GE Hitachi Nuclear Energy

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Revision B

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BWRX-300 UK Generic Design Assessment (GDA) Chapter 19 – Emergency Preparedness and Response

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NEDO-34191 Revision B

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EXECUTIVE SUMMARY

The BWRX-300 Preliminary Safety Report Chapter 19 provides a description of emergency arrangements that will be developed for the BWRX-300 design in order to protect workers (including emergency workers), the public, and the environment in the event of a radiological emergency.

The chapter covers elements of the BWRX-300 design that will facilitate on-site and off-site emergency arrangements. This chapter recognises what will be required for site licensing and operation.

During future licensing activities this chapter will be developed further to provide information on emergency arrangements, demonstrating in a reasonable manner that, in a nuclear or radiological emergency, all actions necessary for the protection of workers (including emergency workers), the public and the environment could be taken, and that the decision-making process for the implementation of these actions would be timely, disciplined, coordinated and effective.

Details of the licensee/duty holder arrangements have yet to be developed. Therefore, at this stage the scope is limited to a summary of the operational philosophies developed for the BWRX-300 design.

Emergency response is the fifth and final Level of Defence-in-Depth. Emergency response is achieved through both the arrangements and the provision of facilities; the emergency response arrangements and the emergency response facilities envisaged for the BWRX-300.

The following emergency response arrangements are described:

- Nuclear Emergency Plan
- Nuclear Emergency Programme
- Emergency Operating Procedures
- Diverse and FLEXible mitigation strategies (FLEX) Support Guidelines
- Severe Accident Management Guidelines
- Emergency Response Organization
- Off-site emergency preparedness

The following emergency response facilities are described:

- The Main Control Room
- The Secondary Control Room
- Emergency Mitigating Equipment / FLEX
- Off-site Support Emergency Response Facility

Claims and arguments relevant to GDA step 2 objectives and scope are summarised in Appendix A, along with an As Low As Reasonably Practicable (ALARP) position. Appendix B provides reference to UK-specific expectations.

ACRONYMS AND ABBREVIATIONS

Acronym	Explanation
ALARP	As Low As Reasonably Practicable
CAE	Claims, Arguments, and Evidence
DEC	Design Extension Condition
DL	Defense Line
DL4a	Defense Line 4a
DL4b	Defense Line 4b
EME	Emergency Mitigating Equipment
EMEG	Emergency Mitigating Equipment Guideline
EOC	Emergency Operations Centre
EOP	Emergency Operating Procedure
ERF	Emergency Response Facility
ERO	Emergency Response Organization
FLEX	diverse and FLEXible mitigation strategies
FSG	FLEX Support Guidelines
HFE	Human Factors Engineering
HSI	Human System Interface
IAEA	International Atomic Energy Agency
I&C	Instrumentation and Control
LC	Licence Condition
MCR	Main Control Room
NAIR	National Arrangements for Incidents involving Radioactivity
NEI	Nuclear Energy Institute
NI Act	The Nuclear Installations Act 1965
ONR	The Office for Nuclear Regulation (UK)
PPE	Personal Protective Equipment
PSR	Preliminary Safety Report
RB	Reactor Building
REPPIR	Radiation (Emergency Preparedness and Public Information) Regulations 2019
SA	Severe Accident
SAA	Severe Accident Analysis
SAG	Severe Accident Guideline
SAMG	Severe Accident Management Guideline
SCDS	Safety Case Development Strategy
SCR	Secondary Control Room

Acronym	Explanation
SSCs	Structures, Systems, and Components

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

19 EMERGENCY PREPAREDNESS AND RESPONSE

Introduction

The BWRX-300 Preliminary Safety Report Chapter 19 provides a description of emergency arrangements that will be developed for the BWRX-300 design in order to protect workers (including emergency workers), the public, and the environment in the event of a radiological emergency.

The chapter covers elements of the BWRX-300 design that will facilitate on-site and off-site emergency arrangements. This chapter recognises what will be required for site licensing and operation.

During future licensing activities this chapter will be developed further to provide information on emergency arrangements, demonstrating in a reasonable manner that, in a nuclear or radiological emergency, all actions necessary for the protection of workers (including emergency workers), the public and the environment could be taken, and that the decision-making process for the implementation of these actions would be timely, disciplined, coordinated and effective.

Details of the licensee/duty holder arrangements have yet to be developed. Therefore, at this stage the scope is limited to a summary of the operational philosophies developed for the BWRX-300 design.

Emergency response is the fifth and final Level of Defence-in-Depth and so the Principle of Defence-in-Depth is discussed first in Section 19.1. Emergency response is achieved through both the arrangements and the provision of facilities; the emergency response arrangements and the emergency response facilities envisaged for the BWRX-300 are discussed in Sections 19.2 and 19.2.6 respectively.

Interfaces with other chapters

The following chapters of Preliminary Safety Report (PSR) will support Chapter 19 – Emergency Preparedness and Response as it develops.

