

167. During Step 2 of GDA the RP submitted a PSR and other supporting references, which outline a preliminary nuclear safety case for the UK HPR1000. These documents have been formally assessed by ONR. The PSR together with its supporting references present the claims in the area of External Hazards topic that underpin the safety of the UK HPR1000.

168. During Step 2 of GDA I have targeted my assessment at the content of the PSR and its references that is of most relevance to the area of External Hazards; against the expectations of ONR's SAPs and TAGs and other guidance which ONR regards as Relevant Good Practice. From the UK HPR1000 assessment done so far, I conclude the following:

- Good progress has been made by the RP in identifying and screening the external hazards applicable to UK HPR1000 and defining the scope of UK HPR1000 GDA. Reasonable high level claims have been made suitable for Step 2 of GDA.
- I have identified aspects of the PSR and its supporting information which require more information or greater clarity in the future Steps of GDA; these are detailed in the assessment section of the report. During Step 2 I have raised RO-UKHPR1000-0002 on the demonstration that the UK HPR1000 design's alignment with the Generic Site Envelope.
- Step 2 of the UK HPR1000 GDA has enabled me to gain a broad understanding of the design. The interactions between ONR and the RP have provided clarity on the approach towards external hazards being adopted by the RP.
- Insufficient evidence was provided to enable a judgement on as to whether the arguments and evidence, anticipated as being available in Steps 3 and 4, are likely to be adequate.

169. Overall, during my GDA Step 2 assessment, I have not identified any fundamental safety shortfalls in the area of External Hazards that might prevent the issue of a Design Acceptance Confirmation (DAC) for the UK HPR1000 design. I have raised one RO (Ref. 17) that will require adequate resolution in order for a DAC to be issued.

5.2 Recommendations

170. My recommendations are as follows.

- Recommendation 1: ONR should consider the findings of my assessment in deciding whether to proceed to Step 3 of GDA for the UK HPR1000.
- Recommendation 2: All the items identified in Step 2 as important to be followed up should be included in ONR's GDA Step 3 External Hazards Assessment Plan for the UK HPR1000.
- Recommendation 3: All the relevant out-of-scope items identified in sub-section 4.15 of this report should be included in ONR's GDA Step 3 External Hazards Assessment Plan for the UK HPR1000.

6 REFERENCES

1. Step 2 Assessment Plan for External Hazards ONR-GDA-UKHPR1000-AP-17-004 - UK HPR1000 GDA - Rev 0 November 2017 TRIM 2017/354871

2. UK HPR1000 Preliminary Safety Report

   Preliminary Safety Report Chapter 3 Generic Site Characteristics HPR-GDA-PSR-0003 - Rev 0 October 2017 TRIM 2017/401349

   Preliminary Safety Report Chapter 18 External hazards HPR-GDA-PSR-0018 - Rev 0 October 2017 TRIM 2017/401381

3. ONR HOW2 Guide NS-PER-GD-014 Revision 6 - Purpose and Scope of Permissioning. November 2016. http://www.onr.org.uk/operational/assessment/index.htm

4. Safety Assessment Principles for Nuclear Facilities. 2014 Edition Revision 0. November 2014. http://www.onr.org.uk/saps/saps2014.pdf

5. Technical Assessment Guides

   External Hazards NS-TAST-GD-013 Revision 6. ONR. December 2017 http://www.onr.org.uk/operational/tech_asst_guides/index.htm

6. ONR-GDA-GD-001 New nuclear reactors: Generic Design Assessment Guidance to Requesting Parties September 2016 Rev 3 http://www.onr.org.uk/new-reactors/guidance-assessment.htm

