



**Office for
Nuclear Regulation**

Civil Nuclear Reactor Build - Generic Design Assessment

**Step 2 Assessment of the Civil Engineering and External Hazards aspects of
Hitachi GE's UK Advanced Boiling Water Reactor (UK ABWR)**

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EXECUTIVE SUMMARY

This report presents the results of my assessment of the Civil Engineering and External Hazards of Hitachi General Electric Nuclear Energy Ltd (Hitachi-GE) UK Advanced Boiling Water Reactor (UK ABWR) 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 getting increasingly detailed 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 review of key nuclear safety, nuclear security and environmental safety claims with the aim of identifying any fundamental safety or security shortfalls that could prevent the proposed design from being licensed in Great Britain. Therefore during GDA Step 2 my work has focused on the assessment of the key claims in the area of Civil Engineering and External Hazards to judge whether they are complete and reasonable in the light of our current understanding of reactor technology.

For Civil Engineering and External Hazards safety claims are interpreted as being that the design and construction of the plant is such that the relevant buildings and structures

- Support Structures, Systems and Components which deliver safety functions for design basis loads
- Maintain appropriate environmental conditions inside buildings appropriate for SSCs
- Protect SSCs, which deliver safety functions from design basis external hazards, natural phenomena, human induced events and internal hazards
- Contain radioactive material and prevent potential release to the environment
- Provide radiation shielding where required
- Maintain their required functions during normal and fault conditions

and external hazards will be:

- Fully identified based on reference sources
- Categorised and screened
- Appropriately considered in sequence and combination
- Used to derive design basis loads
- Included in the Generic Site Envelope

The standards I have used to judge the adequacy of the claims in the area of Civil Engineering and External Hazards have been primarily ONR's Safety Assessment Principles (SAPs) and Technical Assessment Guides (TAGS) referring, where appropriate, to relevant IAEA standards and WENRA Safety Reference Levels and Safety Objectives for New Nuclear Plants.

My GDA Step 2 assessment work has involved continuous engagement with the RP in the form of technical exchange workshops and progress meetings. In addition, my understanding of the ABWR technology, and, therefore, my assessment, has significantly benefited from visits to:

- The construction of the Ōma ABWR Nuclear Power Plant.
- The commissioning of the Shimane ABWR Nuclear Power Plant.
- The Hitachi Works.

My assessment has been based on the RPs Preliminary Safety Report (PSR) and its references relevant to Civil Engineering and External Hazards. The Civil Engineering scope of the PSR includes all non-site specific buildings including the Reactor Building, Control Building, Heat Exchanger Building, Turbine Building, Radwaste Building, Service Building,

Backup Building , Main stack and Aircraft Impact Protection Shell. The External Hazards scope includes the identification and screening and evaluation of external hazards to be considered in the design of the UKABWR

The RPs preliminary safety case claims related to Civil Engineering and External Hazards, as presented in the PSR and supporting documents, can be summarised as follows:

- Identification, screening and evaluation of hazards and development of the design basis
- Definition of the Generic Site Envelope
- Identification of safety requirements, categorisation and classification and seismic categorisation
- Adoption of internationally recognised and accepted design codes and standards
- Design for normal operating and fault conditions to resist applied loads, control environmental conditions, limit radioactive releases and shield radiation.

In order to:

- Maintain the safety functions (control of reactivity, fuel cooling and long term heat removal) of the UKABWR.

During my GDA Step 2 assessment of the UK ABWR aspects of the safety case related to Civil Engineering and External Hazards I have identified the following areas of strength:

- Adoption of internationally recognised and accepted design codes and standards
- During my discussions with the RP a positive contribution has been made by the inclusion of representatives from the civil designers and constructors.
- Consideration of construction and decommissioning at the design stage.
- Application of experience from previous projects

During my GDA Step 2 assessment of the UK ABWR aspects of the safety case related to Civil Engineering and External Hazards I have identified the following areas that require follow-up:

- Generic Site Envelope and hazards
- Aircraft impact protection shell.
- Radwaste building, back-up building and condensate storage tank
- Plant layout and barriers
- Development of compliance with the UK context
- Conventional safety interfaces
- Interfaces with other topic areas

In relation to my interactions with Hitachi GE's Subject Matter Experts (SME) in Civil Engineering and External Hazards, I have found the RP to be professional and to have committed considerable effort and resources to developing the UK ABWR safety case. I have found the SMEs to be responsive to my advice and guidance regarding the UK regulatory regime.

Overall, I see no reason, on Civil Engineering grounds, why the UK ABWR should not proceed to Step 3 of the GDA process

LIST OF ABBREVIATIONS

ABWR	Advanced Boiling Water Reactor
ALARP	As Low As Reasonably Practicable
BAT	Best Available Technique
BMS	Business Management System
BoP	Balance of Plant
BSL	Basic Safety Level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
DAC	Design Acceptance Confirmation
EA	Environment Agency
GEP	Generic Environmental Permit
Hitachi-GE	Hitachi General Electric Nuclear Energy Ltd
IAEA	International Atomic Energy Agency
JPO	(Regulators') Joint Programme Office
MDEP	(OECD-NEA) Multinational Design Evaluation Programme
MSIV	Main Steam Isolation Valve
NPP	Nuclear Power Plant
OECD-NEA	Organisation for Economic Co-operation & Development – Nuclear Energy Agency
ONR	Office for Nuclear Regulation (an agency of HSE)
PCSR	Pre-construction Safety Report
PSR	Preliminary Safety Report
RGP	Relevant Good Practice
RHWG	Reactor Harmonization Working Group (of WENRA)
RI	Regulatory Issue
RIA	Regulatory Issue Action
RO	Regulatory Observation
ROA	Regulatory Observation Action
RP	Requesting Party

LIST OF ABBREVIATIONS

RPV	Reactor Pressure Vessel
RQ	Regulatory Query
RRP	Resource Review Panel
SAP(s)	Safety Assessment Principle(s)
SFAIRP	So far as is reasonably practicable
SME	Subject Matter Expert
SSSI	Soil Structure Soil Interaction
TAG	Technical Assessment Guide(s)
TSC	Technical Support Contractor
TSF	Technical Support Framework
WENRA	Western European Nuclear Regulators' Association

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1 INTRODUCTION

1.1 Background

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 getting increasingly detailed as the project progresses. Hitachi General Electric Nuclear Energy Ltd's (Hitachi-GE) is the RP for the GDA of the UK Advanced Boiling Water Reactor (UK ABWR).
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 its ABWR design. Also, during Step 1 Hitachi-GE prepared submissions to be evaluated by ONR and the Environment Agency (EA) during Step 2.
3. Step 2 of GDA is an overview of the acceptability, in accordance with the regulatory regime of Great Britain, of the design fundamentals, including review of key nuclear safety, nuclear security and environmental safety claims with the aim of identifying any fundamental safety or security shortfalls that could prevent the proposed design from being licensed in Great Britain.
4. This report presents the results of my assessment of the Civil Engineering and External Hazards aspects of Hitachi-GE's UK ABWR as presented in the UK ABWR Preliminary Safety Report (PSR) (Ref. 8) and its supporting documentation (Refs 9-17).

1.2 Methodology

5. My assessment has been undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) How2 Business Management System (BMS) procedure PI/FWD (Ref. 1). The ONR Safety Assessment Principles (SAPs) (Ref. 2), together with supporting Technical Assessment Guides (TAG) (Ref. 3) have been used as the basis for this assessment.
6. My assessment has followed my GDA Step 2 Assessment Plan for Civil Engineering and External Hazards (Ref 6) prepared in December 2013 and shared with Hitachi-GE to maximise openness and transparency.

2 ASSESSMENT STRATEGY

7. This section presents my strategy for the GDA Step 2 assessment of the Civil Engineering and External Hazards of the UK ABWR (Ref 6). It also includes the scope of the assessment and the standards and criteria that I have applied.

