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ASSESSMENT REPORT

Civil Nuclear Reactors Programme

NNB Genco: Hinkley Point C Pre-Construction Safety Report 2012 – Assessment Report for Work Stream B7 External Hazards

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EXECUTIVE SUMMARY

This assessment report (AR) provides a preliminary assessment of the portion of the Hinkley Point C Pre-Construction Safety Report 2012 (HPC PCSR2012) that falls within the scope of Work Stream B7 External Hazards. This material lies in HPC PCSR2012 Chapters 2 and 13.

A final version of the Generic Design Assessment (GDA) Pre-Construction Safety Report (PCSR) issued in November 2012 formed the basis for issue by ONR on 13 December 2012 of a Design Acceptance Confirmation (DAC) for the UK EPR™ design. The GDA PCSR addressed only the key elements of the design of a single UK EPR™ unit, (the generic features on "the nuclear island") and excluded ancillary installations that a potential purchaser of the design could choose after taking the site location into account. Certain matters were also deemed to be outside the scope of the GDA PCSR. This included a number of external hazards design bases, the most important of which is likely to be external flooding from all sources.

In contrast, HPC PCSR2012 addresses the whole Hinkley Point C licensed site comprising the proposed twin UK EPR units and all ancillary installations. Some matters that were outside the scope of GDA PCSR are also addressed in HPC PCSR2012. This is especially relevant to the external hazards technical area, where the main input from GDA is the specification of external hazards design bases (e.g. seismic vibration, rainfall), or conditions that the site must satisfy to meet the intent of the generic design (e.g. the assumption of a dry site in respect of coastal flooding). The external hazards technical work by the Licensee is aimed primarily at supporting the GDA design bases and siting assumptions by site-specific technical work, or justifying changes if necessary.

It is important to note that HPC PCSR2012 alone is not sufficient to inform a future ONR decision on whether to permission construction of Hinkley Point C. NNB GenCo intends to submit a major revision to HPC PCSR2012 before seeking consent for First Nuclear Safety Concrete construction which will fully integrate the final GDA PCSR and will be supported by other documentation. NNB GenCo will also be submitting substantial additional documentation to support permissioning of First Nuclear Safety Concrete, which is the first permissioning point under the Site Licence.

I am content with the work that has been presented, although there are significant areas where a programme of forward work has been specified. The most significant issues relate to groundwater control, external hazards Probabilistic Safety Analysis (PSA) and seismic hazard analysis. The first two are primarily the concern of civil engineering and PSA work streams, although a significant interface will be maintained with the external hazards workstream. Two further issues are also raised and an additional item for consideration, the timing of GDA Assessment Finding resolution, will be considered during routine engagement with the Licensee.

The issues arsing from this assessment are:

- The Licensee shall complete the seismic hazard forward work programme to confirm the seismic design basis to be used for plant design before end December 2014. (Level 3 Issue)
- The Licensee shall complete the HPC frazil ice hazard analysis in order to meet the timescales for permissioning First Nuclear Safety Concrete. (Level 4 Issue)

- The Licensee shall develop a philosophy for its treatment of Beyond Design Basis external hazards and identify a forward work programme for its implementation consistent with the requirements of the overall design process. (Level 4 Issue)

The additional significant items to be considered through routine engagement with the Licensee and/or interfacing with other ONR workstreams are:

- Completion of the external hazards PSA and the availability of PSA results to inform the design process in a timely manner and ensure the overall plant risk is as low as reasonably practicable (ALARP). This issue is being taken forwards primarily by PSA assessors.
- Resolution of the groundwater control issue so that deeply founded structures are able to deliver all their safety functions through the life of the facility. This issue is being taken forwards primarily by civil engineering assessors.
- Re-examine the GDA Assessment Finding milestone dates to gain confidence that the work identified in each finding is undertaken in time to benefit all relevant structures, systems and components (SSCs).

LIST OF ABBREVIATIONS

AF	Assessment Finding
ALARP	As low as is reasonably practicable
AR	Assessment Report
BDB	Beyond Design Basis
BMS	(ONR) How2 Business Management System
BNI	Balance of Nuclear Island
CWS	Cooling Water System
DAC	Design Acceptance Confirmation
EA	Environment Agency
EMI	Electro-Magnetic Interference
EPR	The Pressurised Water Reactor developed and trademarked by AREVA
GDA	Generic Design Assessment
HSE	Health and Safety Executive
HPC PCSR2012	Hinkley Point C Pre-Construction Safety Report 2012
IAEA	International Atomic Energy Agency
LC	Licence Condition
LOOP	Loss of Offsite Power
NAO	North Atlantic Oscillation
NNB GenCo	EDF Nuclear New Build Generation Company Ltd
OECD NEA	Organisation for Economic Cooperation and Development Nuclear Energy Agency
ONR	Office for Nuclear Regulation (an agency of HSE)
PCSR	Pre-Construction Safety Report
PSA	Probabilistic Safety Analysis
PSR	Periodic Safety Review
RPV	Reactor Pressure Vessel
SAP	Safety Assessment Principle(s) (HSE)
SMART	Specific Measurable Attainable Relevant Time based issue
SSC	System, Structure and Component
TAG	Technical Assessment Guide(s) (ONR)
TSC	Technical Support Contractor
US NRC	United States Nuclear Regulatory Commission

LIST OF ABBREVIATIONS

WENRA	Western European Nuclear Regulators Association

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1 INTRODUCTION

1 The purpose of this Assessment Report (AR) is to provide a preliminary assessment of progress by NNB GenCo on analysis of External Hazards for the Hinkley Point C (HPC) site. In December 2012, NNB GenCo submitted a Pre-Construction Safety Report (HPC PCSR2012, Ref.1) to ONR for review. Since that time, additional progress has been made on some of the issues raised within the PCSR and this progress has been reported to ONR via a series of Level 4 meetings and has been summarised by NNB GenCo in an External Hazards Tracking Table, Ref.2.

2 This Assessment Report:

- Presents the findings of the preliminary assessment of the portion of the Hinkley Point C Pre-Construction Safety Report 2012 that falls within the scope of Work Stream B7 External Hazards and focuses on the most significant hazards only.
- Provides a commentary on progress to date based on the NNB GenCo External Hazards Tracking Table.

3 This Assessment Report provides a restricted scope preliminary assessment of this material because the assessment work has not progressed sufficiently at this time to draw firm conclusions, since Technical Support Contractor (TSC) work has not yet been completed. Nevertheless, preliminary conclusions and assessment findings are made regarding the most significant nuclear safety issues arising from external hazards considerations in PCSR 2012; these are not expected at this stage to be changed by subsequent detailed assessment. Remaining work will be covered by the detailed TSC assessment.

4 This AR has been written to support a Summary Assessment Report that addresses whether HPC PCSR2012 demonstrates suitable progress towards meeting ONR's requirement for an adequate Pre-Construction Safety Report. To this end this AR provides guidance through assessment findings on matters that need to be addressed in the next revision of HPC PCSR

1.1 Background

5 *External hazards and HPC Licensing*: An External Hazards AR supported the HPC Licensing decision, Ref. 3. This was published at about the same time as PCSR 2012 was submitted, and much of external hazards work now reported in the PCSR was made available to ONR as "Batch" submissions, to allow me to make an informed judgement in respect of whether or not to support granting of a License for the HPC site. Detailed assessment of these Batch submissions was not necessary in order to make a Licensing decision, but the limited assessment that was done plus routine engagement with NNB GenCo identified a small number of significant safety issues that need to be resolved before the first permissioning Licence Instrument can be issued. The elements of PCSR 2012 that relate to these issues are of particular interest here.

6 *Adequacy of design bases and the External Hazard tracking table*: The external hazards tracking table is a vehicle used by the Licensee to list all the external hazards considered to pose a credible challenge to nuclear safety at the HPC site. It also captures NNB GenCo's progress in completing the various hazard analyses required, makes the comparison between each external hazard design basis value and its associated site-specific challenge value. It also specifies whether NNB GenCo is claiming the design basis does / does not adequately bound the site challenge, or remains uncertain. It is the validity of these claims that are the subject of this AR. Some of these design bases were used by the Requesting Party (EDF and AREVA) to develop the UK EPR design

considered by the GDA project, and generally form the starting point for developing any site-specific design bases needed to design site-specific structures, systems and components (SSCs). If one or more of these design bases proves to be inadequate, then this implies that the plant design may also be inadequate and potentially undermines the quality of the overall station risk calculations.

1.2 Scope

7 This report covers Work Stream B7 External Hazards. Most of the material lies in HPC PCSR2012 Chapters 2 and 13.1, but additional relevant material exists in various other chapters and in detailed technical sections supporting these chapters.