- PSR Chapter 3 – NEDO-34165, “BWRX-300 UK GDA Chapter 3: Safety Objectives and Design Rules for SSCs,” (Reference 19-1) describes the approach to delivering the safety objectives and design rules. The safety objectives and design rules provide important input to the design provisions which the conduct of operations is required to complement.
- PSR Chapter 7 – NEDO-34169, “BWRX-300 UK GDA Chapter 7: Instrumentation and Control,” (Reference 19-2) describes the I&C systems required to support the plant safety strategy described in Chapter 3, which in turn provides an input to the conduct of operations.
- PSR Chapter 13 – NEDO-34176, “BWRX-300 UK GDA Chapter 13: Conduct of Operations,” (Reference 19-3) provides a high-level description of how design and operational documentation developed for the BWRX-300 will facilitate a future licensee/duty holder to implement the safety case.
- PSR Chapter 15 – NEDO-34178, “BWRX-300 UK GDA Chapter 15: Safety Analysis,” (Reference 19-4) provides a description of the safety analyses performed to assess the safety of the plant in normal operation and in response to postulated initiating events and accident scenarios (design extension conditions and event sequences considered to be ‘practically eliminated’. The results of these analyses are used as a basis for the development of the plant operating procedures and guidelines.

- PSR Chapter 16 – NEDO-34188, “BWRX-300 UK GDA Chapter 16: Operational Limits and Conditions of Safe Operation,” (Reference 19-5) describes the approach to developing operating limits and conditions, safety limits will be identified, however the content of individual Technical Specifications is outside the scope of the PSR. The integration of the approach to operating limits and conditions into the Conduct of Operations is described in this chapter.
- PSR Chapter 18 – NEDO-34190, “BWRX-300 UK GDA Chapter 18: Human Factor Engineering,” (Reference 19-6) describes the Concept of Operation for the BWRX-300 including the level of automation and role of humans in the various operating modes, the Main Control Room (MCR) staffing concept and the procedure concept. Integration of these HF factors into the Conduct of Operation is described in this chapter.

Claims and arguments relevant to GDA step 2 objectives and scope are summarised in Appendix A, along with an As Low As Reasonably Practicable (ALARP) position. Appendix B provides UK-specific expectations.

19.1 Defence in Depth

The BWRX-300 is designed for international deployment and therefore follows the safety standards developed and published by the International Atomic Energy Agency (IAEA), in lieu of specific national regulatory requirements 005N9751, "BWRX-300 General Description," (Reference 19-7). The IAEA Safety Standards represent an international consensus on what measures constitute a high level of protection and safety.

IAEA Safety Standards, specifically IAEA, No. SSR-2/1 (Rev. 1), "Safety of Nuclear Power Plants: Design," (Reference 19-8) require the application of defence in depth for all nuclear installations. The defence in depth principle states that multiple independent layers of defence should be in place for any activity that poses a safety risk, such that, should one of them fail, the next level would intervene, with the ultimate goal of avoiding or minimising the consequences for workers and public.

The fifth and final level of defence is the on- and off-site emergency response. IAEA SSR-2/1 (Rev.1) (Reference 19-8) states that the purpose Defense Level 5 is "to mitigate the radiological consequences of radioactive releases that could potentially result from accidents. This requires the provision of adequately equipped emergency response facilities and emergency plans and emergency procedures for on-site and off-site emergency response."

An effective response to an emergency requires strong linkages between accident management and emergency preparedness. Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of Severe Accidents (SAs) are part of Defense Level 4 of the Defence-in-Depth approach.

For the BWRX-300 design, the fourth Defense Line (DL) is split into Defense Line 4a (DL4a) and Defense Line 4b (DL4b), providing independent provisions for prevention and mitigation respectively of Design Extension Conditions (DECs). This is illustrated in Figure 19-1 below.

The use of non-permanent equipment, known as Emergency Mitigating Equipment (EME)/ diverse and FLEXible mitigation strategies (FLEX), is considered an acceptable DL4b provision to restore lost safety functions, but not to be the regular or primary means to achieve these functions in accident conditions. These strategies were developed following learning from Fukushima. FLEX is discussed further in Subsections 19.2.2 and 19.3.3 below.

The fifth DL in Figure 19-1 covers mitigation actions following significant releases of radioactive material and consists of for example the issuing of Iodine tablets and evacuation of workers and the public, NEDO-33989, "BWRX-300 Safety Strategy White Paper," (Reference 19-9).

19.2 Arrangements for Performing Functions Essential for the Emergency Response

Accident management includes multiple components such as equipment and instrumentation, procedures and guidelines, and organisational accountabilities, and it interfaces with many programs established for a reactor facility. An adequate accident management plan ensures the ability to respond to any credible accident in order to prevent the escalation of the accident, mitigate the consequences of the accident, and achieve a long-term stable state after the accident.

Integrated accident management planning consists of a cohesive set of plans and arrangements undertaken to ensure:

- Safety systems and the available Structures, Systems, and Components (SSCs) can be used to control the reactivity, cool the fuel, and contain the radioactive materials such that damage to the reactor vessel and harm to workers, public, and environment is prevented or mitigated.
- Personnel with responsibilities for accident management are adequately prepared to utilise the available resources, procedures, and guidelines to perform effective accident management actions and, when deemed necessary, to call for and interact with the emergency response teams.