2.1 Scope of the Step 2 Civil Engineering and External Hazards Assessment

8. The objective of my GDA Step 2 Civil Engineering and External Hazards assessment for the UK ABWR was to review and judge whether the claims made by the RP related to Civil Engineering and External Hazards that underpin the safety, security and environmental aspects of the UK ABWR are complete and reasonable in the light of our current understanding of reactor technology.
9. For Civil Engineering and External Hazards "safety claim" is interpreted as being:

- Specific and measurable statements that show that Civil Engineering and External Hazards aspects of the UK ABWR meet the relevant Safety Assessment Principles (Ref.3).
 - A clearly documented basis of design for each structure – to include classification, safety functional requirements, operational requirements, structural form, load paths, loads and combinations, materials and construction/decommissioning sequence. It should be noted that:
 - Safety claims and supporting documentation must have a clear structure and hierarchy so that the design basis is set out logically.
 - The UK context should be fully recognised and addressed
 - Internationally recognised standards and relevant good practice should be adopted
 - The codes and standards used for each structure should link to the classification of that structure. Internationally used nuclear codes present less of a challenge than company or national codes that are not used elsewhere in the world. Where non-standard design codes are proposed, a full justification for their use and detailed explanations are needed to demonstrate that a safe design can be achieved.
 - Specific and measurable statements that demonstrate compliance with the UK Construction Design and Management (CDM) Regulations. This needs to be substantiated from concept design to construction, operation and decommissioning.
 - A comprehensive and documented review identifying all external hazards.
 - An external hazards schedule that is clearly presented and notes the load magnitudes used in the generic design and taking account of:
 - The external hazards schedule should note which hazards are truly generic and which are site specific.
 - The screening process to discount those hazards which are not relevant or applicable must be transparent.
 - Combinations of external hazards must include possible coincident events in the light of current good practice and lessons learned from Fukushima.
 - Specific and measurable statements that demonstrate that significant interfaces with other topic areas have been fully addressed.
10. For Civil Engineering and External Hazards “security claim” is interpreted as being:
- Specific and measurable statements that demonstrate that nuclear safety and nuclear security measures have been designed and implemented in an integrated manner so that they do not compromise one another.
11. During GDA Step 2 I have also evaluated whether the safety claims related to Civil Engineering and External Hazards are supported by a body of technical documentation sufficient to allow me to proceed with GDA work beyond Step 2. Detailed ALARP assessment and Security claims will be examined in Step 3.
12. Finally, during Step 2, I have undertaken the following preparatory work for my Step 3 assessment:
- Following engagement with the RP, I have decided on the scope and plan for the Step 3 assessment, including consideration of potential Technical Support Contracts (TSC) and set up the process to put required contracts in place for Step 3;

- I have improved ONR's knowledge of the design by means of site visits to a plant under construction and one under commissioning. I have also considered the use of the 3D model prepared by the RP to inform the plant layout; This has informed ONR's view on how claims on Civil Engineering and External Hazards have been implemented;
- I have liaised with other ONR assessors, as appropriate, to inform and focus my assessment work and undertaken preparatory work regarding interfaces with other disciplines for Step 3.
- I have discussed significant design and safety case changes from previous plants with the RP as appropriate; and
- I have discussed the use of operational experience feedback with the RP and intend to engage with the OECD-NEA Multinational Design Evaluation Programme (MDEP) ABWR working group as appropriate during Step 3.

2.2 Standards and Criteria

13. The goal of the GDA Step 2 assessment is to reach an independent and informed judgment on the adequacy of a nuclear safety, security and environmental case. For this purpose, within ONR, assessment is undertaken in line with the requirements of the How2 Business Management System (BMS) document PI/FWD (Ref. 1). Appendix 1 of Ref. 1 sets down the process of assessment within ONR; Appendix 2 explains the process associated with sampling of safety case documentation.
14. In addition, the Safety Assessment Principles (SAPs) (Ref. 2) constitute the regulatory principles against which duty holders' safety cases are judged, and, therefore, they are the basis for ONR's nuclear safety assessment and therefore have been used for GDA Step 2 assessment of the UK ABWR. The SAPs 2006 Edition (Revision 1 January 2008) were benchmarked against the IAEA standards (as they existed in 2004). They are currently being reviewed.
15. Furthermore, ONR is a member of the Western Regulators Nuclear Association (WENRA). WENRA has developed Reference Levels, which represent good practices for existing nuclear power plants, and Safety Objectives for new reactors.
16. The relevant SAPs, IAEA standards and WENRA reference levels are embodied and enlarged on in the Technical Assessment Guide/s on Civil Engineering and External Hazards (Ref. 3). This/These guides provide the principal means for assessing the Civil Engineering and External Hazards aspects in practice.

2.2.1 Safety Assessment Principles

17. The key SAPs (Ref. 2) applied in the assessment of civil engineering and external hazards were the Engineering Key Principles (EKP.1 to EKP.5), Civil Engineering section (ECE.1 to ECE.24) and the External Hazards section (EHA.1 to 17) of the Engineering Principles. Further Engineering Principles SAPs considered were from the section on integrity of metal components and structures (EMC). Principles EMC.1 to EMC.4, EMC.8 to EMC.10, EMC.12, EMC.15, EMC.18, EMC.20, and EMC.22 to EMC.24 were excluded on grounds of relevance. Other SAPs considered from the Engineering Principles included ECS.1 to ECS.5 (safety classification and standards), EAD.1 to EAD.4 (ageing and degradation), and ELO.1 to ELO.4 (layout). In addition to the Engineering Principles, SAPs relating to decommissioning (DC.1, DC.4 and DC.5) were considered. There is a close interface with internal hazards under EHA.13 to 17 and ESS.18. (See also Table 1 for further details).

2.2.2 Technical Assessment Guides

18. The following Technical Assessment Guides have been used as part of this assessment (Ref. 3):

- NS-TAST-GD-013 External Hazards Issue 4
- NS-TAST-GD-017 Civil Engineering Revision 3

With additional guidance from:

- | | | | |
|---|----------------|------------------------|------------|
| ■ | NS-TAST-GD-014 | Internal Hazards | Revision 3 |
| ■ | NS-TAST-GD-026 | Decommissioning | Revision 3 |
| ■ | T/AST/076 | Construction Assurance | Issue 1 |

2.2.3 National and International Standards and Guidance

19. The following national and international standards and guidance have also been used as part of this assessment:

- Relevant IAEA standards (Ref. 4) (a supplementary sources to the relevant sections of TAGs):
 - 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. 5):
 - 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)
 - Waste and Spent Fuel Storage Safety Reference Levels (February 2011)
 - Decommissioning Safety Reference Levels (March 2012)
 - 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

20. During Step 2 I have not engaged Technical Support Contractors (TSC) to support my assessment of the Civil Engineering and External Hazards area for the UK ABWR:

2.4 Integration with Other Assessment Topics

21. Early in GDA I recognised that during the project there would be a need to consult with other assessors as part of the Civil Engineering and External Hazards assessment process. Similarly, other assessors seek input from my assessment of Civil Engineering and External Hazards for the UK ABWR. I consider these interactions very important to ensure the prevention of assessment gaps and duplications, and, therefore, they are key to the success of the project. Thus, from the start of the project, I made every effort to identify as many potential interactions as possible between the Civil Engineering and External Hazards and other technical areas, with the understanding that this position would evolve throughout the UK ABWR GDA.
22. Also, it should be noted that the interactions between the Civil Engineering and External Hazards and some technical areas need to be formalised since aspects of the assessment in those areas constitute formal inputs to the Civil Engineering and External Hazards assessment, and vice versa. These are:
 - Radioactive Waste and Decommissioning provides input to the design for decommissioning aspects of the Civil Engineering and External Hazards assessment. This formal interaction has commenced during GDA Step 2. This work will be led by Radioactive Waste and Decommissioning. Structural Integrity provides input to the containment aspects of the Civil Engineering and External Hazards assessment. This work will be led by Civil Engineering and External Hazards in coordination with the Structural Integrity team. This formal interaction has not yet commenced during GDA Step 2. The Reinforced Concrete Containment (RCC) will be assessed as a single system.
 - Internal Hazards provides input to the hazard and design aspects of the Civil Engineering and External Hazards assessment. This formal interaction has commenced during GDA Step 2. This work will be led by Internal Hazards.
 - The Civil Engineering and External Hazards assessment provides input to the physical and structural aspects of the Radioactive Waste and Decommissioning assessment. This formal interaction has commenced during GDA Step 2 and will be led by Civil Engineering and External Hazards.
 - The Civil Engineering and External Hazards assessment provides input to the Probabilistic Safety Analysis. This work will be led by PSA.
 - The Civil Engineering & External Hazards assessment will, where required, provide support to the ONR Civil Nuclear Security assessment of the proposed design, plant layouts, fabric of buildings and the findings of any analysis done to look into the impact of major site events (including external hazards). This formal interaction has not yet commenced during GDA Step 2. This work will be led by ONR Civil Nuclear Security.
 - There is the potential for Civil Engineering and External Hazards interfaces with regard to environmental issues. This formal interaction has not yet commenced during GDA Step 2. This will be led by EA.
23. In addition to the above, during GDA Step 2 there have been interactions between Civil Engineering and External Hazards and the rest of the technical areas, ie, internal hazards, radwaste and decommissioning, structural integrity, radiation protection and PSA etc. Although these interactions, which are expected to continue through GDA, are mostly of an informal nature, they are essential to ensure consistency across the technical assessment areas.