8 Given that the work is not developed sufficiently at this time to draw firm conclusions, only a preliminary assessment is possible and the following approach has been used:

- Compare the latest version of the External Hazards Tracking Table made available to ONR on 25/11/13 (Ref.2) against the information provided in PCSR 2012 Chapters 2.1 and 2.2, to establish what progress has been made towards completion of all hazards analyses. Where hazard analysis work remains incomplete, this report will confirm that the Forward Work Programme identified in PCSR 2012 is still being progressed by NNB GenCo. The Forward Work Programme will be reviewed during the detailed assessment work to follow.
- From the significant external hazards issues identified in the Licensing AR, review in detail relevant sections of PCSR 2012 Chapters 2.2 and 13.1 to establish whether NNB GenCo is claiming these issues remain, or have been resolved. Form a judgment as to the adequacy of these claims. Additional post PCSR 2012 work has been reported through routine engagement with NNB GenCo during 2013; with the benefit of this evidence, form a view as to whether the list of significant issues identified in PCSR 2012 and their proposed resolution plans are reasonable.
- On the basis of the above tasks, form a preliminary view of progress to date in respect of defining:
  - An adequate set of design bases to support design of the UK EPR at HPC
  - An adequate set of beyond design basis definitions to provide high confidence that designs will fully meet the design bases.
  - Development of the external hazards PSA as an independent demonstration (to the deterministic design process) that the UK EPR design is consistent with keeping external hazard risks ALARP, and that these risks are taken into account when calculating the overall nuclear risk from the site.

1.3 Methodology

9 Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) procedure AST/003, Ref. 4. The ONR Safety Assessment Principles (SAP), Ref. 5, together with supporting Technical Assessment Guides (TAGs), Ref. 6, have been used as the basis for this assessment.

10 The methodology for the assessment follows the requirements of the ONR BMS ‘produce assessments’ step in the nuclear safety permissioning process and Ref 4, in particular in relation to mechanics of assessment.

11 PCSR 2012 follows on from the GDA Step 4 PCSR submitted to support the Design Acceptance Confirmation (DAC), Ref. 7. For many technical areas PCSR 2012 is a development from the GDA submission, but external hazards analysis is essentially a site-specific programme of work that is bespoke to the HPC site and is consequently not extensively covered in the GDA submission. The definitions of external hazards design bases used by the generic design are however important. The primary objective of this assessment is the comparison of both the GDA and site-specific derived design bases to confirm whether or not they bound the HPC site challenge.

2 ASSESSMENT STRATEGY

12 My assessment strategy is set out in this section. This identifies the scope of the assessment and the standards and criteria that have been or will be applied. It is based on the external hazards strategy document for HPC, Ref. 8 and consists of six tasks:

- Task 1: HPC – Assessment of seismic hazard and capable faulting analyses supporting PCSR
- Task 2: HPC – Assessment of accidental aircraft crash hazard analyses supporting PCSR
- Task 3: HPC – Assessment of PCSR 2012 and miscellaneous supporting external hazards analyses
- Task 4: HPC – Assessment of flood hazard analyses supporting PCSR; and
- Task 5: HPC – Assessment of Precipitation Effects and Surface Water on the HPC Site supporting the PCSR.
- Task 6: HPC – Assessment of Extreme Weather and Extreme Sea State supporting the PCSR.

13 These tasks collectively will provide a comprehensive assessment of external hazards aspects of PCSR 2012 and subsequent safety submissions leading to the first formal permissioning point: First Nuclear Safety Concrete.

14 *Role of this assessment report*: This document is the first of a series of assessment reports that will eventually support a permissioning recommendation from an external hazards perspective for First Nuclear Safety Concrete. The objective here is to identify any issues of substantive nuclear safety significance.

15 The document covers assessment work completed to date, including a preliminary assessment of PCSR 2012 itself, primarily Chapters 2.1, 2.2 and 13.1, plus a summary of related work undertaken both before the PCSR was published and afterwards. It therefore provides an up to date statement of progress of external hazards assessment for the HPC project. Detailed assessment of relevant PCSR chapters and associated supporting documents has not been undertaken at this stage, except for a few hazards as discussed in section 4. A full assessment will be undertaken subsequently in accordance with the strategy.

16 *Layout of this report*: Sections 3 and 4 of this report follow the general format: Identification and screening of external hazards; Design Basis Claims; Beyond Design Basis Analysis; and Overall risk and ALARP (as low as reasonably practicable) Claims. They also report on the closure of GDA Assessment Findings related to external hazards and provide an update on the NNB GenCo's post-Fukushima work stream.

2.1 Standards and Criteria

17 The relevant standards and criteria adopted within this assessment are principally the Safety Assessment Principles (SAP), Ref. 5, internal ONR Technical Assessment Guides (TAG) Ref. 6, relevant national and international standards and relevant good practice informed from existing practices adopted on UK nuclear licensed sites. The key SAPs and relevant TAGs are detailed within this section. National and international standards and guidance have been referenced where appropriate within the assessment report. Relevant good practice, where applicable, has also been cited within the body of the assessment.

2.2 Safety Assessment Principles

18 The key SAPs applied within the assessment are included within Table 1 of this report and include EHA.1 - Engineering principles: external and internal hazards – Identification, EHA.2 - Engineering principles: external and internal hazards – Data Sources, EHA.3 - Engineering principles: external and internal hazards – Design Basis Events, EHA.4 - Engineering principles: external and internal hazards – Frequency of Exceedance, and EHA.7 - Engineering principles: external and internal hazards – "Cliff Edge" Effects.

2.2.1 Technical Assessment Guides

19 The following Technical Assessment Guides have been used as part of this assessment, Ref. 6:

- T/AST/013

20 Two other ONR guidance documents are used. They concern Capable Faulting and Flood hazards:

- Ref.9: Guidance to Inspectors for the Assessment of Licensee Submissions Covering Capable Faulting Hazard.
- Ref.10: ONR & EA, Principles for Flood and Coastal Risk Management

2.2.2 National and International Standards and Guidance

21 A number of standards and guidance documents are used as part of this assessment. These are listed in T/AST/013, and typically include standards from IAEA, WENRA and the USNRC.

2.3 Use of Technical Support Contractors

22 A range of TSC work is underway, and this report offers a preliminary view on the PCSR2012, informed by the substantial levels of work undertaken as part of the Licensing review work.

23 ONR's Expert Panel on Seismic Hazard and Climate Change is a collection of competent consultants with relevant expertise in these technical areas. Their advice has been sought on the quality of the HPC seismic hazard, capable faulting, flood hazard and extreme weather hazard analyses supporting PCSR 2012.

24 Atkins provided a detailed review of NNB GenCo's coastal flood hazard analysis in 2010 to help form a regulatory view on the adequacy of the proposed platform height for the HPC nuclear island structures. This review supports the claims on platform height made in PCSR 2012 because this is based on the same technical work that ONR had reviewed in 2010, but further assessment, especially in respect of climate change effects, is still required. This is not pursued in this preliminary assessment, see para. 79 et seq.

25 Additional contractor support has/will be engaged as follows:

- Task 1: HPC – Assessment of seismic hazard and capable faulting analyses supporting PCSR

26 For the seismic hazard and capable faulting, detailed assessment will be undertaken by seismic hazard specialists from the Expert Panel.

- Task 2: HPC – Assessment of accidental aircraft crash hazard analyses supporting PCSR

27 This hazard will be undertaken by TSC.

- Task 3: HPC – Assessment of PCSR 2012 and miscellaneous supporting external hazards analyses

28 For the PCSR 2012 documents themselves, and supporting analysis documentation covering all external hazards except seismic and accidental aircraft crash, detailed assessment will be undertaken by a TSC.

- Task 4: HPC – Assessment of flood hazard analyses supporting PCSR; and
- Task 5: HPC – Assessment of Precipitation Effects and Surface Water on the HPC Site.

29 TSC support for these tasks will be provided by a contractor with site flooding and geotechnical expertise and will be managed as part of the TSC support for Task 3. Input from the Expert Panel in relation to climate change effects will also be sought and there will be a significant interface with civil engineering assessors.

- Task 6: HPC – Assessment of Extreme Weather and Extreme Sea State. (Level, wave climate, etc.)

30 This task will be covered by the Expert Panel augmented by a detailed assessment of PCSR 2012 safety case claims by the TSC covering Task 3.

31 *Scope of TSC work*: The scope is set out in the strategy document, Ref. 8, but at this stage is defined only in terms of the "desk work" that needs to be undertaken. An additional important component of this work can only be defined once the detailed assessment work in Task 3 has started, namely the scope of any additional work needed to support a permissioning recommendation for First Nuclear Safety Concrete. Examples to be considered include: site and plant inspections; research work; process inspections covering LC14 and LC23 activities generally that might impinge on the quality of safety submissions dealing with external hazards. Interfacing with the ONR project and site inspection leads for HPC are anticipated.