Emergency Operating Procedures (EOPs), Emergency Mitigating Equipment Guidelines (EMEGs)/FLEX Support Guidelines (FSGs) and Severe Accident Management Guidelines (SAMGs) are developed and implemented to facilitate a licensee's capability to manage Design Extension Conditions with and without core damage and practically eliminated events. This will be done with input from the Human Factor Engineering described in PSR Chapter 18 (Reference 19-6).

Further details of these guidelines are provided below.

19.2.1 Emergency Operating Procedures

IAEA, No. SSR-2/2, "Safety of Nuclear Power Plants: Commissioning and Operation," (Reference 19-10) states ".. [g]uidelines or procedures shall be developed for the management of accidents more severe than the design basis accidents. Both event based approaches and symptom based approaches shall be used, as appropriate. The related analysis and justifications shall be documented." IAEA, No. SSG-70, "Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants," (Reference 19-11) provides further guidance stating:

> "Emergency operating procedures should also address design extension conditions without significant fuel degradation. The purpose of emergency operating procedures is to guide the main control room operators and other operating personnel in preventing fuel degradation, considering the full design capabilities of the plant, using both safety systems and non-safety systems, including possibly using them beyond their originally intended function and operating conditions. Emergency operating procedures should be used in the preventive domain of accident management."

Emergency conditions to be addressed include unexpected radiological and non-radiological hazards, excessive emission of radiological and non-radiological liquid or gaseous effluent, fires, and natural disasters. EOPs are kept in prominent, easily accessible locations.

EOPs implement the strategies and measures employed in the integrated accident management plan and ensure that escalation of an accident is avoided, the accident progression is terminated, and radionuclide releases are kept to a minimum.

The EOPs contain a set of information, instructions, and actions designed to prevent the escalation of an accident, mitigate its consequences, and bring the reactor to a safe and stable

state. The development of these procedures takes into consideration the information available to the operating staff and conditions where some of the information may be incomplete with significant uncertainties. Also taken into consideration are long time periods to initiate and complete required actions, human and organisational performance, and the possibility of prolonged times to restore power.

PSR Chapter 16 (Reference 19-5) describes the Operational Limits and Conditions for Safe Operation which if exceeded mark the transition into EOPs.

The EOPs are described further along with other operating procedures in PSR Chapter 13 (Reference 19-3) on the Conduct of Operations.

19.2.2 FLEX Support Guidelines

FLEX Support Guidelines (FSGs) are guidelines for providing strategies for use of installed and portable equipment and resources to maintain or restore core cooling, containment, and Spent Fuel Pond cooling capabilities during beyond design basis events; the US Nuclear Energy Institute has produced a FLEX Implementation Guide NEI 12-06, “Diverse and Flexible Coping Strategies (Flex) Implementation Guide,” (Reference 19-12).

One of the primary lessons learned from the accident at Fukushima Dai-ichi was the significance of the challenge presented by a loss of safety-related systems following the occurrence of a beyond-design-basis external event.

For the BWRX-300, the diverse coping strategies are planned to consist of both:

- An on-site component using equipment stored at the plant site.
- An off-site component for the provision of additional materials and equipment for longer-term response.

By providing multiple means of power and water supply to support key safety functions, the diverse coping strategies increase the likelihood of being able to mitigate the consequences of beyond-design-basis external events.

The objective of the diverse coping strategies is to establish an indefinite coping capability to:

- Prevent damage to the fuel in the reactor and spent fuel pools.
- Maintain the containment function by using installed equipment, on-site portable equipment, and pre-staged off-site resources.

This capability will address both:

- An extended loss of AC power (i.e., loss of off-site power, emergency diesel generators and any alternative AC source).
- A loss of heat sink which could arise following external events that are within the existing design basis with additional failures and conditions that could arise from a beyond-design-basis external event (“Status Report – BWRX-300,” (Reference 19-13)).

Since the beyond-design-basis regime is essentially unlimited, where feasible, plant features and insights from beyond-design-basis evaluations are used to inform coping strategies.

BWRX-300 will have EME/FLEX, and its use is to be covered in EMEGs/FSGs. EME/FLEX will continue to be assessed as part of BWRX-300 design.

FLEX equipment will be located and stored in the general yard area. There may be multiple connection locations in the final BWRX-300 design.

19.2.3 Severe Accident Management Guidelines

IAEA SSR-2/2 (Reference 19-10), Requirement 19 on accident management in the operation of nuclear power plants states: “The operating organization shall establish, and shall periodically review and as necessary revise, an accident management programme.”. IAEA, No. SSG-54, “Accident Management Programmes for Nuclear Power Plants,” (Reference 19-14) provided guidance on developing Severe Accident Management Guidelines.

SAMGs are guidelines that provide strategies to manage the consequences of an accident or event which would be implemented upon receipt of specific plant parameter values indicative of imminent or actual damage to irradiated fuel (e.g., high core exit temperatures or low Reactor Pressure Vessel water level). These guidelines employ strategies intended to arrest the progression of fuel damage, maintain the capability of the containment as long as possible, and minimise radiological releases. The US Nuclear Energy Institute and the Electric Power Research Institute have also produced guidance on developing SAMGs (References 19-15 and 19-16 respectively).