3 REQUESTING PARTY'S SAFETY CASE

24. This section presents a summary of the RP's preliminary safety case in the area of Civil Engineering and External Hazards. It also identifies the documents submitted by Hitachi-GE which have formed the basis of my assessment of the UK ABWR Civil Engineering and External Hazards during GDA Step 2.

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

25. The aspects covered by the UK ABWR preliminary safety case in the area of Civil Engineering and External Hazards can be broadly grouped under # headings which can be summarised as follows:
- Civil Engineering: The RP's safety claims with regard to Civil Engineering are that, through design for normal operating and fault conditions to resist applied loads, control environmental conditions, limit radioactive releases and shield radiation, the safety functions (control of reactivity, fuel cooling and long term heat removal) of the UK ABWR will be maintained. The RP intends to achieve this by the application of appropriate safety and seismic categorisation and safety classification to Civil Engineering SSCs. The RP's intent is to achieve a conservative design commensurate with the importance of the safety function(s) being performed and reflect modern international good practice by the adoption of the latest internationally recognised and accepted nuclear-specific codes and standards.
 - External Hazards: The RP's claims with regard to External Hazards are that a comprehensive external hazard list will be developed, taking all external hazards into account. The comprehensive list will be reviewed, grouped, screened and categorised such that the RP can identify the independent external hazards to be considered in design of UK ABWR. This will include consideration of external hazards combinations. A strategy for protection against each hazard and UK generic conditions will be developed. The RP claims that this will maintain the safety functions (control of reactivity, fuel cooling and long term heat removal) of the UKABWR.
 - Generic Site Envelope: The RP has identified the Generic Site Conditions to be included in the GDA for the UK ABWR. The values for these identified conditions will be defined in Step 3.
 - Considerations in the light of the Fukushima accident: The RP claims that the ground level of the site will be constructed above the level of the established external flooding level and that coastal sea level protection measures will be constructed around the nuclear power station as required. In addition watertight doors will be used where applicable for the protection of important SSCs. Unlike previous ABWR designs, the UKABWR will have an Aircraft Impact Protection shell.

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 Civil Engineering and External Hazards for the UK ABWR is:
- UK ABWR GDA PSR Chapter on Civil Engineering and External Hazards XE-GD-0112 (Ref. 8). This document presents the Hitachi-GE UKABWR initial safety case for civil engineering and external hazards to be used for the design of the

new build nuclear power plant in UK. The scope of the civil engineering section covers the following buildings within the ABWR Generic Plant Scope:

- Reactor Building
- Control Building
- Heat Exchanger Building
- Turbine Building
- Radwaste Building
- Service Building
- Backup Building

The external hazards section considers a high-level description of:

- The identification of external hazards to be considered in the design of the UKABWR.
 - Screening of hazards.
 - Meteorological phenomena
 - Hydrological phenomena
 - Seismic phenomena
 - Electrical phenomena
 - Geophysical phenomena
 - Man-made hazards
 - Biological hazards
 - Other hazards
 - General resilience
-
- UK ABWR Basis of Safety Case document on Reactor Building Civil Design LE-GD-0021 (Ref. 8). This document presents and identifies safety functions and requirements of the UK ABWR Reactor Building and assesses the safety performance of the building design.
 - UK ABWR Basis of Safety Case document on Control Building Civil Design LE-GD-0022 (Ref. 8). This document presents and identifies safety functions and requirements of the UK ABWR Control Building and assesses the safety performance of the building design.
 - UK ABWR Basis of Safety Case document on Other Structures Civil Design LE-GD-0023 (Ref. 8). This document presents and identifies safety functions and requirements of the UK ABWR other structures and assesses the safety performance of the other building designs.
 - UK ABWR Civil Engineering Supporting Report - Reinforced Concrete Containment Vessel and Reactor Building Structural Design Report LE-GD-0024 (Ref. 8). This document presents the structural design and analysis of the UK ABWR Reactor Building and Reinforced Concrete Containment Vessel. The scope includes the design and analysis of the structures for various load conditions, applicable codes and structural materials.
 - UK ABWR Basis of Safety Case document on Civil Engineering Supporting Report Reactor Building Aircraft Impact Assessment (Structural Integrity) Report LE-GD-0025 (Ref. 8). This report describes, at a high level, the analysis method and aircraft impact assessment on the Reactor Building structural design. This

report provides a link to more detailed work to be carried out in Step 3 and Step 4.

- UK ABWR Civil Engineering Supporting Report - Control Building Structural Design Report LE-GD-0026(Ref. 8). This document presents the structural design and analysis of the UK ABWR Control Building. The scope includes the design and analysis of the structures for various load conditions, applicable codes and structural materials.
- UK ABWR Basis of Safety Case document on Civil Engineering Supporting Report Control Building Aircraft Impact Assessment (Structural Integrity) Report LE-GD-0027 (Ref. 8). This report describes, at a high level, the analysis method and aircraft impact assessment on the Reactor Building structural design. This report provides a link to more detailed work to be carried out in Step 3 and Step 4.
- UK ABWR Topic Report on External Hazard Protection AE-GD-0126 (Ref. 8). This document presents the RP's strategy for dealing with external hazards and high level safety claims
- UK ABWR Topic Report on Generic Site Envelope XE-GD-0183 (Ref. 8). This document describes the methodology for defining the generic site data envelope, relating to appropriate external hazards, into a series of Generic Site Conditions.
- UK ABWR Report HNP-S3-GDA-REP-00003: Rev. 1 "Derivation and Justification of the External Hazards for the GDA PCSR" (Ref. 8). This document was prepared for Hitachi GE by Horizon Nuclear Power and provides information to underpin the external hazards process.
- UK ABWR GDA tracking sheet (Ref. 7).
- Responses to Regulatory Queries
 - RQ-ABWR-0125 External Hazards Strategy
 - RQ-ABWR-0126 ABWR Lined Pools and Structures
 - RQ-ABWR-0127 ABWR RCCV Strategy
 - RQ-ABWR-0131 ABWR Use of Shielding Concrete
 - RQ-ABWR-0175 Construction (Design and Management) Regulations 2007 (CDM 2007)

27. In addition, in May 2014 Hitachi-GE has submitted to ONR for information an advance copy of the UK ABWR Pre-Construction Safety Report (PCSR). Chapter 7 (Ref. 8) addresses Civil Works and Structures and Chapter 5.7 (Ref. 8) addresses External Hazards. Although I have not covered these reports in my GDA Step 2 formal assessment, seeing these has been useful to start planning and preparing my GDA Step 3 work and has provided additional confidence that the required standard is being met.