7. IAEA Guidance. www.iaea.org

   - IAEA Fundamental Safety Principles Series No. SF-1, 2006. ISBN:92-0-110706-4
   - IAEA Specific Safety Requirements Series No. SSR-2/1 Safety of Nuclear Power Plants: Design, 2012. ISBN:978-92-0-121510-9
   - IAEA Safety Guide Safety Standards Series No. NS-G-1.5- External Events Excluding Earthquakes in the Design of Nuclear Power Plants
   - IAEA Safety Guide Safety Standards Series No. NS-G-1.6 - Seismic Design and Qualification for Nuclear Power Plants Safety Guide
   - IAEA Safety Guide Safety Standards Series No. NS-G-3.1 - External Human Induced Events in Site Evaluation for Nuclear Power Plants
   - IAEA Safety Guide Safety Standards Series No. NS-G-3.3 - Evaluation of Seismic Hazards for Nuclear Power Plants Safety Guide
   - IAEA Safety Guide Safety Standards Series No. NS-G-3.4 - Meteorological Events in Site Evaluation for Nuclear Power Plants Safety Guide
   - IAEA Safety Guide Safety Standards Series No. NS-G-3.5 - Flood Hazard for Nuclear Power Plants on Coastal and River Sites Safety Guide

8. WENRA Guidance

   - Natural Hazards Guidance on Seismic Events (October 2016)
   - Natural Hazards Guidance on External Flooding (October 2016)
   - Natural Hazards Guidance on Extreme Weather Conditions (October 2016)
   - Reactor Safety Reference Levels (January 2008)
   - Safety Objectives for New Power Reactors (December 2009) and Statement on Safety Objectives for New Nuclear Power Plants (November 2010)
   - Statement on Safety Objectives for New Nuclear Power Plants (March 2013) and Safety of New NPP Designs (March 2013)

9. Generic Site Report Rev.000 - HPR-GDA-REPO-0015 - November 2017 TRIM 2017/422398

10. The General Requirements of Protection Design against Internal and External Hazards UK HPR1000 - GDA-REC-CGN-001175 GHX00100028DOZJ03GNC - Rev 0 March 2018 TRIM 2018/98992

11. The Identification and Screening of Internal & External Hazards in PSA UK HPR1000 - GDA-REC-CGN-001259 GHX00650034DOZJ02GN A - Rev 0 April 2018 TRIM 2018/139583

12. UK HPR1000 Methodology Reports:

- Tornado Safety Evaluation Methodology Report GH-X-00100-034-DOZJ-03-GN May 2018 TRIM 2018/181250
- Explosion Safety Evaluation Methodology Report GH-X-00100-031-DOZJ-03-GN May 2018 TRIM 2018/181240
- Earthquake Safety Evaluation Methodology Report GH-X-00100-053-DOZJ-03-GN May 2018 TRIM 2018/181233
- Flood Safety Evaluation Methodology Report GH-X-00100-038-DOZJ-03-GN May 2018 TRIM 2018/178938
- Methodology of External Hazards PSA GH-X-00650-032-DOZJ-03-GN May 2018 TRIM 2018/180086
- Aircraft Crash Safety Evaluation Methodology Report GH-X-00100-036-DOZJ-03-GN June 2018 TRIM 2018/199771

13. RP responses to External Hazards Regulatory Queries, complete list of RQs from Step 2 is contained in Regulatory Query (RQ) Tracking Sheet - 2 November 2017 - Reference for Step 2 Assessment Reports 2018/315144

RQ Identifier	Title	RQ reference
RQ-UKHPR1000-0008	Definition and applicability of the Generic Site Envelope (external hazards)	TRIM 2018/7185
RQ-UKHPR1000-0009	Screening and treatment of specific external hazards in GDA step 2 (external hazards)	TRIM 2018/7205
RQ--UKHPR1000-0087	Aircraft Impact Assessment Safety Case Strategy	TRIM 2018/188565
RQ-UKHPR1000-0096	Ground Bearing Capacity	TRIM 2018/208136
RQ-UKHPR1000-0112	Clarification from workshop	TRIM 2018/207291
RQ-UKHPR1000-0126	Location of feed and steam systems (external hazards)	TRIM 2018/233720