2.4 Integration with other Assessment Topics

32 External Hazards provides an input on withstand requirements to other disciplines. As such, various interfaces exist between external hazards and other ONR technical disciplines, especially civil engineering, internal hazards and PSA. Given the preliminary nature of the assessment reported here, these interfaces have not been interrogated in detail, but their importance is recognised here and a recommendation is made on ONR to formally identify them:

- *Civil engineering:* Ground water control of the main HPC site is a significant flood hazard issue that was identified before licensing and is being handled primarily by civil engineering assessors since this is considered a geotechnical issue. External hazards are relevant because groundwater under the site is primarily controlled by the height of the water table, which in turn is driven mainly by rainfall onto the areas surrounding the HPC site. Extreme low seawater temperature is also of potential interest to civil engineering assessors, but the PCSR claims that the value for this hazard defined during the GDA process will not be a requirement for the HPC specific intake structures; although a site-specific design value will be defined. These issues were considered during the assessment of the HPC Licensing submissions and are discussed further in section 4 of this AR.
- *Internal hazards*: There are many secondary hazards that can be initiated by an external hazard, such as fire or steam release following an earthquake. The fault sequences associated with these secondary hazards are typically similar to those

considered as internal hazards. This interface has not been progressed at this preliminary stage.

- *PSA*: This is being assessed primarily as part of the main station PSA by specialist PSA assessors, supported by myself. The nature of the interface is reported in the main text of sect. 4 with regard to the pace of development of NNB GenCo's external hazards PSA analysis, which took place as part of routine engagement after PCSR 2012 was published.
- *Emergency arrangements and severe accidents analysis*: Recently, especially since the Fukushima accident, external hazards are now explicitly considered as potential severe accident scenarios that need to be considered by the Licensee's on-site emergency arrangements and the Local Authority's offsite plan. This is in part because of the common cause nature of these hazards and their ability to affect both on-site, adjacent sites and off-site infrastructure simultaneously. This interface has not been progressed at this preliminary stage.

2.5 Out-of-scope Items

33 The external hazards analysis is generally only concerned with external hazards magnitude and frequency analysis, or for those few hazards analysed deterministically, with their maximum credible effect onto the HPC site. In both cases, the objective is to review the adequacy of the claims made in respect of individual external hazard design bases when compared to the site challenge defined by these hazard analyses. The adequacy of the plant designed in accordance to these design bases is not the subject of this assessment, but is covered by other discipline areas such as civil and mechanical engineering, PSA and fault studies.

34 Malicious aircraft crash hazard is a security related external hazard and will be assessed by other parts of ONR, however accidental aircraft crash is within the scope of this assessment, although has not been considered at this preliminary stage.

3 LICENSEE'S SAFETY CASE

3.1 HPC PCSR2012 Material Assessed

35 The majority of material relating to Work Stream B7 External Hazards is located in Chapters 2 and 13, specifically in sub-Chapters 2.1, 2.2, and 13.1. Other material is contained in the many documents submitted as part of PCSR 2012 to support these chapters.

36 In most technical areas, the site-specific elements of PCSR 2012 extend and add site-specific detail to those presented during the GDA process. For external hazards this is not the case. In this technical area the main input from GDA is the specification of external hazards design bases (e.g. seismic vibration, rainfall), or conditions that the site must satisfy to meet the intent of the generic design (e.g. the assumption of a dry site in respect of coastal flooding). The external hazards technical work by the Licensee is aimed primarily at supporting the GDA design bases and siting assumptions by site-specific technical work, or justifying changes if necessary.

37 Table 2 lists each external hazard considered by PCSR 2012, identifies where design values have been specified for the generic design (GDA value) and provides a summary of progress to date based on NNB GenCo's External Hazards Tracking Table, Ref. 2.

3.2 External Hazards Identification and Screening for the HPC Site

38 As a first step towards external hazards identification and screening for the HPC site, NNB GenCo performed a Hazard Identification Study and the results of this are summarised in PCSR Sub-Chapter 13.1 section 0.2.1, Ref. 12. The result of this study is a list of all external hazards considered as potentially applicable to the HPC site. The list is based on a literature search which encompassed guidance from the International Atomic Energy Agency (IAEA), Western European Nuclear Regulators Association (WENRA), EDF NGL internal guidance, United States Nuclear Regulatory Commission (US NRC), Nuclear Energy Agency (OECD NEA), the Health & Safety Executive (HSE), and other organisations. The list generated by the literature review was then confirmed by checking it against the list of external hazards considered during the GDA process.

39 Once this list of hazards had been compiled, NNB GenCo's next step was to perform a screening exercise for the HPC site. Hazards were screened out if their frequency of occurrence was judged to be less than 1×10^{-7} per annum based on a best-estimate assessment, or when their occurrence would have no significant effect on safety. The list of hazards is presented in this Assessment Report in Table 2 along with the results of the screening process.

40 *Capable Faulting*: NNB GenCo intend to demonstrate that Capable Faulting hazard can be screened out; if the hazard cannot be screened out, providing effective mitigation or protection against it would be challenging. When PCSR 2012 was submitted in December 2012, the screening process for Capable Faulting was ongoing and has since been submitted in May 2013, Ref.13. These submissions conclude that Capable Faulting can indeed be screened out on the basis of low frequency.

3.3 Design Basis Claims

41 For each external hazard that NNB GenCo did not screen out due to either low frequency or insignificant consequence, the definition of a design basis event is required [EHA.3]. External hazards are defined by NNB GenCo as design basis events at the following frequencies of occurrence:

- 1×10^{-4} p.a. (at 84th percentile confidence) for natural external hazards such as earthquakes,
- 1×10^{-5} p.a. for man-made external hazards such as industrial hazards.

42 For the majority of hazards, NNB GenCo has defined a design basis event for each hazard not screened out as part of the scoping exercise.

Comparison of UK EPR GDA Design Bases and HPC Site Challenge

43 For the majority of external hazards, including, for example, earthquake and air and seawater temperatures, the design withstand capacity for the EPR intended for Hinkley Point C was defined as part of the Generic Design Assessment (GDA). For these hazards, NNB GenCo has performed a verification of the bounding character of the GDA site envelope. NNB GenCo's conclusion is that the GDA site envelope is bounding for the majority of external hazards. The exceptions to this claim include High Air Temperature and High Sea Temperature. The PCSR sect. 7.1 states that low sea temperature for the GDA site envelope is the freezing point of sea-water, assumed to be approximately -1.6°C depending on salinity. However, site-specific work has indicated that sea-water salinity local to the Hinkley site may imply the need for a lower design basis value. The Licensee has further work planned to resolve this issue.

44 *High Air Temperature*: For this hazard the GDA value is 42°C (29% relative humidity) whereas the HPC site challenge at 10^{-4}/yr is 44 °C (26%). NNB GenCo is content with the hazard analysis performed and therefore recognises that the GDA design basis is inadequate. NNB GenCo has performed a safety study and claim that they can produce a solution by attending to plant-specific details to extend the performance of affected SSCs to meet the site challenge.

45 *High Sea Temperature*: For this hazard the GDA value is 26°C / 30°C whereas the HPC site challenge at 10^{-4}/yr is 30°C. NNB GenCo claim that a specific study will be carried out to evaluate the impact of high sea-water temperature above 26°C during normal operating transients and during design extension conditions, see Table 2.

46 *Seismic Hazard*: For this hazard sub-Chapter 2.2 of the PCSR, Ref.14, includes a justification that the site-specific and GDA Design Basis Earthquake spectra conservatively bound the assessed 10^{-4}/yr seismic hazard at the HPC site. This assessment is based on studies by AMEC and SHWP. See section 4 of this AR for more details.

47 *Extreme Low Sea Temperature*: This hazard was considered as part of the GDA process, but clogging by Frazil Ice is dealt with on a site-specific basis. This is because the extreme low seawater temperature for the GDA site envelope was taken to be the average freezing point of seawater (approximately -1.6°C, depending on salinity) and no further work was performed. NNB GenCo has now reported that the maximum recorded salinity at Hinkley Point corresponds to a sea-water freezing temperature of -1.8°C. Two separate studies have determined that the 10^{-4}/yr frequency sea-water temperature is slightly below the freezing temperature of -1.8°C, and hence the GDA value for extreme low sea temperature is not bounding for the HPC Site. Work is ongoing to finalise the low sea-water temperature design basis for HPC, see Table 2.

Comparison of Site-Specific Design Bases and HPC Site Challenge

48 Certain hazards, such as flooding due to extreme sea level, are considered as dependent on site-specific details to the extent that a generic design basis cannot usefully be

defined. Instead, it is left to the site-specific phase of work to develop appropriate design bases for these hazards based on the results of site-specific hazard analysis.

49 *Groundwater Control:* Groundwater control forms part of the external flooding hazard which also includes coastal flooding, rainfall and surface run-off, and cooling water system (CWS) trip due to a surge event in the forebay. NNB GenCo has assessed the external flooding hazard and adequacy of flooding protection provisions for the HPC site in site-specific studies.