GEH will develop the SAMGs using as a basis the Boiling Water Reactor Owners Group generic Severe Accident Guidelines (SAGs). These guidelines will be reviewed for their applicability and revised to account for design specific equipment and instrumentation and the results from the Severe Accident Analysis (SAA) undertaken for BWRX-300. The SAMGs will also account for the results of the Human Factors Engineering (HFE) particularly related to task achievability in harsh and stressful conditions.

The SAA to be described in PSR Chapter 15 will model the accident progression and the results will be used as inputs to determine the time available to implement emergency actions in the SAMGs.

The outcome from this set of inputs will be a set of SAMGs that are specific to the standard plant and specific recommended human actions.

The future licensee/duty holder will then further develop the SAMGs specific for the organisation, plant, and site.

19.2.4 Emergency Response Organization

The Emergency Response Organisation (ERO) is an organisational structure within the licensee/duty holder organisation which defines command and control roles to on-shift staff to perform the on-site emergency response and liaise with any off-site emergency response organisations in the event of an emergency. Examples of such positions include those responsible for plant operations and safe shutdown, and firefighting activities. In addition, there may be roles defined in an Augmented ERO for off-shift staff who may be called in NEI 10-05, “Assessment of On-Shift Emergency Response Organization Staffing and Capabilities,” (Reference 19-17) and NEI 13-06, “Enhancements to Emergency Response Capabilities for Beyond Design Basis Events and Severe Accidents,” (Reference 19-18).

For example, a senior authorised person on shift during a declared emergency will be designated as the ’Ultimate Decision Maker’ with the ERO and will undertake the following:

- Assume command and control of emergency response operations from the outset of the emergency.
- Be located in either the MCR, Secondary Control Room (SCR) or On-site Emergency Operations Centre (EOC).
- Fulfil the responsibilities of the emergency response Commander until relieved by the call-in emergency response Commander supported by the augmented ERO.

- Until relieved, execute both the senior shift licence duties and specific responsibilities of the emergency response Commander (e.g., off-site interface role, overall site commander and chief of response).
- Perform an emergency assessment in order to declare a Site Incident or Off-Site Nuclear Emergency and determine the following:
  - Extent of the on-site response and staff mobilisation required for the protection of on-site personnel and equipment.
  - Extent of the off-site response required for the protection of the public and the environment.

19.2.5 Off-Site Emergency Preparedness

IAEA No. GSR Part 7, "Preparedness and Response for a Nuclear or Radiological Emergency," (Reference 19-19) establishes requirements for an adequate level of preparedness and response for a nuclear or radiological emergency (on and off-site). The national government should apply these requirements by adopting legislation and establishing regulations, and by making other arrangements, including assigning responsibilities (e.g. to the operating organisation or the operating personnel of a facility or an activity, local or national officials, response organisations or the regulatory body) and verifying their effective fulfilment.

IAEA No. GS-G-2.1, "Arrangements for Preparedness for a Nuclear or Radiological Emergency," (Reference 19-20) provides guidance – *inter alia* – on establishing off-site emergency planning zones.

The integration of resources and support from both internal and external parties is essential to ensure on and off-site measures are administered per the nuclear emergency plan. Consequently, licensees/duty holders need to work with government agencies, regional partners, and other stakeholders to protect the public and plan for recovery following a nuclear emergency.

19.2.6 Nuclear Emergency Plan

A future licensee/duty holder will develop a Nuclear Emergency Plan to address site specific emergency planning including – for example - the following:

- The basis for emergency planning
- Selection and qualification of workers
- Emergency preparedness and response organisation
- Emergency training
- Drills and exercises
- Emergency procedures
- Assessment of emergency response capability
- Assessment of accidents
- Activation and termination of emergency responses
- Protection of facility workers and equipment
- Interface with off-site organisations
- Recovery program
- Public education program

The Emergency Plan can also be called upon to respond to any potential hazardous events or business disruption, so as to ensure that safe and stable conditions are established. As a consequence, the arrangements will be effectively practised during real events, in addition to being subject to a regular exercise program.

19.3 Emergency Response Facilities

The BWRX-300 Emergency Response Facilities (ERFs) will include:

- The EOC located on-site.
- The EOC is located near the MCR, where site shift staff assemble to manage and coordinate event response.
- Site Management Centre/Technical Support Centre.
- Located on-site, but outside of the protected area. The Site Management Centre is staffed with on-call teams of ERO personnel, which includes technical support.
- An ERF located off-site.

As the BWRX-300 design progresses, further details will be developed.

The EOC and Site Management Centre will contain the equipment necessary to gather, store and display data needed in these facilities to analyse plant conditions. Information on radiological conditions in the plant and its immediate surroundings, and meteorological conditions in the vicinity of the plant, are accessible from the EOC and Site Management Centre.

The plant information necessary to support overall emergency response from the MCR, SCR, EOC, Site Management Centre and ERFs located off-site is provided by instrumentation and controls which will be described in PSR Chapter 7 as the design develops.

The EOC and Site Management Centre will include secure means of communication with the MCR, SCR and other important points in the plant, and with on-site and off-site EROs.