14. Demonstration that the UK HPR1000 Design is Suitably Aligned with the Generic Site Envelope Revised Resolution Plan RO-UKHPR1000-0002 TRIM 2018/242307

15. UK HPR1000 Pre-Construction Safety Report

Pre Construction Safety Report - Chapter 3 General Site Characteristics - UK HPR1000 - GDA-REC-CGN-000807 - March 2018 TRIM 2018/105342

Pre Construction Safety Report - Chapter 18 External Hazards UK HPR1000 - GDA-REC-CGN-000822 - rev B March 2018 TRIM 2018/105308

16. Contact records for External Hazards Step 2

Level 4 interaction	**Principal Topics**	**Contact Record (CR) reference**
Level 4 meeting in UK December 2017	Hazard screening RQ discussion Generic Site Envelope January workshop agenda	TRIM 2017/462518
Level 4 workshop in UK January 2018	Response to RQs ONR's intent to raise RO-UKHPR1000-0002	TRIM 2018/43923
Level 4 meeting in UK February 2018	Joint meeting with Civil Engineering on Aircraft Crash	TRIM 2018/57229
Level 4 meeting in UK May 2018	RO resolution plan GDA Step 3 entry requirements	TRIM 2018/121059
Level 4 workshop in Shenzhen May 2018	Plant familiarisation RO resolution plan External Hazards methodologies Joint discussions with Internal Hazards	TRIM 2018/142637
Level 4 meeting in UK June 2018	PCSR update RQ updates Aircraft crash Tornado	TRIM 2018/211978

17. Demonstration the UK HPR1000 Design is Suitably Aligned with the Generic Site Envelope RO-UKHPR1000-002 February 2018 TRIM 2018/43924

18. UK HPR1000 - Regulatory Observation (RO) Tracking Sheet TRIM 2018/315147

19. The Identification and Screening Process of Internal and External Hazards Rev C - UK HPR1000 - GDA-REC-CGN-001176 GHX00100037DOZJ03GNC - March 2018 TRIM 2018/99013

20. GDA Step 2 Assessment of Internal Hazards of the UK HPR1000 Reactor ONR-GDA-UKHPR1000-AR-18-003 TRIM 2018/208486

21. Scope for UK HPR1000 GDA Project - Rev 000 Final - UK HPR1000 - HPR-GDA-REPO-0007 - May 2018 TRIM 2018/179809

22. A Comparison Report for the Generic Site Envelopes of the EPR, AP1000 and ABWR 2016 TRIM 2016/148592

23. UK HPR1000 GDA - Step 2 Assessment Report - Civil Engineering ONR-GDA-UKHPR1000-AR-18-005 - TRIM 2018/206452

24. Demonstration that the UK HPR1000 Design is Suitably Aligned with the Generic Site Envelope Revised Resolution Plan TRIM 2018/242307 http://www.onr.org.uk/new-reactors/uk-hpr1000/ro-res-plan.htm

25. Letter - UK HPR1000 – UK Expectations – Aircraft Impact UK HPR1000-REG-GNS-0017N ONR to RP January 2018 TRIM 2018/28201

26. GNS Aircraft Impact Multi-Disciplinary Working Group Term of Reference HPR-GDA-PROC-0093 063-GN-P-SP-G11-036 Rev000 TRIM 2018/249627