50 NNB GenCo claims that the following protection measures protect the site against design basis external flooding, Ref.12:

- Setting of the platform level.
- Design of sea wall and wave-return wall able to withstand high waves. These protect the platform from erosion.
- The design of suitable water drainage systems and volumetric protection for rainwater and groundwater.
- Raised finished floor level of some safety buildings.
- For flooding from the CWS, fixed or mobile protection devices including control and instrumentation to detect the ingress of flood water.

51 Groundwater levels will be controlled by the installation of a drainage gallery, which discharges, under gravity, to one or both of the forebays. Although NNB GenCo considers that flooding assessment and mitigation are well advanced, including control of groundwater levels, a number of forward actions remain to be completed, see Table 2.

52 *Frazil Ice:* The potential for frazil ice formation depends on several factors including air temperature, water temperature, and salinity. NNB GenCo estimates the upper bound freezing sea-water temperature for HPC of -0.9° based on the lowest salinity recorded at HPB in the period 1981 to 2007. Considering the water freezing point criterion in isolation, the upper bound frequency of frazil ice formation at HPC is estimated to be slightly greater than 2.0×10^{-2}/yr and therefore the design must take into account the risks from frazil ice.

53 NNB GenCo state that the heat sink design has been assessed with respect to frazil ice and freeze-up, and is considered to be robust against these hazards. Work is ongoing to confirm this position, see Table 2.

54 *Bulk Freezing and Pack Ice*: NNB GenCo state that it is not credible for bulk freezing to occur to a sufficient extent at a frequency of 10^{-4}/yr to obstruct the flow of water into the intake heads and impair cooling safety functional requirements. This is due to the significant depth of water at this location, and the relatively short time over which the sea-water temperature would be below the nominal freezing point. NNB GenCo plan to perform a further study to confirm that the design provides adequate protection against bulk freezing at a return frequency of 10^{-4}/yr, see Table 2.

3.4 Beyond Design Basis Claims

55 PCSR 2012 makes a very limited number of references to Beyond Design Basis (BDB) external hazards event definitions. Chapter 13.1 section 1.1 notes that “Beyond …design basis frequencies, cliff edge effects are considered”, and goes on to reproduce the text from SAP EH.7, which is the relevant Principle here.

56 A BDB definition is provided for seismic hazard in the form of a Margin Earthquake at 1.6 times the DB earthquake level. For other natural hazards, e.g. flooding, the absence of cliff edges has been established by examination of the physical margin of protection measures over the design basis severity, or by engineering judgment. There do not appear to be BDB definitions for other hazards.

3.5 Balance of risk and external hazards risk ALARP claims

57 This aspect is being considered in detail by PSA colleagues in their AR covering PCSR 2012, and will be covered from an external hazards perspective during detailed assessment work to follow.

3.6 Closure of GDA Assessment Findings

58 At the end of the UK EPR GDA process, ONR issued a Design Acceptance Confirmation (DAC) accepting the generic AREVA design as, in principle, a licensable nuclear reactor system for use in the UK. At the same time a number of GDA Assessment Findings (AFs) were raised covering issues that needed resolution by the Licensee, NNB GenCo, during the site-specific phase of construction. A number of these GDA AFs have been identified by me as relevant to external hazards directly, or have some external hazards involvement; these are listed in Table 3.

59 The PCSR 2012 Head document, Ref.15, covers forward work programme activities and reports progress on the GDA AFs. This document notes that resolution plans will be drawn up at appropriate times depending on the permissioning milestone to which each AF is connected. Ref. 15 indicates that progress on the most urgent AFs is currently underway, and timescales have been specified, and in some cases the progress of resolution plans is noted as “routine business”. Ref. 15 only identifies AF-UK EPR-CE-056 as relevant to the external hazards topic area, noting that its resolution will be presented in future versions of the PCSR.

60 At a recent routine Level 4 meeting in November 2013, Ref.16, NNB GenCo presented progress on closure of AFs, noting that the following were “owned” by NNB GenCo external hazards specialists and had the following status:

GDA Assessment Finding	Status
AF-UK EPR-CE-001	Considered closed
AF-UK EPR-CE-002	Considered closed
AF-UK EPR-CE-003	Considered closed
AF-UK EPR-CE-051	Considered closed
AF-UK EPR-CE-056	Superseded by AF-UK EPR-CC-23
AF-UK EPR-CE-057	Resolution for PCSR 3
AF-UK EPR-CC-023	Resolution plan in production

61 The status of other AFs relevant to external hazards was not reported. A sampled assessment of AFs in Table 3 will be undertaken when the resolution plans become available.

3.7 Progress with post Fukushima work

62 NNB GenCo responded to both the “Weightman reports” and the ONR Stress Test report in line with other UK Licensees, Ref.17. HPC was not a licensed site at that time (May 2012), but given the maturity of NNB GenCo’s project, they decided to respond as if they were a licensee. ONR assessed the NNB GenCo response and this was published as ONR’s Fukushima “Implementation report”, Ref.18. The NNB GenCo report noted that the

lessons learned from the Fukushima event would be fed into the normal design process for HPC and ONR accepted this as a reasonable way to proceed.

63 PCSR 2012, Ref.12, reinforces this view, referring to a number of issues identified by NNB GenCo as specific enhancements to the engineered and local building flood defences that will be reported in due course.

4 ONR ASSESSMENT

64 This assessment has been carried out in accordance with ONR HOW2 BMS policy (Ref.4).

4.1 Scope of Assessment Undertaken

65 The scope of the full assessment is set out in Section 2 and refers the strategy document [8]. The elements of the strategy that will not be undertaken as part of this preliminary assessment, or assessment work that is reported on submissions that do not form part of PCSR 2012, are detailed as follows:

- Task 1: HPC – Assessment of seismic hazard and capable faulting analyses supporting PCSR

66 Preliminary assessment was undertaken on NNB GenCo's initial seismic hazard analysis by the Expert Panel and regulatory comments made and communicated to NNB GenCo by letter, Ref.11, in March 2012. A revised analysis is still awaited by ONR and NNB GenCo recognises that PCSR 2012 is deficient in this respect.

67 The relevant documents dealing with the Capable Faulting hazard do not form part of the PCSR 2012 submission, but were submitted subsequently in May 2013. A preliminary assessment has been made of these documents and is reported herein. A detailed assessment has had to wait for the development of ONR guidance on this subject, Ref. 9. This has matured to the stage where it has just become available to be incorporated into the guidance already in TAG 13, and will enable a detailed assessment of the submission to be undertaken in due course.

- Task 2: HPC – Assessment of accidental aircraft crash hazard analyses supporting PCSR

68 Detailed assessment will be undertaken by a TSC but this must wait until the TSC has been engaged, which will be in early 2014.

- Task 3: HPC – Assessment of PCSR 2012 and miscellaneous supporting external hazards analyses

69 Detailed assessment will be undertaken by a TSC but this must wait until the TSC has been engaged, which will be in early 2014.

- Task 4: HPC – Assessment of flood hazard analyses supporting PCSR; and
- Task 5: HPC – Assessment of Precipitation Effects and Surface Water on the HPC Site.

70 Preliminary assessment has already been undertaken on the adequacy of platform level to sea flooding by Atkins and some input from the Expert Panel on climate change effects has been made; both aspects are reported at para. 89. Detailed assessment work is still needed and will be provided through TSC support for Task 3.

- Task 6: HPC – Assessment of Extreme Weather and Extreme Sea State.

71 Preliminary assessment of PCSR 2012 supporting documents on extreme weather and extreme sea states has been undertaken by climate change specialists on the Expert Panel and is reported herein. However, this work needs to be augmented by a detailed assessment of PCSR 2012 provided through TSC support for Task 3.

Additional Out of Scope Items

72 This preliminary assessment and the assessment undertaken for Licensing of the HPC site did not consider those external hazards judged to be of minor significance, e.g. biofouling hazards and industrial hazards generally, so no assessment has yet been undertaken for these. This will be done as part of the general PCSR 2012 assessment work (Task 3) once a TSC has been engaged for this work.

4.2 Assessment

4.2.1 External Hazards Identification and Screening for the HPC Site

73 The external hazards identification and screening process performed by NNB GenCo, for the majority of hazards, appears to have been subject to a rigorous and thorough process that is aligned with the expectations of ONR TAG 13, Ref.6; this will be confirmed as part of the detailed assessment under Task 3. The exception to this statement is the screening of the Capable Faulting Hazard, which was not complete at the time of PCSR submission.

74 A series of separate exercises has been performed to screen out the Capable Faulting Hazard, and the latest report was received by ONR in May 2013, Ref.13. The May 2013 submission has been considered by NNB GenCo's internal reviewers, by their own external reviewers (BGS and others), and by ONR's Expert Panel, Ref.19. The conclusion by NNB GenCo and their own external reviewers is that the Capable Faulting Hazard can be screened out.

75 ONR's expert panel confirmed that this conclusion "may well be appropriate," but raised concerns at the quality of the submission. Criticisms included the lack of fault rock characterisation and mechanics, lack of stress and slip-tendency analysis, and the lack of integration of geology and seismicity. The Expert Panel also recommended that the provision of a 3D geological model for the site would be in line with modern good practice.