4 ONR ASSESSMENT

28. My assessment has been carried out in accordance with ONR How2 BMS document PI/FWD, "Purpose and Scope of Permissioning" (Ref. 1).
29. My GDA Step 2 Civil Engineering and External Hazards assessment has followed the strategy described in Section 2 of this report.
30. My Step 2 assessment work has involved continuous engagement with the RP's Civil Engineering and External Hazards Subject Matter Experts (SMEs) through Technical Exchange Workshops in Japan and the UK and in the progress meetings (mostly video conferences) that have been held. These meetings have also included discussions with the RP's specialist technical support consultants Shimizu and Kajima. I have also visited:
- Ohma ABWR which is around 50% constructed. The visit to the Ohma nuclear power plant construction site was very useful in giving a good impression of the scale and juxtaposition of the main systems, structures and components of the ABWR. The Hitachi-GE and Kajima staff present clearly explained the modular all-weather construction method employed and the methods used to improve safety, constructability and site controls.
 - Shimane Unit 3 ABWR at the commissioning stage, where I was able to tour the whole facility including areas within the reactor building, reinforced concrete containment vessel (RCCV), under the reactor pressure vessel (RPV), the suppression chamber, control building and turbine building. I also observed post-Fukushima enhancements including the construction of the back-up building and the seawall and flood defence augmentation. In addition, I examined internal barriers and segregation of safety related plant with the ONR internal hazards inspector.
 - Hitachi Works (reactor internals workshop), where I was able to gain a good impression of the RP's quality, manufacture and construction systems.
31. During my GDA Step 2 assessment, I have identified some shortfalls in documentation which have generally led to the issue of RQs; overall I have raised five RQs. The number of RQs raised has been minimised through close and positive engagement with the relevant SMEs within the RP organisation and specialists from the RP's technical support consultants (Shimizu and Kajima). I have also assisted in the preparation of RQs submitted by ONR inspectors responsible for interfacing topic areas.
32. Details of my GDA Step 2 assessment of the UK ABWR preliminary safety case in the area of Civil Engineering and External Hazards including the areas of strength that I have identified, as well as the items that require follow-up and the conclusions reached are presented in the following sub-sections.

4.1 Civil Engineering

4.1.1 Assessment

33. I have carried out an assessment of the Preliminary Safety Report on Civil Engineering and External Hazards XE-GD-0012 which gives a high level presentation of the safety claims in order to:

- Identify and explain any novel or complex features including their importance to safety
 - Identify and explain any deviations from modern international good practice
 - Provide sufficient detail to demonstrate that the SAPs are likely to be satisfied
 - Identify outstanding information that remains to be developed and its significance
 - Identify significant interfaces with other disciplines
34. I have considered the design philosophy, standards and criteria used in sufficient detail to obtain an overview of the fundamental design, safety case and claims with regard to Civil Engineering commensurate with the GDA Step 2 process.
35. My assessment has been based on the contents of the Preliminary Safety Report on Civil Engineering and External Hazards XE-GD-0012 and its supporting documents giving the basis of safety case for key structures and structural design reports. In addition, although not formally reviewed, the draft PCSR documents have provided additional confidence that the required standard is being met.

4.1.2 Strengths

36. During my assessment, I identified the following areas of strength:
- The use of the latest internationally recognised and accepted nuclear-specific codes and standards should lead to a conservative design commensurate with the importance of the safety function(s) being performed and reflect modern international good practice.
 - The use of non-US or Japanese standards and specifications for construction materials in the UK context has been recognised.
 - A high level rationale for the application of codes and standards in the UK context has been demonstrated in the support documents.
 - Four ABWRs have been safely and successfully constructed and operated in Japan, and two additional ABWRs are currently under construction. Feedback from these activities has been incorporated into the UK ABWR proposals.
 - The Preliminary Safety Report on Civil Engineering and External Hazards and its supporting documents present a structured approach to the definition of the safety case.
 - The provision of the Aircraft Impact Protection shell is a major change from previous ABWR reactor building designs and represents an augmentation to nuclear safety.
 - The RP has clearly identified the relevant criteria for the classification and categorisation of systems, structures and components and this has been carried out in a logical and consistent manner.
 - Consideration of construction and decommissioning at the design stage.
37. I note that the supporting documentation submitted by the RP confirms that construction, whole-life-management and decommissioning will be considered from the design phase onwards. I also note that this will draw on experience from previous ABWR construction although the extent of modularisation will be considered on a site by site basis.

4.1.3 Items that Require Follow-up

38. During my GDA Step 2 assessment of Civil Engineering I have identified the following shortcomings:

- Generic criteria with regard to nuclear safety for the siting of the Heat Exchanger Building, Back-up Building, Spent Fuel Storage Facility and Circulating Water Structure have not been sufficiently developed.
- The design of the aircraft impact protection shell and its influence on the reactor building design will have to be fully considered.
- The methodology for including SSSI in the design and standard soil parameters will have to be described in detail.
- The potential for structural issues relating to the installation of filtered containment ventilation will be investigated.
- Justification of the approach used in the selection and combination of standards including a full comparison matrix analysis of the differences between the US, UK and European design and material codes and standards will be required.
- Development of EMIT provisions is required.
- Interfaces with the External Hazards and Generic Site Envelope require further development and enhancement.
- The classification and categorisation of systems, structures and components, as presented, is sufficient for Step 2, However, this will be subject to detailed examination and a check for consistency with the detailed requirements of other disciplines in Step 3,

These shortcomings will be addressed in later stages of the GDA process.

39. During my GDA Step 2 assessment of Civil Engineering, I have identified the following additional potential shortcomings that I will follow-up during Step 3:

- The links from design classification and seismic categorisation to design standards will require further justification. I will examine this, particularly in plant areas representing classification boundaries and in seismic category 1A SSCs, based on SSC safety functions and categorisation. I will also pay regard to justification consistent with fault studies and PSA
- Safety classification and seismic categorisation for the radwaste building, back-up building and condensate storage tank will have to be developed further. I will examine this in Step 3 and Step 4 with the relevant SMEs.
- Interfaces with Balance of Plant SSCs will have to be examined in more detail. I will progress this in Step 3.
- The Reinforced Concrete Containment Vessel is considered under Civil Engineering and Structural Integrity topics. I will follow this up by assessment of the Reinforced Concrete Containment Vessel as a combined system in Step 3 and Step 4. in conjunction with the Structural Integrity SMEs.
- Definition of location and functional performance of barriers required for nuclear safety requires development. I will examine this in Step 3 and Step 4 with the relevant SMEs (principally internal hazards).
- Definition of location, specification and functional performance of barriers required for radiological shielding requires improvement. I will examine this in Step 3 and Step 4 with the relevant SMEs.
- Demonstration of consideration of construction and decommissioning in the UK ABWR design.
- Justification of the approach adopted for the design, construction, use, maintenance and decommissioning of lined structures and ponds.
- Groundwater ingress and potential contamination egress to/from buried structures requires to be addressed. This is particularly the case with structures containing large volumes of water such as the Suppression Pool/Reactor Building.
- The construction sequence for the UK ABWR requires to be reviewed in terms of its safety impact, if any, on the safe decommissioning of the facility at the end of life. I will progress this in Step 3 with the decommissioning SME.

- The selection, use and validation of design and analysis software will require justification in Step 3 and Step 4.
40. I attended an initial workshop on the Balance of Plant (BoP) on 18 February 2014. This meeting provided me with a basic introduction to these areas of the plant. This was insufficient to allow an assessment to be carried out in relation to the overall effects on the safety case and a number of areas require further detailed examination in Step 3, including:
- Details of the specific characteristics of the ABWR BoP
 - The effects of steam overpressure following a large steam break
 - Identification of areas of the BoP that must remain intact to allow operator actions to be carried out during fault conditions including access and egress routes
 - Shielding requirements and their structural implications
 - Consistency between the safety cases for BoP and civil engineering aspects of other safety cases including the influence of internal and external hazards.
 - Confirmation of the safety classifications and categorisation of BoP structures including internal structures requiring special consideration.
41. During my GDA Step 2 Civil Engineering assessment, I have identified that there are currently no areas that may require research to be undertaken by Hitachi-GE in order to underpin safety claims. This situation may change as the detailed examination of the Aircraft Impact Protection is developed.

4.1.4 Conclusions

42. Based on the outcome of my assessment of Civil Engineering, I have concluded that the submission by the RP is adequate for GDA Step 2. The Preliminary Safety Report on Civil Engineering and External Hazards XE-GD-0012 does not generally identify compliance with the SAPs within the text of the document. However, I consider that general compliance with the SAPs exists based on consideration of the bases of safety case, topic and design reports augmented by the draft PCSR documents and detailed discussions with the relevant SMEs in the RP, which have provided additional confidence.