27. Summary of the Step 2 Assessment of the UK HPR1000 Reactor ONR-NR-PAR-18-007 TRIM 2018/238474

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No and Title	Description	Comment
EHA.1 Identification and Characterisation	An effective process should be applied to identify and characterise all external and internal hazards that could affect the safety of the facility.	Assessed in section 4.1of this report. The RP has provided an identification and screening process which has developed through Step 2.
EHA.2 Data sources	For each type of external hazard, either site-specific or, if this is not appropriate, best available relevant data should be used to determine the relationship between event magnitudes and their frequencies.	Assessed in section 4.3 of this report. The RP has defined a Generic Site Envelope to define the external hazards magnitudes.
EHA.3 Design basis events	For each internal or external hazard which cannot be excluded on the basis of either low frequency or insignificant consequence (see Principle EHA.19), a design basis event should be derived.	Assessed in section 4.3 of this report. The RP has defined a Generic Site Envelope to define the external hazards magnitudes.
EHA.4 Frequency of initiating event	For natural external hazards, characterised by frequency of exceedance hazard curves and internal hazards, the design basis event for an internal or external hazard should be derived to have a predicted frequency of exceedance that accords with Fault Analysis Principle FA.5. The thresholds set in Principle FA.5 for design basis events are 1 in 10 000 years for external hazards and 1 in 100 000 years for man-made external hazards and all internal hazards (see also paragraph 629).	Assessed in section 4.3 of this report. The RP has defined a Generic Site Envelope to define the external hazards magnitudes.
EHA.6 Analysis	The effects of internal and external hazards that could affect the safety of the facility should be analysed. The analysis should take into account hazard combinations, simultaneous effects, common cause failures, defence in depth and consequential effects.	Assessed in section 4.4 of this report. The RP has provided approaches and outline methodologies for hazards which are in scope of GDA. Detailed analysis has not been provided.
EHA.7 'Cliff-edge' effects	A small change in design basis fault or event assumptions should not lead to a disproportionate increase in radiological consequences.	Assessed in section 4.5 of this report. The RP has indicated that cliff edge effects will be considered in the detailed

SAP No and Title	Description	Comment
		analysis of external hazards.
EHA.8 Aircraft crash	The total predicted frequency of aircraft crash, including helicopters and other airborne vehicles, on or near any facility housing structures, systems and components should be determined.	Assessed in section 4.6 of this report. The RP has provided an aircraft impact methodology and initial outline of the approach to protection from aircraft impact.
EHA.9 Earthquakes	The seismology and geology of the area around the site and the geology and hydrogeology of the site should be evaluated to derive a design basis earthquake (DBE).	Assessed in section 4.7 of this report. The RP has provided an earthquake methodology and initial outline of the approach to protection from earthquake.
EHA.10 Electromagnetic interference	The facility design should include preventative and/or protective measures against the effects of electromagnetic interference.	Assessed in section 4.8 of this report. The RP has provided initial indication that EMI is considered in the Reference Design.
EHA.11 Weather conditions	Facilities should be shown to withstand weather conditions that meet design basis event criteria. Weather conditions beyond the design basis that have the potential to lead to a severe accident should also be analysed.	Assessed in section 4.9 of this report. The RP has provided a Generic Site Envelope and the Reference Design meteorological hazard magnitudes. Some of the Reference Design magnitudes do not envelope the Generic Site Envelope, An RO has been raised to address this shortfall.
EHA.12 Flooding	Facilities should be shown to withstand flooding conditions up to and including the design basis event. Severe accidents involving flooding should also be analysed.	Assessed in section 4.10 of this report. The RP has provided initial indication of flooding protection against platform flooding.
EHA.18 Beyond design basis events	Fault sequences initiated by internal and external hazards beyond the design basis should be analysed applying an appropriate combination of engineering, deterministic and probabilistic assessments.	Assessed in section 4.5 of this report. The RP has indicated that beyond design basis events will be considered in the external hazards safety assessment.
EHA.19 Screening	Hazards whose associated faults make no significant contribution to overall risks from the facility should be excluded from the fault analysis.	Assessed in section 4.2 of this report. The RP has provided screening of

SAP No and Title	Description	Comment
		external hazards to identify those external hazards which are relevant to the UK HPR1000 GDA and those which will be addressed during site licensing.