76 I agree that the provision of additional information along with a geological model would provide further assurance regarding the characterisation of the capable faulting hazard for the site. However, I judge that sufficient information has now been provided that it is likely to support NNB GenCo's claim that capable faulting hazard can be screened out on the basis of low frequency, but this will be confirmed by completion of assessment work by the Expert Panel.

77 As noted in Section 3.3 of this report, work is currently ongoing by NNB GenCo to further analyse the seismic hazard at the site. It would be appropriate for this work to feed into the capable faulting analysis in order to strengthen its conclusions, when it becomes available.

4.2.2 Design Basis Claims

78 NNB GenCo's approach toward the definition of design basis events is in accordance with the SAPs, in particular SAPs paragraph 212 and EH.3 and appears at this preliminary stage to be acceptable. I judge that this approach is therefore acceptable. There are a number of forward actions related to the definition of design basis events for external hazards as detailed in Table 2. On the basis that this is a preliminary assessment of PCSR 2012, only the issues relating to NNB GenCo's design basis claims that I consider the most significant are discussed in the relevant sections below.

79 Climate Change effects are relevant to a number of External Hazards including high and low air and sea temperatures, and sea levels, wind speed, rainfall and storm severity. An assessment of the consideration of climate change for high and low air and sea

temperatures and sea levels in a number of documents supporting the PCSR 2012, Refs. 20, 21, 22, 23, 24, 25, 26, 27, 28, has been performed by ONR's Climate Change Expert Panel, Ref.29 (the Expert Panel has not yet assessed wind speed, rainfall, or storm severity). The main thrust of the comments received from the Expert Panel relate to the fact that several of the assessments have taken a potentially non-conservative view of possible climate events by the end of this century. In addition, consideration of the North Atlantic Oscillation (NAO)[1] appears not have been performed and excursions in NAO behaviour seem to have been dismissed. Finally, data quality is poor in some cases, particularly in the assessment of Low Sea Temperatures, and this is compounded by the dismissal of outliers from the data, although the PCSR does allude to the problem of poor quality data.

80 I agree with the judgments provided by the Expert Panel. However, a mitigating factor is that the effects of climate change will be reviewed at each Periodic Safety Review (PSR). In the case of flooding from extreme sea levels, the height of the "possible setback wall" (PCSR sect. 5.3.1) can be increased in case climate change is more severe than predicted (PCSR sect. 5.3.1.4). This is an example of the "managed adaptive approach" recommended within the Flood Principles issued jointly by the ONR and the Environment Agency, Ref 10.

81 We recognise that there are some issues that we will consider as part of the detailed assessment tasks. These include the treatment of non-stationary data series and other sources of uncertainty.

Comparison of UK EPR GDA Design Bases and HPC Site Challenge

82 *High Air Temperature, High Sea Temperature*: NNB GenCo has assessed these hazards at the Hinkley Point site and found that the GDA values do not bound the site challenge values, see Table 2. NNB GenCo are committing to provide solutions by modifying SSC designs affected by High Air Temperature hazard, and undertaking a specific study to evaluate the impact of high sea temperature during normal operating transients, and during so called "design extension conditions"[2]. Both of these commitments form Forward Work Programmes (FWPs) and are listed in Table 2 of this report. I recognise that for extreme high air and sea temperatures, advanced warning is possible, and time would likely be available to implement additional protection measures or possibly even station shutdown. This makes these hazards more amenable to solutions involving plant modifications and operator actions in response to weather warnings from UK agencies. This issue with be considered further during Task 3, with discussion with relevant technical disciplines, see Recommendation 2. I am content in principle with NNB GenCo's approach to these hazards, and will confirm that the approach is adequate when the detailed PCSR 2012 assessment is undertaken. An aspect that may not have been captured by NNB GenCo's approach is an adequate application of the hierarchy of safety principle, EKP.5.

83 *Low Sea Temperature:* NNB GenCo has made a commitment as part of a FWP to determine the extreme low seawater temperature, taking due cognisance of the salinity of the water in the Bristol Channel. The results will then be used to complete the design of

[1] The NAO is a large-scale mode of natural climate variability that has important impacts on the weather and climate of the North Atlantic region and surrounding continents, especially Europe.

[2] ONR does not recognise the terms Design Extension Conditions, which has been introduced recently by, for example, IAEA, Ref 30, as an approach to beyond design basis and cliff edge analysis.

the Balance of Nuclear Island (BNI) and the sizing of the bypass for the exchanger. While I welcome this commitment, I remain concerned regarding the quality of the previous Low Sea Temperature submissions. One of the comments made by ONR's Expert Panel on the previous submission, as stated above, was that data quality is poor and is compounded by the removal of outliers from the data. The additional analysis to be performed as part of the FWP will be assessed by the Expert Panel, to ensure that there has been an improvement in the quality of data used, or the uncertainty brought about by using poor quality data is fully accounted for in accordance with SAP EHA.2

84 Advice from ONR Civil Assessors indicates that low sea temperature is not a hazard that has a nuclear safety significance in and of itself, but frazil ice is a potential hazard. Frazil Ice is discussed in Paragraph 90 of this assessment report. PCSR 2012 also implies that low seawater temperature is not a significant hazard – this will be taken forward as part of Recommendation 2 with other assessors.

85 *Seismic Hazard*: Seismic hazard has been the subject of ongoing discussions and meetings post- PCSR 2012 submission due to the gap between the work performed by NNB GenCo to define the design basis earthquake, and the expectations of ONR in that regard. NNB GenCo's original design basis earthquake submission was essentially a rebranding of the SHWP seismic analysis performed for the Hinkley Point B site. This SHWP work was a product of its time and does not conform to modern standards. These documents were assessed in some detail by ONR's Expert Panel; this led to the issue of a regulatory letter, Ref.11, advising that the analysis was not adequate, and listing a large number of detailed technical points to be addressed. This position was accepted by NNB GenCo and is reflected in sub-Chapter 13.1 of PCSR 2012. The Licensee intends to commission further work to address ONR's concerns, and this is noted in the Forward Work Programme, see Table 2. Further discussions and meetings ensued but little progress on performing an adequate seismic hazard analysis has been made to date. In October 2013 a regulatory issue (1794) was raised to highlight my concern on this matter.

86 On 28 November 2013 a meeting took place between NNB GenCo and ONR where NNB GenCo confirmed its commitment to perform further seismic hazard analysis work, including both probabilistic and deterministic workstreams. I welcome this commitment from NNB GenCo, and ONR will assess future submissions from NNB GenCo on these matters once they become available. In the meantime, one of the results of this assessment is that issue 1794 should be amended to make it SMARTer:

The Licensee shall complete the seismic hazard forward work programme to confirm the seismic design basis to be used for plant design before end December 2014.

87 *Other GDA Design Bases*: No significant issues have arisen during this preliminary assessment. Further consideration will be given during the detailed assessment of PCSR 2012 in accordance with the strategy defined in Ref. 8.

Comparison of Site-Specific Design Bases and HPC Site Challenge

88 *Groundwater control:* Groundwater control is a requirement of the civil engineering design process because high water table levels can cause foundation stability problems for deeply founded structures, such as the CW Pumphouse. This is being considered primarily as a geotechnical issue by civil engineering assessors, see section 2. Groundwater drainage effectively controls the water table height, but the quantities of water that need to be removed from the site depend on off-site rainfall levels and groundwater drainage flows under the site. Further consideration will be given during detailed assessment with TSC support. ONR external hazards and civil engineering

assessors will ensure that the external hazard severity and civil assessment is joined up as part of this detailed assessment. This will be taken forward as part of Recommendation 2.

89 *Coastal flooding*: NNB GenCo has performed work to set the platform height, but a preliminary assessment by ONR concluded that the effects of climate change may not have been adequately addressed, based on work by the Expert Panel that is still ongoing. NNB GenCo intend the HPC sea defences to be adaptable to cope with future climate change effects, I consider it likely that the currently stated platform height will prove to be adequate, but this must remain a preliminary judgment until detailed assessment is complete. NNB GenCo has a number of forward actions planned for external flooding analysis and these will be the subject of detailed assessment in due course, see Table 2.

90 *Frazil Ice:* For this hazard no specific design basis is available, but implicitly the requirement is that blockage sufficient to impair cooling safety functions must not occur. I recognise that NNB GenCo has agreed a forward action to confirm the design provides adequate protection against frazil ice and similar work is planned for bulk freezing, see Table 2. At present, the discussion of bulk freezing in the PCSR is essentially qualitative and no quantitative evaluation is in evidence and the rationale for selecting the design basis for bulk freezing is unclear. A forward work plan action address this issue and this will be subject to consideration during the detailed assessment of the PCSR.