4.2 External hazards and Generic Site Envelope

4.2.1 Assessment

43. I have carried out an assessment of the Preliminary Safety Report on Civil Engineering and External Hazards XE-GD-0012 which gives a high level presentation of the safety claims in order to:
- Identify and explain any novel or complex features including their importance to safety
 - Identify and explain any deviations from modern international good practice
 - Provide sufficient detail to demonstrate that the SAPs are likely to be satisfied
 - Identify outstanding information that remains to be developed and its significance
 - Identify significant interfaces with other disciplines
44. I have considered the design philosophy, standards and criteria used in sufficient detail to obtain an overview of the fundamental design, safety case and claims with regard to External Hazards commensurate with the GDA Step 2 process.

45. My assessment has been based on the contents of the Preliminary Safety Report on Civil Engineering and External Hazards XE-GD-0012 and its supporting documents giving the basis of safety case for key structures and structural design reports. In addition, although not formally reviewed, the draft PCSR documents have provided additional confidence that the required standard is being met.
46. As it relies heavily on outputs from external hazards studies, I have carried out an assessment of the Topic Report on Generic Site Envelope XE-GD-0183. This report requires further input from External Hazards to be complete. This information will not be available until Step 3.
47. Although the External hazards section of the Preliminary Safety Report on Civil Engineering and External Hazards was relatively weak, the RP has put considerable effort into development of the Topic Report on External Hazard Protection and has produced a comprehensive hazard listing.
48. I acknowledge that much work has been carried out since the issue of the PSR and I note that the recently issued HNP report (HNPS3-GDA-REP-00003: Rev. 1) "Derivation and Justification of the External Hazards for the GDA PCSR" does provide evidence of underpinning to the External Hazards process.

4.2.2 Strengths

49. During my assessment, I identified the following areas of strength:
 - The RP has developed a comprehensive hazard listing has presented this in the Topic Report on External Hazard Protection.

4.2.3 Items that Require Follow-up

50. During my GDA Step 2 assessment of External Hazards I have identified the following shortcomings:
 - The external hazards section of the Preliminary Safety Report on Civil Engineering and External Hazards was relatively weak and there was insufficient consideration of generic hazard rather than site specific hazard definition. The RP has put effort into improving the situation as reflected in the Topic Report on External Hazard Protection. Further work is required and I will follow this up in Step 3.
 - The RP has identified the Generic Site Conditions to be included in the GDA for the UK ABWR. The values for these identified conditions will be defined in Step 3. A review of the data, including both UK generic information and some site specific information is currently underway by the RP. The structure of the document is clearly presented but the document is incomplete. Further work is required to define the preliminary values given in the report. I will follow this up in Step 3.
 - The review, grouping, screening, categorisation and combination of external hazards will require further justification.
 - Further work is required to develop the Aircraft Impact Protection safety case and this is planned for Step 3.
 - The Topic Report on Generic Site Envelope requires further input from External Hazards to be complete. This information will not be available until Step 3.
51. During my GDA Step 2 assessment of External Hazards I have identified the following additional potential shortcomings that I will follow-up during Step 3:
 - Further discussion is required with regard to hazard combinations and hazard screening. I will follow this up in Step 3.

- During Step 3, the interfaces with Internal Hazards and PSA will have to be developed in more detail and consistency demonstrated.

52. During my GDA Step 2 assessment of Civil Engineering and External Hazards, I have identified the following areas that may require research to be undertaken by Hitachi-GE in order to underpin the safety claims in the External Hazards area. I will follow these matters, as appropriate, during Step 3:

- Derivation, underpinning and justification of UK generic hazard values.
- Derivation, underpinning and justification of climate change assumptions.

4.2.4 Conclusions

53. Based on the outcome of my assessment of 4.2 External hazards and Generic Site Envelope, I have concluded that, based on the RP's programme of ongoing development of this topic, the PSR, supported by the Topic Report on External Hazard Protection, is adequate for Step 2.

4.3 Construction Design and Management) Regulations

4.3.1 Assessment

54. The supporting documentation states that the Construction (Design and Management) Regulations 2007 (CDM 2007) will be appropriately applied to the project in a timely manner to ensure that the design of the buildings and associated plant; takes into consideration conventional safety throughout all of project phases. The RP states that a designer's Risk Assessment shall be produced and updated during the design of the project. Engagement with ONR conventional safety Inspectors has commenced and I am satisfied that the RP is making satisfactory progress for Step 2.

4.3.2 Strengths

55. During my assessment, I identified the following areas of strength:

- The RP has started early engagement to comply with CDM 2007.

4.3.3 Items that Require Follow-up

56. I will monitor the RP's progress during Step 3 in association with the ONR conventional safety inspector.

4.3.4 Conclusions

57. Based on the outcome of my assessment of Civil Engineering and External hazards, I have concluded that the RP is making satisfactory progress in complying with the requirements of CDM 2007.

4.4 Considerations in the Light of the Fukushima Accident

58. I note that the RP claims that the ground level of the site will be constructed above the level of the established external flooding level and that coastal sea level protection measures will be constructed around the nuclear power station as required. In addition the RP states that watertight doors will be used where applicable for the protection of important SSCs. I also note that, unlike previous ABWR designs, the UKABWR will have an Aircraft Impact Protection shell. These areas will be subjected to assessment in Step 3. Hazard combinations have been covered under External hazards above.

4.5 Out of Scope Items

59. The following items have been left outside the scope of my GDA Step 2 assessment of the UK ABWR Civil Engineering and External Hazards.
- Back-up Building The reason for leaving this matter out of the scope of my GDA Step 2 assessment is that insufficient information has been supplied
 - Overall effects on the safety case of Balance of Plant structures and constructions. The reason for leaving this matter out of the scope of my GDA Step 2 assessment is that insufficient information has been supplied.
60. It should be noted that the above omissions do not invalidate the conclusions from 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.

4.6 Comparison with Standards, Guidance and Relevant Good Practice

61. In Section 2.2 above I have listed the standards and criteria I have used during my GDA Step 2 assessment of the UK ABWR Civil Engineering and External Hazards to judge the adequacy of the preliminary safety case. My overall conclusions in this regard can be summarised as follows:
- SAPs: The RP's preliminary safety case does not generally identify compliance with the SAPs within the text of the document. However, I consider that general conformity with the SAPs exists based on consideration of the bases of safety case, topic and design reports augmented by the draft PCSR documents and detailed discussions with the relevant SMEs in the RP, which have provided additional confidence. Table 1 provides further details.
 - TAGs: The RP's preliminary safety case generally complies with the higher level intent of the relevant TAGs appropriate to Step 2 of GDA. Thorough consideration will be given to the more detailed requirements in Step 3 and Step 4.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

62. Hitachi-GE has provided a PSR for the UK ABWR for assessment by ONR during Step 2 of GDA. The PSR together with its supporting references present the claims in the area of Civil Engineering that underpin the safety of the UK ABWR.
63. The claims in the PSR together with its supporting references in the area of External Hazards are presented at a high level. The RP will present further enhancement in Step 3 to underpin the safety of the UK ABWR.
64. During Step 2 of GDA I have conducted an assessment of the parts of the PSR and its references that are relevant to the area of Civil Engineering and External Hazards against the expectations of the SAPs and TAGs. From the UK ABWR assessment done so far I conclude the following:
- I believe that the claims made are reasonable with regard to Civil Engineering. In the area of External Hazards, I am confident that the RP will be able to articulate reasonable claims in the PCSR and underpin them with sufficient arguments and robust evidence.
 - I have identified a number of shortcomings that I will follow up in Steps 3 and 4
 - The RP has presented a positive attitude to the resolution of shortfalls and compliance with the UK regulatory regime. Major resources (including specialist technical support) have been committed to development of the UK ABWR safety case. The RP has been open and responsive in dealings with the ONR]
65. Overall, I see no reason, on Civil Engineering and External Hazards grounds, why the UK ABWR should not proceed to Step 3 of the GDA process.

5.2 Recommendations

66. My recommendations are as follows
- Recommendation 1: The UK ABWR should proceed to Step 3 of the GDA process.
 - Recommendation 2; All the items identified in Step 2 as important to be followed up should be included in ONR's GDA Step 3 Assessment Plan for the UK ABWR Civil engineering and External Hazards
 - Recommendation 3: All the relevant out-of-scope items identified in sub-section 4.7 of this report should be included in ONR's GDA Step 3 Assessment Plan for the UK ABWR Civil engineering and External Hazards.