Table 2 GDA External Hazards Screening Results

Treatment	Hazard Group	Hazard Parameter
GDA	Seismic	Response spectra, Shear wave velocity
	Hydrological	Flooding
	Man Made	Aircraft crash, Electromagnetic Interference (EMI)
	Meteorological	Extremes of air temperature*, Humidity, High wind*, Tornado, Missiles, Rainfall*, Extreme hail, Sleet, Snow, Extremes of sea or river temperature*, Icing, Lightning, Drought, Space weather
Site Licence	Seismic	Extended period ground motion
	Hydrological	Dam failure, Instability of the coastal area, Storm surge, Wind generated waves, Changes in river channel or obstruction of river channel, Bore, Snow melt, Water course containment failure, Tidal effects, Tsunami, Sea level, Seiche
	Biological	Biological fouling, Seaweed, Fish, Jellyfish, Marine growth, Infestation, Airborne swarms, Crustacean or mollusc growth, Biological flotsam, Microbiological corrosion, Water debris
	Man Made	Impacts from adjacent sites, Gas clouds, Liquid release, Fires, Explosions, Structural failure, Transport, Pipelines, Vibrations, Malicious activity, Industrial plants, Military facilities, Transport of nuclear material, Forest Fire, Ship Collision, Unexploded Ordnance
	Meteorological	Extremes of ground temperature, Sand storms, Air pressure, Low groundwater, Low sea water level, Water spout, Surface ice on lake or sea, Mist, fog, freezing fog, Salt Storm
	Geological	Contaminated land, Landslides (slope instability), Radon / Methane, Groundwater flooding
	Landscape Change	Windblown sand and dune movement, Coastal erosion, Long shore drift, Shingle mounding, Sediment deposition, Water course erosion, Water course path change, Water table movements, Changes in land use and water use
Screened Out	Meteorological	Meteorite
	Geological	Volcanoes

* parameters affected by climate change
Table 2 GDA External Hazards Screening Results (Ref. 21)

Table 3 Main Identified Gaps in response to RO-UKHPR1000-0002

Parameter		FCG Unit 3	Generic Site Envelope
Air Temperature	Maximum	37.9°C	41.5°C
	Minimum	-1.8°C	-22°C
Snow	Maximum	None	1.5 kPa
Water Temperature	Maximum	38°C	28°C
	Minimum	8.9°C	-2°C
Icing	Clear Ice Thickness	None	117 mm
	Clear Ice Density	None	9 kN/m
Seismic	Shear wave velocity	1100 m/s to 3000 m/s	Site specific
Space weather	---	None	---

Table 3 Main Identified Gaps in response to RO-UKHPR1000-0002 (Ref. 14)

Table 4 UK HPR1000 Generic Site Envelope Parameters and Values

Parameter	Proposed Generic Site Envelope Value
Maximum Air Temperature (Dry bulb)	41.5°C +5.4°C climate change consideration
Minimum Air Temperature (Dry bulb)	-22°C
Maximum Relative Humidity	100%
Minimum Relative Humidity	12%
Average Relative Humidity	80%
Wind Speed (3 second gust)	58 m/s
Tornadic Wind Speed	60 m/s
Pressure Drop	3.1 kPa
Pressure Drop Rate	0.94 kPa/s
Tornadic Missile (Timber Plank 65 kg)	32 m/s
Tornadic Missile (Steel Pipe 34.5 kg)	22 m/s
Rainfall (1 hour)	100 mm (123 mm with climate change consideration)
Rainfall (24 hour)	200 mm (246 mm with climate change consideration)
Ground Snow Load	1.5 kPa
Clear Ice Thickness	117 mm
Clear Ice Density	9 kN/m
Maximum Sea Water Temperature	28°C + 4°C climate change consideration
Minimum Sea Water Temperature	-2°C
Seismic Peak Ground Acceleration*	0.3g
Shear wave velocity*	250 – 1100 m/s

Soil Bearing Capacity (static)	1000 to 1500 kPa

*Subject to site investigation studies

Table 4 - UK HPR1000 Generic Site Envelope Parameters and Values (Ref. 9)