91 The assessment of the design withstand for frazil ice and bulk freezing takes into account the presence of four intake heads and cross-linked forebays. While this is an example of redundancy, there is no argument presented in terms of diversity or separation, and as the intake heads are located fairly close together it seems reasonable to conclude they would all be affected in the same way by frazil ice and bulk freezing. I am therefore not convinced that an adequate case has been made and I await the results of the forward action before making a judgement on this hazard. It is not clear from the PCSR chapters reviewed what the ultimate heat sink is and therefore how significant a hazard frazil ice is to nuclear safety. This will be pursued with other assessors through routine Level 4 meetings, but is raised as a new issue:

The Licensee shall complete the HPC frazil ice hazard analysis in order to meet the timescales for permissioning First Nuclear Safety Concrete.

92 *Other Site Specific Design Bases*: No significant issues have arisen during this preliminary assessment in respect to other design bases. Further consideration will be given during the detailed assessment of PCSR 2012.

4.2.3 Beyond Design Basis Claims

93 SAP EH.7 identifies the need for safety cases to demonstrate the absence of cliff edges for all credible external hazards. The Beyond Design Basis analysis for each hazard helps to demonstrate that the design basis contains an adequate level of conservatism, as required by SAP EH.4. There are two issues to address in relation to beyond design basis plant response:

- The absence of cliff edges, i.e. a small change in DBA parameters should not lead to a disproportionate increase in radiological consequences.
- *Seismic hazard*: Representative fragility curves from the literature for nuclear quality SSCs generally have median failure capacities beyond the design basis. This implies that most of the seismic risk is likely to be accrued in this region. It is unclear whether similar conclusions can be drawn for other hazards, but this will be pursued through routine engagement with the Licensee.

94 As noted in section 3.4, the PCSR addresses the first point explicitly only in respect of seismic hazard, where a Beyond Design Basis event is defined as 60% above the design basis, although physical margins implicit between protection measures and design basis hazard severity are examined for other natural hazards. The PCSR implicitly claims that the margins analyses undertaken for these hazards demonstrate the absence of cliff edges, but such arguments would benefit, where practicable, from a link back to the frequency of hazard occurrence. This could be done within Chapter 13.1 to provide context to the stated margins. For example, does the 2.28m claimed for coastal flooding in Chapter 13.1, section 5.3.1.2 provide a large margin, or only a small margin that might be completely consumed by the arrival of a flooding event just beyond the design basis? This aspect will be examined again when the detailed assessment of the PCSR is undertaken and is identified as a new issue here:

The Licensee shall develop a philosophy for its treatment of Beyond Design Basis external hazards and identify a forward work programme for its implementation consistent with the requirements of the overall design process.

95 The external hazards PSA would be expected to address the second aspect directly, but is not well developed at this time. This is identified as a shortfall and is a specific element that is covered generally by a number of existing GDA PSA Assessment Findings: AF-UK EPR-PSA-002, AF-UK EPR-PSA-031, AF-UK EPR-PSA-032 and AF-UK EPR-PSA-037. In addition ONR's assessment of the PCSR 2012 PSA has raised an issue relating to completeness of the HPC PSA model.

4.2.4 External hazards risk contribution ALARP claims

96 This aspect is being considered in detail by PSA colleagues in their AR covering PCSR 2012, and will be covered from an external hazards perspective during detailed assessment work to follow.

97 As noted in para. 93, the majority of seismic risk is expected from the beyond design basis region. It is therefore important that a link is made between the Beyond Design Basis analysis and relevant parts of the PSA, so that the claims made in both areas are consistent, and collectively contribute towards a demonstration that station risk is ALARP. This issue will be pursued as part of normal regulatory business through routine Level 4 meetings

4.2.5 Closure of GDA Assessment Findings

98 There is nothing in PCSR 2012, or provided through routine Level 4 interactions more recently, to assess in respect of GDA Assessment Findings. Assessment work will be undertaken when submission of resolution plans is received in due course.

99 The set of AFs considered by NNB GenCo to be relevant to external hazards was provided at a recent Level 4 meeting on 28th November 2013. This set differs from the one I would have expected, which is given in Table 3. These differences will be reviewed at the next routine Level 4 meeting with NNB GenCo. A finding is not raised in this report because there may be good reason why NNB GenCo is dealing with them in this way. The AFs at issue are:

AF-UK EPR-CE-021	Not captured by ONR's external hazards assessment
AF-UK EPR-CE-054	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-CE-058	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-CE-069	Not captured by ONR's external hazards assessment
AF-UK EPR-CE-073	Not captured by ONR's external hazards assessment

AF-UK EPR-CE-074	Not captured by ONR's external hazards assessment
AF-UK EPR-CE-079	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-ME-020	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-PSA-002	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-PSA-028	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-PSA-031	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-PSA-032	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-PSA-037	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-PSA-038	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-PSA-044	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-SI-032	Not captured by NNB GenCo's external hazards assessment
AF-UK EPR-EE-026	Not captured by NNB GenCo's external hazards assessment

100 However, milestones by which some AFs will be addressed are queried here. Of concern is a subset of AFs, which if resolved at the milestones specified in Table 3, would not be applied to SSCs designed and constructed to meet early milestones. For example, AF-UK EPR-CE-059 requires confirmation that seismic fragilities are valid for HPC site conditions by *Fuel Load*. It is not clear to me why seismically vulnerable plant to be designed and installed following permissions granted for earlier milestones, would not benefit from application of seismic fragility analysis (see also PSA AR finding AF-HPC-PCSR2012-PSA-006). The following AFs in Table 3 are affected:

AF-UK EPR-CE-059
AF-UK EPR-CE-060
AF-UK EPR-CE-061
AF-UK EPR-CE-066
AF-UK EPR-PSA-002
AF-UK EPR-PSA-031
AF-UK EPR-PSA-037
AF-UK EPR-PSA-038
AF-UK EPR-CC-13

The Licensee has reviewed all GDA Assessment Finding timescales to ensure they meet the needs of all plant & SSCs to which they apply. This aspect will be pursued as part of normal regulatory business through routine Level 4 meetings and the ability to influence timescales is available as part of the existing arrangements for resolution of GDA AFs.

4.2.6 Progress with post Fukushima work

101 As noted in section 3.8, there is no Fukushima specific work reported in PCSR 2012 and therefore nothing to assess at this time. NNB GenCo has claimed that the lessons from the Fukushima event will be incorporated into the design as part of routine business. ONR's review of NNB GenCo's response to this event, Ref. 31, concluded that this was a reasonable claim, given that the HPC project was still at the design stage.

4.3 Comparison with Standards, Guidance and Relevant Good Practice

102 Comparison with codes and standards, where relevant, has been done within section 4.2 of this report.

5 CONCLUSIONS AND RECOMENDATIONS

5.1 Conclusions

103 This report presents the findings of ONR's assessment of the external hazards aspects of the Hinkley Point C PCSR 2012 safety submission. It represents a preliminary assessment only because detailed work needs to be undertaken by a TSC and this will begin in early 2014.

104 I am content with the work that has been presented, although there are significant areas where a programme of forward work has been specified. The most significant issues are:

- The Licensee shall complete the seismic hazard forward work programme to confirm the seismic design basis to be used for plant design before end December 2014. (Level 3 Issue)
- The Licensee shall complete the HPC frazil ice hazard analysis in order to meet the timescales for permissioning First Nuclear Safety Concrete. (Level 4 Issue)
- The Licensee shall develop a philosophy for its treatment of Beyond Design Basis external hazards and identify a forward work programme for its implementation consistent with the requirements of the overall design process. (Level 4 Issue)

105 This assessment has also identified the following issues to be taken forwards as part of routine engagement through Level 4 meetings with the Licensee and interfacing with other ONR assessors:

- Completion of the external hazards PSA and the availability of PSA results to inform the design process in a timely manner and ensure the overall plant risk is as low as reasonably practicable (ALARP). This issue is being taken forwards primarily by PSA assessors.
- Resolution of the groundwater control issue so that deeply founded structures are able to deliver all their safety functions through the life of the facility. This issue is being taken forwards primarily by civil engineering assessors.
- Re-examine the GDA Assessment Finding milestone dates to gain confidence that the work identified in each finding is undertaken in time to benefit all relevant structures, systems and components (SSCs).

5.2 Recommendations

106 There are no recommendations.

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Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No.	SAP Title	Description
EKP.5	Safety Measures	Safety measures should be identified to deliver the required safety function(s).
EHA.1	Identification	External and internal hazards that could affect the safety of the facility should be identified and treated as events that can give rise to possible initiating faults.
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.
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, a design basis event should be derived.
EHA.4	Frequency of Exceedance,	The design basis event for an internal and external hazard should conservatively have a predicted frequency of exceedance in accordance with the fault analysis requirements (FA.5).
EHA.7	“Cliff Edge” Effects	A small change in DBA parameters should not lead to a disproportionate increase in radiological consequences.
Para. 212	Screening	Any generic type of hazard with a total frequency that is demonstrably below once in ten million years may be excluded. Any generic type of hazard, the impact of which has no effect on the safety of the facility, can also be excluded. This screening should retain all hazards for which the frequency of realisation and the potential impact might make a significant contribution to overall risks from the facility.
FA.10	Need for PSA	Suitable and sufficient PSA should be performed as part of the fault analysis and design development and analysis.