The BWRX-300 design includes an MCR, as well as an SCR which is physically and electrically separate from the MCR. The concept of having both the MCR and SCR is to minimise the possibility of a single event affecting both.

The MCR, located in the Control Building, is the primary location for plant monitoring and control.

In the current concept design, the SCR is located in the Reactor Building (RB). A qualified route exists from the MCR to the SCR for events that necessitate evacuation of the MCR. An alternative route exists for fire events which does not go through the same fire zones as the primary route.

The MCR and SCR provide the ability to place and maintain the reactor in a safe shutdown state in the event of a MCR evacuation event.

Prior to evacuating the MCR, operators trip the reactor, and initiate the Isolation Condenser System and containment isolation.

The BWRX-300 design does not rely on operator action, instrumentation, or controls outside of the MCR to maintain safe shutdown. The design includes monitoring parameters displayed in the SCR to allow operators to monitor the reactor for safe shutdown condition, 005N3747, “Human Factors Engineering Concept of Operation for BWRX-300,” (Reference 19-21).

19.3.1 Main Control Room

The MCR includes controls, indications and alarms that enable operators to perform the defined set of functions during normal operation modes and Postulated Initiating Event conditions.

The MCR is designed with Human System Interfaces (HSIs) to support the following tasks:

- Assessing the overall status and performance of the plant in any condition and providing necessary information to support operator actions.
- Monitoring and controlling Fundamental Safety Functions.
- Monitoring the status and trends of key plant parameters (such as reactor power and rates of power change).
- Operating the plant safely during operational states when the MCR is available, automatically, or manually.
- Taking measures to maintain the plant in a safe state or to bring it back into a safe state after design basis events and DECs.
- Maintaining the plant within the specified limits and conditions for the parameters associated with plant systems and equipment.
- Monitoring for failure of critical instrumentation and equipment.
- Confirming safety actions for the actuation of safety systems are automatically initiated when needed and that the relevant systems perform as intended.
- Determining the need and the time for manual initiation or intervention of specified safety actions.
- Implementing EOPs, emergency mitigating equipment guidelines, and SAMGs.

The MCR is designed to be optimal for the nominal shift complement of the control room operator role-holders. The size and layout of the MCR are expected to be adjusted as the design progresses as a result of the staffing analysis being conducted as part of the HFE process.

The MCR is designed in accordance with current international best practice codes and standards for control room design, integrating results from HFE analyses and specified HFE design requirements.

The MCR also contains an emergency communications workspace. The intent of the workspace is to allow designated personnel as required during events to communicate externally to the MCR, in such a way as to not disrupt the personnel focused on monitoring and controlling the plant in response to the event.

The emergency communications workspace is located and designed with suitable provisions to minimise disturbance to the operating crew. The emergency communications workspace also contains space for required communications equipment and administrative tasks, 005N3747 (Reference 19-21).

19.3.2 Secondary Control Room

The SCR includes the required HSI that enables operators to perform the defined set of functions required for responding to the identified plant events and conditions for which the MCR cannot be used, 005N3747 (Reference 19-21).

Access to the SCR is under strict administrative controls and indicated by alarms in the MCR to ensure unauthorised access is detected. The SCR includes HSI inventory required to maintain the plant in a safe state for scenarios requiring MCR evacuation. Suitable provisions are provided inside the SCR for transferring control to the SCR whenever the MCR is abandoned, as well as to transfer control back to the MCR. Any design features, if needed to effect I&C control transfer, are located in a suitable location determined through HFE analysis, either in the SCR or accessible via the qualified access path.

The SCR is utilised to perform the functions required to keep the plant in a safe state when the MCR is unavailable. The required functions are derived as a result of safety and HFE analyses.

The SCR includes suitable facilities for habitability and well as workspace for tasks to support required usage. The SCR contains a suitable supply of food and water. The SCR also contains adequate space and provisions for sleeping as required by the postulated scenarios in which it is used.

The SCR is designed to accommodate the expected staffing based on HFE staffing analysis for the expected usage conditions. A suitable number of workstations are provided to support the specific task, communication, and work coordination needs for expected personnel.

The layout of the workstations and HSI in the SCR provides the personnel with adequate information to assess the plant state and perform actions to maintain the plant in a safe state, if required for the expected usage scenarios.

To reduce the likelihood of human errors and time needed to resume monitoring and control tasks within the SCR, the layout and HSI of the SCR are designed to be consistent with the MCR to the extent possible, with differences driven by different purpose and user task needs.

The SCR has an emergency communications workspace located and designed with suitable provisions to minimise disturbance to the operating crew. The emergency communications workspace also contains space for communications equipment, procedures, and drawings in support of performing administrative tasks, 005N3747 (Reference 19-21).

19.3.3 FLEX Capability

The BWRX-300 has been designed to incorporate and facilitate the use of FLEX in responding to beyond design basis events. The primary objectives of the FLEX will be to provide multiple means of supplying electric power and/or water to support key safety functions for both the reactor and the spent fuel pool. It will consist of portable equipment stored at the site plus the provision from off-site of additional materials and equipment for longer-term response and provision of an indefinite coping capability.