6 REFERENCES

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- 2 *Safety Assessment Principles for Nuclear Facilities.* 2006 Edition Revision 1. HSE. January 2008. www.hse.gov.uk/nuclear/SAP/SAP2006.pdf.
- 3 *Technical Assessment Guides.*
NS-TAST-GD-013 External Hazards Issue 4
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NS-TAST-GD-026 Decommissioning Revision 3
T/AST/076 Construction Assurance Issue 1
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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
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www.iaea.org.
- 5 *Western European Nuclear Regulators' Association.*
Reactor Safety Reference Levels WENRA January 2008
WENRA Statement on Safety objectives for new nuclear power plants WENRA November 2010
Safety of new NPP designs WENRA March 2013 <http://www.wenra.org/>
- 6 *Generic Design Assessment of HGNE's Advanced Boiling Water Reactor (ABWR) - Step 2 Assessment Plan for Civil Engineering and External Hazards* ONR-GDA-AP-13-001 Revision 0. ONR December 2013. TRIM Ref 2013/441602

- 7 *UK ABWR Document Tracking Sheets*. Updated versions submitted to the Joint Programme Office (JPO) throughout GDA Step 2. TRIM Ref. 2014 260246.
- 8 *Hitachi GE Reports*
- UK ABWR GDA PSR Chapter on Civil Engineering and External Hazards XE-GD-0112.
- UK ABWR Basis of Safety Case document on Reactor Building Civil Design LE-GD-0021.
- UK ABWR Basis of Safety Case document on Control Building Civil Design LE-GD-0022.
- UK ABWR Basis of Safety Case document on Other Structures Civil Design LE-GD-0023.
- UK ABWR Civil Engineering Supporting Report - Reinforced Concrete Containment Vessel and Reactor Building Structural Design Report LE-GD-0024.
- UK ABWR Basis of Safety Case document on Civil Engineering Supporting Report Reactor Building Aircraft Impact Assessment (Structural Integrity) Report LE-GD-0025.
- UK ABWR Civil Engineering Supporting Report - Control Building Structural Design Report LE-GD-0026.
- UK ABWR Basis of Safety Case document on Civil Engineering Supporting Report Control Building Aircraft Impact Assessment (Structural Integrity) Report LE-GD-0027.
- UK ABWR Topic Report on External Hazard Protection AE-GD-0126
- UK ABWR Topic Report on Generic Site Envelope XE-GD-0183
- UK ABWR Report HNP-S3-GDA-REP-00003; Rev. 1 "Derivation and Justification of the External Hazards for the GDA PCSR" (Prepared for Hitachi GE by Horizon Nuclear Power)
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Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No and Title	Description	Interpretation	Comment
Civil Engineering SAPs within the Engineering Principles			
ECE.1 Engineering principles: civil engineering	Functional performance	The required safety functions and structural performance of the civil engineering structures under normal operating, fault and accident conditions should be specified.	PSR gives high level functions and safety functions. Covered by Basis of Safety Case Reports
ECE.2 Engineering principles: civil engineering	Independent arguments	For structures requiring the highest levels of reliability, multiple independent and diverse arguments should be provided in the safety case.	To be covered in Step 3 and Step 4.
ECE.3 Engineering principles: civil engineering	Defects	It should be demonstrated that structures important to safety are sufficiently free of defects so that their safety functions are not compromised, that identified defects can be tolerated, and that the existence of defects that could compromise safety functions can be established through their life-cycle.	Tolerance to defects to be considered in Step 3 and Step 4.
ECE.4 Engineering principles: civil engineering: investigations	Natural site materials	Investigations should be carried out to determine the suitability of the natural site materials to support the foundation loadings specified for normal operation and fault conditions.	Site specific
ECE.5 Engineering principles: civil engineering: investigations	Geotechnical investigation	The design of foundations and sub-surface structures should utilise information derived from geotechnical site investigation.	Site specific

SAP No and Title	Description	Interpretation	Comment
ECE.6 Engineering principles: civil engineering: design	Loadings	Load development and a schedule of load combinations, together with their frequencies should be used as the basis for structural design. Loadings during normal operating, testing, design basis fault and accident conditions should be included.	Covered at high level in PSR Covered by Basis of Safety Case Reports Covered in Structural Design Reports Frequencies not covered at Step 2.
ECE.7 Engineering principles: civil engineering: design	Foundations	The foundations and sub-surface structures should be designed to meet their safety functional requirements specified for normal operation and fault conditions with an absence of cliff edge effects immediately beyond the design basis.	Covered at high level in Structural Design Reports
ECE.8 Engineering principles: civil engineering: design	Inspectability	Designs should allow key load-bearing elements to be inspected and, where necessary, maintained	To be covered in Step 3 and Step 4. Link to CDM compliance
ECE.9 Engineering principles: civil engineering: design	Earthworks	The design of embankments, natural and excavated slopes, river levees and sea defences close to the facility should not jeopardise the safety of the facility.	Site specific. Any special requirements to be addressed in Step 3 and Step 4.
ECE.10 Engineering principles: civil engineering: design	Ground-water	The design should be such that the facility remains stable against possible changes in the groundwater conditions.	Covered in Structural Design Reports
ECE.11 Engineering principles: civil engineering: design	Naturally occurring gases	The design should take account of the possible presence of naturally-occurring explosive gases or vapours in underground structures such as tunnels, trenches and basements.	To be considered in Step 3 and Step 4 with internal hazards.
ECE.12 Engineering principles: civil engineering: design	Structural analysis and model testing	Structural analysis and/or model testing should be carried out to support the design and should demonstrate that the structure can fulfil its safety functional requirements over the full range of loading for the lifetime of the facility.	Covered in Structural Design Reports

SAP No and Title	Description	Interpretation	Comment
ECE.13 Engineering principles: civil engineering: structural analysis and model testing	Use of data	The data used in structural analysis should be selected or applied so that the analysis is demonstrably conservative.	To be considered in Step 3 and Step 4. Limited information in Structural Design Reports
ECE.14 Engineering principles: civil engineering: structural analysis and model testing	Sensitivity studies	Studies should be carried out to determine the sensitivity of analytical results to the assumptions made, the data used, and the methods of calculation.	To be considered in Step 3 and Step 4.
ECE.15 Engineering principles: civil engineering: structural analysis and model testing	Validation of methods	Where analyses have been carried out on civil structures to derive static and dynamic structural loadings for the design, the methods used should be adequately validated and the data verified.	To be considered in Step 3 and Step 4.
ECE.16 Engineering principles: civil engineering: construction	Materials	The construction materials used should comply with the design methodologies employed, and shown to be suitable for enabling the design to be constructed and then operated, inspected and maintained throughout the life of the facility.	Inferred by reference to material standards. To be considered in Step 3 and Step 4.
ECE.17 Engineering principles: civil engineering: construction	Prevention of defects	The construction should use appropriate materials, proven techniques and approved procedures to minimise defects that might affect the required integrity of structures.	Inferred by reference to standards. To be considered in Step 3 and Step 4.
ECE.18 Engineering principles: civil engineering: construction	Inspection during construction	Provision should be made for inspection and testing during construction to demonstrate that appropriate standards of workmanship etc have been achieved.	Inferred by reference to standards. To be considered in Step 3 and Step 4.