Table 2

Summary of status of external hazards considerations in the Hinkley Point C

Highlighted figures define the expected hazard values for the design envelope

Highlighted figures represent works not yet complete, where a hazard value is yet to be defined

External Hazards		HPC relevant	GDA Value	HPC PCSR Value (12/01/2013)	Commentary on Progress and Work Completed (20/12/2013)
Primary	**Type**				
Earthquake	Ground vibration	Y	Structures - 0.25g EUR hard ground. Plant & equipment – 0.25g EUR envelope of ground conditions.	AMEC 1 x 10-4/yr URS SHWP 1 x 10-4/yr URS Modified GDA bounding Spectrum	Work Ongoing to be included in PCSR3 -13.1_FWP_2.1 -13.1_FWP_2.3 -13.1_FWP_2.5 -13.1_FWP_2.8
	Ground rupture (Capable Faulting)	Not defined	N/A	Not yet confirmed	Work complete. 0.0m displacement at 1 x 10^{-7}/yr 0.1m displacement at 1 x 10^{-8}/yr Submitted to ONR May 2013, see Ref. 13 See this AR sect. 3.4 & 4.4
	Tsunami	Y	N/A	Tide & Surge Coastal Flooding 1 x 10^{-4}/yr (bounds tsunami)	Work Ongoing to be included in PCSR3 -13.1_FWP_5.3
	Long Period Ground Motion	Y	N/A	Not yet confirmed	Work Ongoing to be included in PCSR3 -13.1_FWP_2.2
Geotechnical	Slope instability	Y	Site-specific	No specific value, design to withstand / mitigate	Work Ongoing to be included in PCSR3 Geotechnical Design Report in preparation.
	Settlement	Y	Site-specific	No specific value, design to withstand / mitigate	

Table 2

Summary of status of external hazards considerations in the Hinkley Point C

Highlighted figures define the expected hazard values for the design envelope

Highlighted figures represent works not yet complete, where a hazard value is yet to be defined

External Hazards			HPC relevant	GDA Value	HPC PCSR Value (12/01/2013)	Commentary on Progress and Work Completed (20/12/2013)
Primary	Type					
						Civil engineering leading
	Liquefaction & Dynamic Compaction		Y	Site-specific	No specific value, excluded by design – nature of material such that it will not liquefy.	Work Ongoing to be included in PCSR3 -13.1_FWP_2.6
Aircraft impact	Accidental		Y	5.5 10^{-7}/yr	Not yet confirmed	Work Ongoing to be included in PCSR3 Assumption that the aircraft shell will withstand any aircraft impact. For other unshielded buildings GDA bounds.
	Malicious		Y		Screened Out	Addressed in security submissions, Civil engineering leading
Extreme weather	Wind Loading / Speed		Y	From Eurocodes 60m/s, 1.6kN/m^2 (FA3 figure at 10m) Site-Specific Tornados Screened out	From Eurocodes 50.1m/s, 1.54kN/m^2	Work ongoing to be included in PCSR3 -13.1_FWP_6.4
	Tornado		Y		45.2 m/s (tornado) 51.2m/s (tornado & conventional wind speed) Max pressure drop 2068Pa Max dP/dt 1190Pa/s	Work ongoing to be included in PCSR3 13.1_FWP_6.3
	Air Temp. High	- Instantan.	Y	42°C (29% rh)	44 °C (26%)	Work ongoing to be included in PCSR3. See this AR sects. 3.4 & 4.4
		-12hr mean	Y	36°C (40% rh)	40 °C (32%)	
	Air low	-Long duration (7-		-15°C	-6.1°C	

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External Hazards			HPC relevant	GDA Value	HPC PCSR Value (12/01/2013)	Commentary on Progress and Work Completed (20/12/2013)
Primary	Type					
		day mean)				
		-Daily mean		-25°C (7 days)	-10.9 °C	
		-Instantan.		-35°C (6 hours)	-12.3°C	
	Sea Temp	High		26°C /30°C[3]	30°C	Work ongoing to be included in PCSR3. 13.1_FWP_6.1
		Low		-1.6°C	<-1.8°C	Work ongoing to be included in PCSR3. 13.1_FWP_6.5
	Rain	15 min		Site-specific	171.7mm	Work ongoing to be included in PCSR3. 13.1_FWP_5.6 13.1_FWP_5.11 Addressed in drainage system design
		1hr		Site-specific	197.5mm	
		24hr		Site-specific	294.8mm	
	Snow Loading		Y	1.30kN/m^2	1.08kN/m2 (55.8cm depth)	Work ongoing to be included in PCSR3.
	Snow & Wind		Y	Screened out	Emergency procedures in case of snow & wind	Work ongoing to be included in PCSR3.

[3] 26°C for normal operation (PCC-1) and for operating conditions with multiple failures (RRC-A and RRC-B) 30°C for reference transients, incidents and accidents (PCC-2, 3, 4)

Table 2

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External Hazards		HPC relevant	GDA Value	HPC PCSR Value (12/01/2013)	Commentary on Progress and Work Completed (20/12/2013)
Primary	Type				
	Hail	Y	Screened out Bounded by snow and frazil		Work ongoing to be included in PCSR3. 13.1_FWP_6.8
	Other:				
	-Freezing rain	Y	LOOP only	Screened out	Work ongoing to be included in PCSR3.
	-Frazil ice	Y	Site specific	-0.9 °C Upper bound freezing point	Work ongoing to be included in PCSR3. 13.1_FWP_8.2
	Lightning	Y	200kA	Not yet confirmed	Work ongoing to be included in PCSR3. 13.1_FWP_7.1 13.1_FWP_7.2
	Low sea water level	Y	Site specific	-7.62mAOD	Work ongoing to be included in PCSR3. 13.1_FWP_6.7
	Sea- High level	Y	Site-specific	8.62mAOD high sea water level (tide & surge) +0.9 (2080) or 1.0m (2110) for sea climate change allowance for 60/100 year structures 8.46m wave height +0.5m wave climate change	Work ongoing to be included in PCSR3. 13.1_FWP_5.1 13.1_FWP_5.3 13.1_FWP_5.4 13.1_FWP_5.5

Table 2

Summary of status of external hazards considerations in the Hinkley Point C

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External Hazards		HPC relevant	GDA Value	HPC PCSR Value (12/01/2013)	Commentary on Progress and Work Completed (20/12/2013)
Primary	**Type**				
				allowance	
Flooding	River		Site-specific	Not applicable	Screened out
	Ground run-off	Y	Site-specific	See Rainfall	Work ongoing to be included in PCSR3. 13.1_FWP_5.6 13.1_FWP_5.11 Addressed in drainage system design
	Groundwater	Y	Site-specific	Not confirmed yet Drainage Gallery at 8.0mAOD	Work ongoing to be included in PCSR3. Drainage gallery level subject to change and 7.0mAOD proposed by NNB Genco. NNB GenCo is developing a Groundwater Safety Strategy Document – see Civil Engineering Assessment Report AR-13-080.
	Other, e.g. dams		Site-specific	Not applicable	Screened out
	Marine organisms by sea	Y	Site-specific	0.18/yr	Work ongoing to be included in PCSR3. 13.1_FWP_8.3
Biological fouling	Infestation by land	Y	Site-specific	Negligible	Work ongoing to be included in PCSR3.
Other off-	EMI	Y	1V/m	<0.4V/m	Work ongoing to be included in

Table 2

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External Hazards		HPC relevant	GDA Value	HPC PCSR Value (12/01/2013)	Commentary on Progress and Work Completed (20/12/2013)
Primary	**Type**				
site hazards					PCSR3. 13.1_FWP_7.4 13.1_FWP_7.5 13.1_FWP_7.6
Solar Activity	Coronal Mass Ejection Geomagnetically Induced Currents	?	N/A	Not confirmed yet	Work ongoing to be included in PCSR3. 13.1_FWP_7.3
Industrial Hazards	Chemical release	Y	Site specific	Ammonia (dilute, 20% & 35%), CO2 & Hydrazine assessed as bounding events.	Work ongoing to be included in PCSR3. 13.1_FWP_4.1
	Explosion	Y	[redacted]	[redacted]	Work ongoing to be included in PCSR3.
	Fire	Y	[redacted]	[redacted]	Work ongoing to be included in PCSR3.
	Vehicles	Y	Site specific Frequency of road or maritime accident which would threaten the plant safety by a chemical release drift < 10^{-5}/year	Chemical deliveries to site Assumed that risk is lower than 1 x 10^{-5}/yr	Work ongoing to be included in PCSR3.
	Ship collision	Y	Site specific	Frequency of ship striking: One intake $3x10^{-6}$/yr (most exposed	Work ongoing to be included in PCSR3.