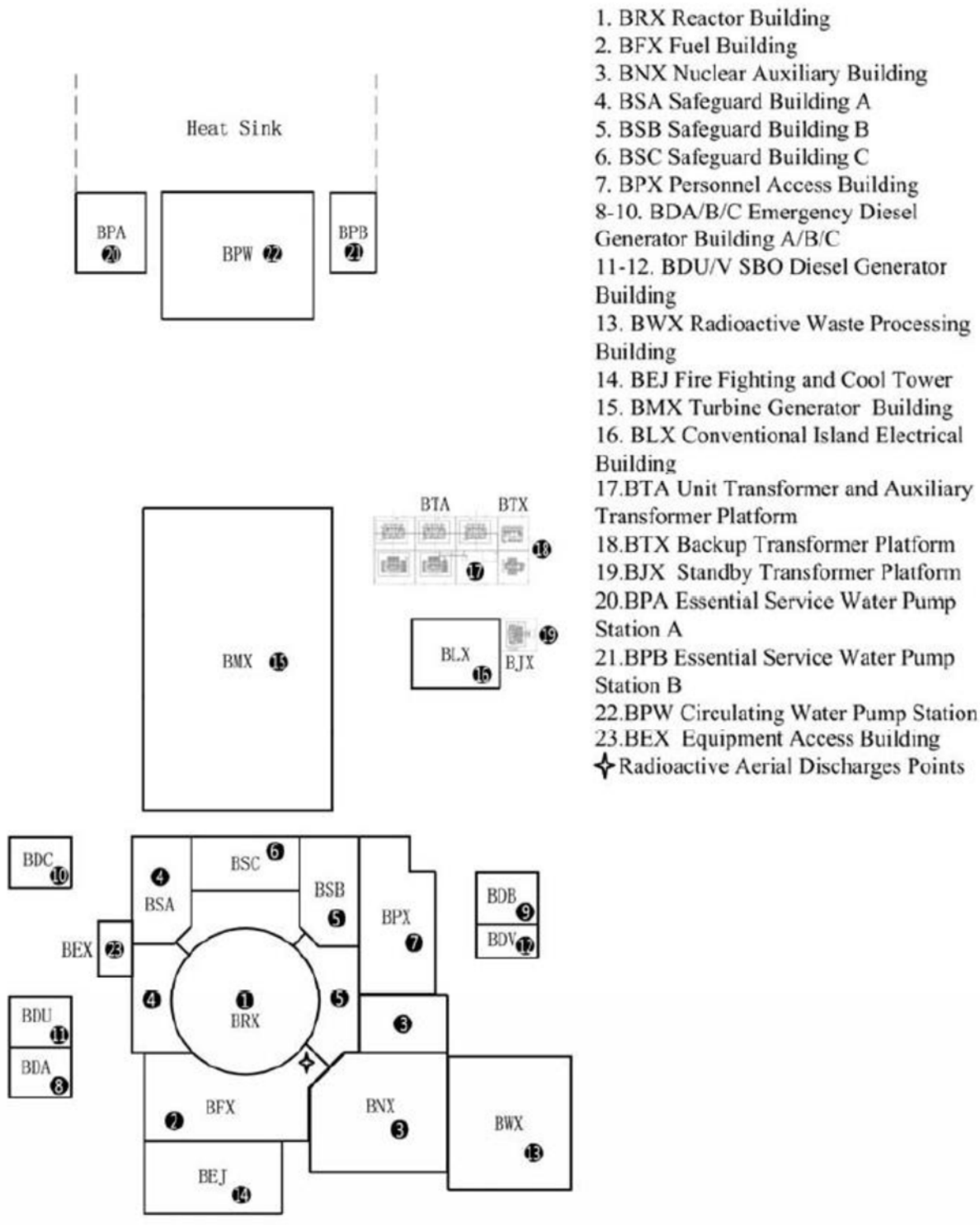

Figure 1 UK HPR1000 Plant Layout – from GDA scope document (Ref. 21)