SAP No and Title	Description	Interpretation	Comment
ECE.19 Engineering principles: civil engineering: construction	Non-conformities	Where construction non-conformities or identified defects are judged to have a significant detrimental effect on integrity, remedial measures should be applied to ensure the original design intent is still achieved.	Inferred by reference to standards. Tolerance to defects to be considered in Step 3 and Step 4.
ECE.20 Engineering principles: civil engineering: in-service inspection and testing	In-service inspection and testing	Provision should be made for inspection, testing and monitoring during normal operations aimed at demonstrating that the structure continues to meet its safety functional requirements.	Inferred by reference to standards. To be considered in Step 3 and Step 4. (Comparison with arrangements on existing plants required)
ECE.21 Engineering principles: civil engineering: in-service inspection and testing	Proof pressure tests	Pre-stressed concrete pressure vessels and containment structures should be subjected to a proof pressure test, which may be repeated during the life of the facility.	Inferred by reference to standards. To be considered in Step 3 and Step 4. (Comparison with arrangements on existing plants required)
ECE.22 Engineering principles: civil engineering: in-service inspection and testing	Leak tightness	Civil engineering structures that retain or prevent leakage should be tested for leak tightness prior to operation.	To be considered in Step 3 and Step 4.
ECE.23 Engineering principles: civil engineering: in-service inspection and testing	Inspection of sea and river flood defences	Provision should be made for the routine inspection of sea and river flood defences to determine their continued fitness for purpose.	Site specific

SAP No and Title	Description	Interpretation	Comment
ECE.24 Engineering principles: civil engineering: in-service inspection and testing	Settlement	<p>There should be arrangements to monitor civil engineering structures during and after construction to check the validity of predictions of performance made during the design. This information should be fed back into design reviews and may include:</p> <ul style="list-style-type: none"> a) Settlement b) deformations of the ground affected by the structure; c) values of actions; d) values of contact pressure between ground and structure; e) pore-water pressures; f) forces and displacements (vertical or horizontal movements, rotations or distortions) in structural members. 	<p>Inferred by reference to standards. To be considered in Step 3 and Step 4. (Comparison with arrangements on existing plants required)</p>
External Hazards SAPs within the Engineering Principles			
EHA.1 Engineering principles: External and internal hazards	Identification	<p>An effective process should be applied to identify all external and internal hazards that could affect the safety of the facility. Hazards should be defined in terms of their severity and frequency of occurrence and characterised as either having a discrete frequency of occurrence “discrete hazards”, or having a continuous frequency-severity relation “non-discrete hazards”. All hazards should be treated as initiating events in the fault analysis.</p>	<p>Little information in PSR. Identified in Topic Report.</p>
EHA.2 Engineering principles: External and internal hazards	Data sources	<p>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.</p>	<p>Little information in PSR. Identified at high level in Topic Report. To be considered in Step 3.</p>

SAP No and Title	Description	Interpretation	Comment
EHA.3 Engineering principles: External and internal hazards	Design basis events	For each internal or external hazard that cannot be excluded on the basis of either low frequency or insignificant consequence, a design basis event should be derived. Hazards whose associated faults make no significant contribution to overall risks from the facility should be excluded from the fault analysis.	Little information in PSR. Identified at high level in Topic Report. To be considered in Step 3.
EHA.4 Engineering principles: External and internal hazards	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	To be considered in Step 3
EHA.5 Engineering principles: External and internal hazards	Operating conditions	Design basis events should be assumed to occur simultaneously with the facility's most adverse permitted operating state.	To be considered in Step 3
EHA.6 Engineering principles: External and internal hazards	Analysis	Analyses should take into account hazard combinations, simultaneous effects, common cause failures, defence in depth, and consequential effects.	Little information in PSR. Identified in Topic Report. To be considered in Step 3.
EHA7 Engineering principles: External and internal hazards	'Cliff-edge' effects	A small change in DBA parameters should not lead to a disproportionate increase in radiological consequences.	Little information in PSR. Identified in Topic Report. To be considered in Step 3.
EHA.8 Engineering principles: External and internal hazards	Aircraft impact	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.	Covered at high level in PSR. Identified in Topic Report. To be considered in Step 3.

SAP No and Title	Description	Interpretation	Comment
EHA.9 Engineering principles: External and internal hazards	Earthquakes	The seismology and geology of the area around the site and the geology of the site should be evaluated to derive a design basis earthquake (DBE).	Site specific and generic. Topic Report – listed. Generic site envelope – basic consideration. To be considered in Step 3.
EHA.10 Engineering principles: External and internal hazards	Electromagnetic interference	The facility design should include preventative and/or protective measures against the effects of electromagnetic interference.	Covered at high level in PSR. Listed in Topic Report.
EHA.11 Engineering principles: External and internal hazards	Extreme weather	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.	Little information in PSR. Identified atl in Topic Report. To be considered in Step 3.
EHA.12 Engineering principles: External and internal hazards	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.	In PSR. Identified in Topic Report. To be considered in Step 3.
EHA.13 Engineering principles: External and internal hazards	Fire, explosion, missiles, toxic gases etc – use and storage of hazardous materials	The on-site use, storage or generation of hazardous materials should be minimised, controlled and located, taking due account of potential faults.	To be determined with internal hazards topic. In PSR. Identified in Topic Report. To be considered in Step 3.and/or Step 4.
EHA.14 Engineering principles: External and internal hazards	Fire, explosion, missiles, toxic gases etc – sources of harm	Sources that could give rise to fire, explosion, missiles, toxic gas release, collapsing or falling loads, pipe failure effects, or internal and external flooding should be identified, quantified and analysed within the safety case.	To be determined with internal hazards topic. To be considered in Step 3.and/or Step 4.

SAP No and Title	Description	Interpretation	Comment
EHA.15 Engineering principles: External and internal hazards	Fire, explosion, missiles, toxic gases etc – effect of water	The design of the facility should prevent water from adversely affecting structures, systems and components important to safety	To be determined with internal hazards topic. To be considered in Step 3.and/or Step 4.
EHA.16 Engineering principles: External and internal hazards	Fire, explosion, missiles, toxic gases etc – fire detection and fighting	Fire detection and fire-fighting systems of a capacity and capability commensurate with the worst-case design basis scenarios should be provided.	To be determined under internal hazards topic. To be considered in Step 3.and/or Step 4.
EHA.17 Engineering principles: External and internal hazards	Fire, explosion, missiles, toxic gases etc – use of materials	Non-combustible or fire-retardant and heat-resistant materials should be used throughout the facility.	To be confirmed in Step 3 and/or Step 4.
Other SAPs from the Engineering Principles			
EKP.1 Engineering principles: key principles	Inherent safety	The underpinning safety aim for any nuclear facility should be an inherently safe design, consistent with the operational purposes of the facility.	Covered at high level in PSR Covered by Basis of Safety Case Reports Covered in Structural Design Reports To be confirmed in Step 3 and/or Step 4.
EKP.2 Engineering principles: key principles	Fault tolerance	The sensitivity of the facility to potential faults should be minimised.	Covered at high level in PSR Covered by Basis of Safety Case Reports Covered in Structural Design Reports To be confirmed in Step 3 and/or Step 4.
EKP.3 Engineering principles: key principles	Defence in depth	A nuclear facility should be so designed and operated that defence in depth against potentially significant faults or failures is achieved by the provision of several levels of protection.	Covered at high level in PSR Covered by Basis of Safety Case Reports Covered in Structural Design Reports To be confirmed in Step 3 and/or Step 4.
EKP.4 Engineering principles: key principles	Safety function	The safety function(s) to be delivered within the facility should be identified by a structured analysis.	Covered at high level in PSR Covered by Basis of Safety Case Reports Covered in Structural Design Reports To be confirmed in Step 3 and/or Step 4.

SAP No and Title	Description	Interpretation	Comment
EKP.5 Engineering principles: key principles	Safety measures	Safety measures should be identified to deliver the required safety function(s).	Covered at high level in PSR Covered by Basis of Safety Case Reports Covered in Structural Design Reports To be confirmed in Step 3 and/or Step 4.
EMC.5 Engineering principles: integrity of metal components and structures: general	Defects	It should be demonstrated that safety-related components and structures are both free from significant defects and are tolerant of defects.	Inferred by reference to standards. Construction phase.
EMC.6 Engineering principles: integrity of metal components and structures: general	Defects	During manufacture and throughout the operational life the existence of defects of concern should be able to be established by appropriate means.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4.
EMC.7 Engineering principles: integrity of metal components and structures: design	Loadings	For safety-related components and structures, the schedule of design loadings (including combinations of loadings), together with conservative estimates of their frequency of occurrence should be used as the basis for design against normal operating, plant transient, testing, fault and internal or external hazard conditions.	Refer to ECE.6 Covered at high level in PSR Covered by Basis of Safety Case Reports Covered in Structural Design Reports Frequencies not covered at Step 2.
EMC.11 Engineering principles: integrity of metal components and structures: design	Failure modes	Failure modes should be gradual and predictable.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4.