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External Hazards		HPC relevant	GDA Value	HPC PCSR Value (12/01/2013)	Commentary on Progress and Work Completed (20/12/2013)
Primary	**Type**				
				intake) Two intakes (different tunnels) 1.4×10^{-12}/yr (worst intake orientation)	
	Grid reliability	Y	[redacted]	[redacted]	Work ongoing to be included in PCSR3.
	HPB turbine disintegration	Y	Site specific	Frequency 7.68×10^{-7}/yr	Work ongoing to be included in PCSR3.

Table 3

UK EPR GDA Assessment Findings Relevant to External Hazards

Unshaded – External hazards is primary interest, Shaded – external hazards has a contributing interest

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-UK EPR-CE-001	The Licensee shall examine the potential for EMI, Industrial hazards, transport threats, fire and release of chemical/toxic material from adjacent sites once a site has been chosen.	First structural concrete
AF-UK EPR-CE-002	The Licensee shall derive hazard magnitudes on a site specific basis for those hazards screened out as only capable of evaluation on a site specific basis, including rainfall, flooding, biological fouling and infestation.	First structural concrete
AF-UK EPR-CE-003	The Licensee shall confirm that the magnitude of all external hazards considered generically envelope those for the particular site under consideration	First structural concrete
AF-UK EPR-CE-004	The Licensee shall confirm that for any structure designed using generic site data that that data is enveloped for the particular site under consideration	First structural concrete
AF-UK EPR-CE-020	The Licensee shall ensure that due regard is taken of the effects of Structure- Soil Structure Interaction in the seismic analysis of the Class 1 and 2 structures.	First structural concrete
AF-UK EPR-CE-029	The Licensee shall demonstrate the suitability of the equivalent lateral load method for the application of seismic loads to Seismic Class 1 and 2 structures if this approach is used.	Nuclear island safety related concrete
AF-UK EPR-CE-030	The Licensee shall demonstrate the stability of the NAB in terms of sliding and overturning under seismic loading.	Nuclear island safety related concrete
AF-UK EPR-CE-050	The Licensee shall undertake site specific analyses of the behaviour of the nuclear island under aircraft impact to confirm the in-structure responses are within the GDA	Install polar crane

Table 3

UK EPR GDA Assessment Findings Relevant to External Hazards

Unshaded – External hazards is primary interest, Shaded – external hazards has a contributing interest

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
	envelope	
AF-UK EPR-CE-051	The Licensee shall undertake a probabilistic study of accidental aircraft impact on a site specific basis.	Install polar crane
AF-UK EPR-CE-054	The Licensee shall provide justification of the seismic class of all items of structures systems and components in the MCR	Mechanical, Electrical and C&I Safety Systems - Before delivery to Site
AF-UK EPR-CE-056	The Licensee shall develop a fault schedule incorporating external hazards	First structural concrete
AF-UK EPR-CE-057	The Licensee shall develop a consolidated external hazards safety case.	Fuel load
AF-UK EPR-CE-058	The Licensee shall confirm that relay chatter is not a concern for the proposed plant and equipment for a particular site either through elimination of components which exhibit this behaviour or by suitable testing.	Mechanical, Electrical and C&I Safety Systems - Before delivery to Site
AF-UK EPR-CE-059	The Licensee shall confirm that the seismic fragilities used are valid for the particular site conditions	Fuel load
AF-UK EPR-CE-060	The Licensee shall develop a more refined set of containment fragilities for site specific application to the PSA	Fuel load
AF-UK EPR-CE-061	The Licensee shall develop a set of arrangements for the qualification of plant and equipment against the demands from Internal and external hazards.	Install polar crane
AF-UK EPR-CE-066	The Licensee shall demonstrate that adequate margins beyond the design basis exist for all Class 1 civil structures	Nuclear island safety related concrete

Table 3

UK EPR GDA Assessment Findings Relevant to External Hazards

Unshaded – External hazards is primary interest, Shaded – external hazards has a contributing interest

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-UK EPR-ME-020	The licensee shall verify the site specific design air temperatures and humidity values against those used as the basis for the UK EPR design, to ensure that the nuclear ventilation systems can adequately perform their safety functions.	Mechanical, Electrical and C&I Safety Systems - Before delivery to Site
AF-UK EPR-PSA-002	The licensee shall ensure that the scope of the PSA is expanded to include hazards, such as fire and flooding during non power operating states.	Fuel on-site
AF-UK EPR-PSA-028	The licensee shall ensure that the dependency between a LOOP and extreme weather events is taken into account and if necessary the PSA amended.	Fuel load
AF-UK EPR-PSA-031	The licensee shall ensure that hazards such as internal explosion, turbine missiles and animal infestation are considered and if necessary included in the PSA model	Mechanical, Electrical and C&I Safety Systems - Before delivery to Site
AF-UK EPR-PSA-032	The licensee shall ensure that the screening criteria used in the GDA PSA are confirmed to bound specific site hazard characteristics and include in the PSA any hazards and combination of hazards that have been screened in.	Nuclear island safety related concrete
AF-UK EPR-PSA-037	The licensee shall provide a seismic PSA for the site. The seismic analysis should take account of consequential hazards that might be caused by a seismic event, such as fire or flooding, and if appropriate include them in the PSA	Mechanical, Electrical and C&I Safety Systems - Before delivery to Site
AF-UK EPR-PSA-038	The licensee shall ensure that the impact of seismic faults during shutdown is addressed in a consistent manner with other contributions to the risk during shutdown.	Fuel load
AF-UK EPR-PSA-044	The licensee should ensure that the Level 3 PSA is developed to modern standards, in particular by placing less reliance on design basis dose assessments and by fully incorporating probabilistic factors such as weather. For each new plant the Site-	Fuel load

Table 3

UK EPR GDA Assessment Findings Relevant to External Hazards

Unshaded – External hazards is primary interest, Shaded – external hazards has a contributing interest

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
	specific Level 3 PSA will need to incorporate site specific source term and release frequency analyses together with site specific dispersion and consequence modelling parameters (such as weather data and distribution of population and agriculture) for all releases.	
AF-UK EPR-SI-032	The Licensee shall ensure that more detailed guidance on the use of the RCC-M procedure is provided to support earthquake design of pipework.	Install RPV
AF-UK EPR-CE-71	The licensee shall justify that the final seismic analysis methodology used for the site specific design of the UK EPR is adequate for the site specific conditions. Any deviations from the generic methodology documents, ENGSGC100140 Rev C, ENGSDS100268 Rev B and ENGSDS100269 Rev B shall be highlighted and adequate justification provided	First structural concrete
AF-UK EPR-CC-12	The licensee shall provide the review of emergency plans and building walkdowns that are to be carried out for the civil structures classified as C1 “other structures” as part of the robustness review in light of Fukushima. This review shall justify that the structural performance specified for each structure following an extreme event, provides sufficient beyond design basis margin such that its post event condition does not adversely affect the emergency plans.	Mechanical, Electrical and C&I Safety Systems - Before inactive commissioning
AF-UK EPR-CC-13	A future licensee shall analyse the detailed site specific UK EPR™design to demonstrate its robustness against beyond design basis seismic events for all plant operating states to a level consistent with the Seismic Margin Assessment provided in GDA.	Mechanical, Electrical and C&I Safety Systems - Before delivery to Site

Table 3

UK EPR GDA Assessment Findings Relevant to External Hazards

Unshaded – External hazards is primary interest, Shaded – external hazards has a contributing interest

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-UK EPR-CC-23	A future licensee shall develop and complete a hazard fault schedule based upon the format defined in the sample hazard schedule ECESN120418 for all remaining site-specific internal and external hazards.	Long lead item and SSC procurement specifications
AF-UK EPR-EE-26	The licensee should make arrangements to address the influence of Geomagnetically Induced Currents (GIC) and other space weather related effects.	Long lead item and SSC procurement specifications
AF-UK EPR-CE-79	The licensee shall confirm that there is adequate margin beyond design basis for safety critical non-massive structural elements, e.g. concrete columns or steel frames, such that if plasticity occurs in any part of those elements for the event considered, this will not lead to sudden failure.	Nuclear island safety related concrete

Table 4

ONR Issues raised and/or changed as part of the assessment reported

Issue No.	Issue title	Issue	Completion / review date
1794	HPC seismic hazard analysis	The Licensee shall complete the seismic hazard forward work programme to confirm the seismic design basis to be used for plant design before end December 2014.	end December 2014
2059	HPC frazil ice analysis	The Licensee shall complete the HPC frazil ice hazard analysis in order to meet the timescales for permissioning First Nuclear Safety Concrete.	Permissioning for First Nuclear Safety Concrete
2060	HPC beyond design basis criteria	The Licensee shall identify Beyond Design Basis criteria for each external hazard that has a Design Basis. This should be done to meet the programme timescales required for using of each external hazards design basis.	In time to support design process