Taking learning from events at Fukushima, sockets for the direct connection of the portable equipment will be provided in the design where feasible.

The plans for the storage and deployment of the portable equipment on-site will consider the conditions that might prevail during beyond design basis events and provide appropriate protection.

Procedures and guidance to implement the FLEX will be developed and, where feasible, insights from the severe accident analysis will be used to inform coping strategies.

19.3.4 Off-site Support Emergency Response Facility

Off-site facility/ies to support units at a single site or for the fleet which can perform analysis and liaise with other local and national emergency response facilities is something else that maybe considered by a future licensee.

19.4 Capability of the Operating Organisation for the Assessment of Potential Radioactive Releases in Accident Conditions

Instrumentation and Control equipment are provided such that essential information is available to support plant procedures during normal operations and following Design Basis Accidents and DECs.

Refinement and selection of designated instruments and displays for accident monitoring and control are based on those deemed necessary to provide the parameters required to accomplish the goals of EOPs and SAMGs. Parameters necessary for accident monitoring are specified in accordance with recognized and generally accepted standards, in particular IEC 63147:2017 / IEEE Std 497-2016, Criteria for accident monitoring instrumentation for nuclear power generating stations. The selected parameters support verification of fundamental safety functions, verification of mitigative defense line functions, identification of radioactive releases, and others as necessary for execution of AOPs, EOPs, and SAMGs.

The preliminary list of accident monitoring variables is provided in PSR Chapter 7, Table 7.3-2 (Reference 19-2).

Sufficient Personal Protective Equipment (PPE) and provisions to respond to emergencies and protect the emergency responders for the first 72 hours without off-site assistance will be provided. The PPE and response equipment will be maintained, calibrated (e.g., electronic dosimeters, radiation instrumentation) and staged for use in an emergency.

Habitability design requirements for the EOC and Site Management Centre will be developed for site licensing.

19.5 Emergency Preparedness for Multiple Unit Sites

This Preliminary Safety Report considers only a single unit; emergency preparedness for multi-unit sites is not considered here other than that the BWRX-300 design or intended operation should not prevent or inhibit emergency response for muti-unit events or mutual support between units in the event of an emergency.

DL	Objective	Design Means	Operational Means
DL1	Prevention of abnormal operation and failures	Conservative design and high quality in construction of normal operation systems, including monitoring and control systems	Operational rules and normal operating procedures
DL2	Control of abnormal operation and detection of failures	System functions for limitation and protection systems and other surveillance features	Abnormal operating procedures/emergency operating procedures
DL3	Control of design basis accidents	System functions for engineered safety features	Emergency operating procedures
DL4a	Control of design extension conditions to prevent core damage	System functions for safety features for design extension conditions without core damage	Emergency operating procedures
DL4b	Control of design extension conditions to prevent or mitigate the consequences of severe accidents	System functions for safety features for design extension conditions that may result in core damage	Emergency operating procedures/Severe Accident management guidelines (SAMG)
DL5	Mitigation of radiological consequences of significant releases of radioactive materials	On-site and off-site emergency response facilities	On-site and off-site emergency plans

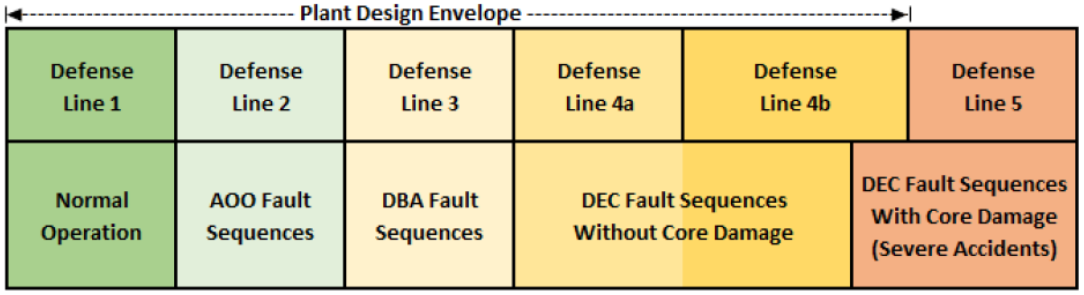

Figure 19-1: Defense Lines for the BWRX-300 (Reference 19-9)

19.6 References

19-1 NEDO-34165, “BWRX-300 UK GDA Chapter 3: Safety Objectives and Design Rules for SSCs,” Rev B, GE-Hitachi Nuclear Energy, Americas, LLC.

19-2 NEDO-34169, “BWRX-300 UK GDA Chapter 7: Instrumentation and Control,” Rev B, GE-Hitachi Nuclear Energy, Americas, LLC.