SAP No and Title	Description	Interpretation	Comment
EMC.13 Engineering principles: integrity of metal components and structures: manufacture and installation	Materials	Materials employed in manufacture and installation should be shown to be suitable for the purpose of enabling an adequate design to be manufactured, operated, examined and maintained throughout the life of the facility.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4. CDM interface.
EMC.14 Engineering principles: integrity of metal components and structures: manufacture and installation	Techniques and procedures	Manufacture and installation should use proven techniques and approved procedures to minimise the occurrence of defects that might affect the required integrity of components or structures.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4.
EMC.16 Engineering principles: integrity of metal components and structures: manufacture and installation	Contamination	The potential for contamination of materials during manufacture and installation should be controlled to ensure the integrity of components and structures is not compromised.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4.
EMC.17 Engineering principles: integrity of metal components and structures: manufacture and installation	Examination during manufacture	Provision should be made for examination during manufacture and installation to demonstrate the required standard of workmanship has been achieved.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4.
EMC.19 Engineering principles: integrity of metal components and structures: manufacture and installation	Non-conformities	Where non-conformities with the procedures are judged to have a detrimental effect on integrity or significant defects are found and remedial work is necessary, the remedial work should be carried out to an approved procedure and should be subject to the same requirements as the original.	Construction phase.

SAP No and Title	Description	Interpretation	Comment
EMC.21 Engineering principles: integrity of metal components and structures: operation	Safe operating envelope	Throughout their operating life, safety-related components and structures should be operated and controlled within defined limits consistent with the safe operating envelope defined in the safety case.	Arrangements to be confirmed in Step 4.
EMC.25 Engineering principles: integrity of metal components and structures: monitoring	Leakage	Means should be available to detect, locate, monitor and manage leakage that could indicate the potential for an unsafe condition to develop or give rise to a significant radiological effect.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4. Interface with Radwaste.
EMC.26 Engineering principles: integrity of metal components and structures: monitoring	Forewarning of failure	Detailed assessment should be carried out where monitoring is claimed to provide forewarning of significant failure.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4.
EMC.27 Engineering principles: integrity of metal components and structures: pre- and in-service examination and testing	Examination	Provision should be made for examination that is reliably capable of demonstrating that the component or structure is manufactured to the required standard and is fit for purpose at all times during service.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4. (Comparison with arrangements on existing plants required)
EMC.28 Engineering principles: integrity of metal components and structures: pre- and in-service examination and testing	Margins	An adequate margin should exist between the nature of defects of concern and the capability of the examination to detect and characterise a defect.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4.

SAP No and Title	Description	Interpretation	Comment
EMC.29 Engineering principles: integrity of metal components and structures: pre- and in-service examination and testing	Redundancy and diversity	Examination of components and structures should be sufficiently redundant and diverse.	To be confirmed in Step 3 and/or Step 4.
EMC.30 Engineering principles: integrity of metal components and structures: pre- and in-service examination and testing	Control	Personnel, equipment and procedures should be qualified to an extent consistent with the overall safety case and the contribution of examination to the structural integrity aspect of the safety case.	Inferred by reference to standards. To be confirmed in Step 3 and/or Step 4.
EMC.32 Engineering principles: integrity of metal components and structures: analysis	Stress analysis	Stress analysis (including when displacements are the limiting parameter) should be carried out as necessary to support substantiation of the design and should demonstrate the component has an adequate life, taking into account time-dependent degradation processes.	To be confirmed in Step 3 and/or Step 4.
EMC.33 Engineering principles: integrity of metal components and structures: analysis	Use of data	The data used in analyses and acceptance criteria should be clearly conservative, taking account of uncertainties in the data and the contribution to the safety case.	To be confirmed in Step 3 and/or Step 4.
EMC.34 Engineering principles: integrity of metal components and structures: analysis	Defect sizes	Where high reliability is required for components and structures and where otherwise appropriate, the sizes of crack-like defects of structural concern should be calculated using verified and validated fracture mechanics methods with verified application.	Inferred by reference to standards To be confirmed in Step 3 and/or Step 4.

SAP No and Title	Description	Interpretation	Comment
EAD.1 Engineering principles: ageing and degradation	Safe working life	The safe working life of structures, systems and components that are important to safety should be evaluated and defined at the design stage.	To be confirmed in Step 3 and/or Step 4
EAD.2 Engineering principles: ageing and degradation	Lifetime margins	Adequate margins should exist throughout the life of a facility to allow for the effects of materials ageing and degradation processes on structures, systems and components that are important to safety.	To be confirmed in Step 3 and/or Step 4
EAD.3 Engineering principles: ageing and degradation	Periodic measurement of material properties	Where material properties could change with time and affect safety, provision should be made for periodic measurement of the properties.	To be confirmed in Step 3 and/or Step 4
EAD.4 Engineering principles: ageing and degradation	Periodic measurement of parameters	Where parameters relevant to the design of plant could change with time and affect safety, provision should be made for their periodic measurement.	To be confirmed in Step 3 and/or Step 4
Other SAPs			
MS.2 Leadership and management for safety	Capable organisation	The organisation should have the capability to secure and maintain the safety of its undertakings.	To be confirmed in Step 3 and/or Step 4
DC.1 Decommissioning	Design and operation	Facilities should be designed and operated so that they can be safely decommissioned.	Contained in Basis of Safety Case Reports
DC.4 Decommissioning	Planning for decommissioning	A decommissioning plan and programme should be prepared and maintained for each nuclear facility throughout its life-cycle to demonstrate that it can be safely decommissioned.	Contained in Basis of Safety Case Reports
DC.5 Decommissioning	Passive safety	The facility should be made passively safe before entering a care and maintenance phase.	N/A – Operational Phase

SAP No and Title	Description	Interpretation	Comment
RL.2 Control and remediation of radioactively contaminated land	Actions to establish the existence of radioactively contaminated land	Steps should be undertaken to detect any areas of radioactively contaminated land on or adjacent to the site.	Site specific issue not covered under GDA
ELO.1 Engineering principles: layout	Access	The design and layout should facilitate access for necessary activities and minimise adverse interactions during such activities.	Linked to CDM compliance & conventional safety. Contained in Basis of Safety Case Reports
ELO.2 Engineering principles: layout	Unauthorised access	Unauthorised access to or interference with safety systems and their reference data and with safety-related structures and components should be prevented.	May be considered under security considerations in Step 3.
ELO.3 Engineering principles: layout	Movement of nuclear matter	Site and facility layouts should minimise the movement of nuclear matter.	To be confirmed in Step 3 and/or Step 4
ELO.4 Engineering principles: layout	Minimisation of the effects of incidents	The design and layout of the site and its facilities, the plant within a facility and support facilities and services should be such that the effects of incidents are minimised.	To be confirmed in Step 3 and/or Step 4
ESS.18 Engineering principles: safety systems	Failure independence	No fault, internal or external hazard should disable a safety system	This will be assessed during Step 3 especially those areas where exceptions to segregation by safety barriers exist (in conjunction with the Internal Hazards assessment).
ECS.1 Engineering principles: safety classification and standards	Safety categorisation	The safety functions to be delivered within the facility, both during normal operation and in the event of a fault or accident, should be categorised based on their significance with regard to safety.	Covered by PSR Section 3.1.2

SAP No and Title	Description	Interpretation	Comment
ECS.2 Engineering principles: safety classification and standards	Safety classification of structures, systems and components	Structures, systems and components that have to deliver safety functions should be identified and classified on the basis of those functions and their significance with regard to safety.	Covered by PSR Sections 3.2 to 3.10
ECS.3 Engineering principles: safety classification and standards	Standards	Structures, systems and components that are important to safety should be designed, manufactured, constructed, installed, commissioned, quality assured, maintained, tested and inspected to the appropriate standards.	Covered by Sections PSR 4.1 to 4.3 Internationally recognised standards applied.
ECS.4 Engineering principles: safety classification and standards	Codes and Standards	For structures, systems and components that are important to safety, for which there are no appropriate established codes or standards, an approach derived from existing codes or standards for similar equipment, in applications with similar safety significance, may be applied.	Not claimed under current submission. Internationally recognised standards applied.
ECS.5 Engineering principles: safety classification and standards	Use of experience, tests or analysis	In the absence of applicable or relevant codes and standards, the results of experience, tests, analysis, or a combination thereof, should be applied to demonstrate that the item will perform its safety function(s) to a level commensurate with its classification.	Not claimed under current submission. Internationally recognised standards applied.