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APPENDIX A CLAIMS, ARGUMENTS AND EVIDENCE

A.1 Claims, Argument, Evidence

The Office for Nuclear Regulation (ONR) "Safety Assessment Principles for Nuclear Facilities," (Reference 19-22) identify ONR's expectation that a safety case should clearly set out the trail from safety claims, through arguments to evidence. The Claims, Arguments, and Evidence (CAE) approach can be explained as follows:

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

The GDA CAE structure is defined within the Safety Case Development Strategy (SCDS) NEDO-34140, "BWRX-300 UK GDA Safety Case Development Strategy," (Reference 19-23) and is a logical breakdown of an overall claim that:

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

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

The Level 3 sub-claims that this chapter demonstrates compliance against are identified within the SCDS (Reference 19-23) and are as follows:

> *2.2.4 Future arrangements can be developed to support an operational facility including normal and emergency arrangements.*
>
> *2.3.3 Beyond Design Basis and Severe Accidents have been appropriately assessed to identify further risk reducing measures and inform emergency arrangements.*
>
> *2.3.5 Human Factors assessments have been appropriately integrated into the design, safety assessments and management arrangements, to meet the relevant safety requirements.*

In order to facilitate compliance, demonstration against the above Level 3 sub-claims, this PSR chapter has derived a suite of arguments that comprehensively explain how their applicable Level 3 sub-claims are met (see Table A-1 below).

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

A.2 Risk Reduction As Low As Reasonably Practicable

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

- The chapter-specific arguments derived may be supported by existing and future planned evidence sources covering the following topics:
  - Relevant Good Practice has demonstrably been followed,

  - Operational Experience has been taken into account within the design process,
  - All reasonably practicable options to reduce risk have been incorporated within the design.
- It supports its applicable level 3 sub-claims, defined within the SCDS (Reference 19-23)

Probabilistic safety aspects of the ALARP argument are addressed within PSR Chapter 15 (Reference 19-4).

Table A-1: Emergency Preparedness and Response Arguments

Level 19 Chapter Claim	Chapter 19 Argument	Sub-Sections and/or Reports that Evidence the Arguments
2.2 The BWRX-300 has been developed in accordance with approved procedures, with appropriate governance and assurance arrangements by a competent and clearly defined organization.		
2.2.4 Future arrangements can be developed to support an operational facility including normal and emergency arrangements.	This chapter outlines the principles and guidance that will be followed.	All
2.3 A suitable and sufficient safety analysis has been undertaken which presents a comprehensive faut and hazards analysis that specifies the requirements on the safety measures and informs emergency arrangements.		
2.3.3 Beyond Design Basis and Severe Accidents have been appropriately assessed to identify further risk reducing measures and inform emergency arrangements	The principle of Defence-in-Depth has been followed in the design.	19.1 Defence in Depth
2.3.5 Human Factors assessments have been appropriately integrated into the design, safety assessments and management arrangements, to meet the relevant safety requirements.	Human Factors Engineering and Human Systems Interface have been used in the design of the MCR and SCR	19.3.1 Main Control Room 19.3.2 Secondary Control Room

APPENDIX B UK EXPECTATIONS

B.1 UK Legislation and Requirements

The Nuclear Site Licence granted by the ONR comprises 36 Licence Conditions (LCs), "Licence condition handbook," (Reference 19-24). LC 11 encompasses the entirety of the emergency arrangements, together with, No. 703, "The Radiation (Emergency Preparedness and Public Information) Regulations (REPPIR)," (Reference 19-25), which relates to radiation emergencies specifically.

LC 11 is, like most of the licence conditions, goal-setting in nature and non-prescriptive and so the adequacy of a licensee's arrangements for compliance is a matter for the licensee to decide and for ONR, as the enforcing authority, to adjudicate upon.

There are interactions with other Licence Conditions, namely:

- LC 09: Instructions to persons on the site; requires every person authorised to be on the site to receive instructions on the action to be taken in response to an emergency or accident on the site.
- LC 10: Training; requires the licensee to make and implement arrangements for the training of all those staff that have responsibilities for any operations which may affect safety. A site's emergency organization is clearly responsible for activities/operations which may affect safety and thus LC 10 is relevant to the training of personnel in a licensee's emergency organization.

The off-site emergency response comes under REPPIR 2019 regulations (Reference 19-25)] under which the Local Authority is responsible for determining both a Detailed Emergency Planning Zone and Outline Planning Zone following receipt of the consequence report and a discussion with the licensee.

ONR also regulates the relevant sections of:

- The No. 1075, "Ionising Radiations Regulations 2017," (Reference 19-26).
- No. 1370, "The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment (Amendment) (EU Exit) Regulations 2021," (Reference 19-27).
- No. 403, "The Nuclear Industries Security Regulations 2003 (NISR)," (Reference 19-28).
- No.483, "The Control of Major Accident Hazards Regulations 2015 (COMAH)," (Reference 19-29) with respect to emergency arrangements on nuclear sites.

This is achieved by processes of inspection and assessment of the arrangements a duty holder has made to demonstrate its compliance with the full range of statutory requirements. This is described in the ONR NS-INSP-GD-011 Issue 7.1, "Nuclear Safety Technical Inspection Guide LC 11 – On-site Emergency Arrangements," (Reference 19-30).

In addition, Licensees must comply with the "Health and Safety at Work etc. Act 1974 (HSWA)," (Reference 19-31) and its relevant statutory provisions.

Sections of the "Nuclear Installations Act 1965 (NI Act)," (Reference 19-32) relating to the licensing and inspection of nuclear installations are relevant statutory provisions of the "Energy Act 2013," (Reference 19-33). These sections of the NI Act apply to all licensees.

B.2 UK Off-Site Emergency Arrangements and Mutual Aid

External response from local authorities and emergency services would be activated according to the "Civil Contingencies Act 2004," (Reference 19-34). In the event of an Off Site Nuclear Emergency, support from off-site responders is expected to become operational within 60 minutes from the declaration of the emergency; a Strategic Coordination Centre is established in the territory of the local authority where the site is located to coordinate the activities undertaken for the protection of the public "Command, control and coordination," (Reference 19-35).

As a utility company, the operator will be listed as a Category 2 responder in the framework set up by the Civil Contingencies Act 2004. As such, the licensee will have to comply with a number of duties, including that to liaise with and provide advice to the external response organisations. Additionally, during an Off-Site Nuclear Emergency, a Scientific and Technical Advice Cell is instituted to provide technical support to the organisations engaged in the protection of the public, "Provision of scientific and technical advice in the strategic co-ordination centre: guidance to local responders," (Reference 19-36).

This works in the reverse sense also as local authorities can call upon expertise from the operator in support of RADSAFE and NAIR (National Arrangements for Incidents involving Radioactivity):

- RADSAFE is a mutual-aid association whose members collaborate, sharing knowledge and experience, to define and manage initial emergency response procedures for incidents occurring in the UK during transportation of members radiological materials, "Statement of Intent," (Reference 19-37).
- NAIR provides quick and widely available assistance to the police and other emergency services where no radiation expert is otherwise available. Assistance is provided in two stages and is drawn from hospitals, the nuclear industry and government departments, "National arrangements for incidents involving radioactivity (NAIR)," (Reference 19-38).

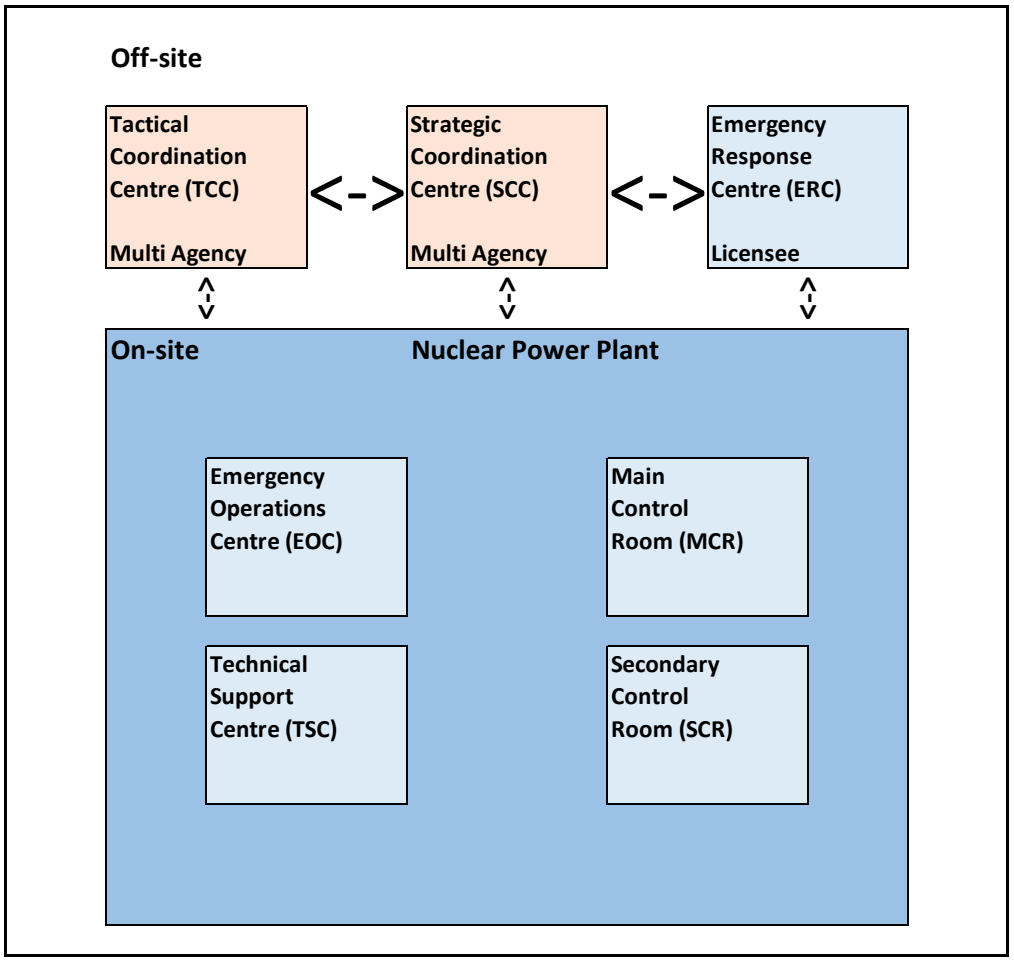

Figure B-1: Typical Arrangements for Control Centres and Command Structure

Note: Blue boxes for licensee operated locations, red for off-site multi-agency centres. Figure modified from Reference 19-30.