Bradwell:
Response to EU Stress Tests following the Events at Fukushima, Japan

Following the nuclear accident at Fukushima in Japan, the European Union agreed on assessments for all of its 143 nuclear power plants, based on a set of common criteria. These criteria have been developed by ENSREG (the European Nuclear Safety Regulators Group) and have become known as 'Stress Tests'.

In response to the Stress Tests, operators of UK nuclear power plants have reviewed the resilience of their plants to extreme situations, in particular the loss of safety functions however caused, including the loss of electrical power or loss of ultimate heat sink for heat removal from the reactor or spent fuel storage areas.

This report details the results of the Stress Test for Bradwell Site. It has been submitted to the Office for Nuclear Regulation (an agency of the Health and Safety Executive) who will review all UK submissions and prepare a summary national report. This will be reviewed by ENSREG who will report to the European Council in June 2012.

Issued by

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0 Executive Summary

This report is the response from Bradwell Site to the ENSREG Stress Tests following the events at Fukushima, Japan in March 2011.

Both reactors are permanently defuelled and the irradiated fuel cooling pond has been declared fuel-free and substantially drained. There is no fuel remaining on site and so there are no requirements for reactivity control, cooling or ultimate heat sinks.

It is considered that risks from extreme natural external events and any combinations thereof are ALARP and that it is not reasonably practicable to provide additional protection against them.

The site is not reliant on off-site infrastructure to maintain nuclear safety. The most onerous fault sequence for the site (fire in a waste vault) which could occur following loss of electrical power has radiological consequence well below that which would require any off-site countermeasures beyond sheltering.

Procedures are in place to deal with any emergency or incident which does occur and their adequacy is demonstrated to regulators on an annual basis.

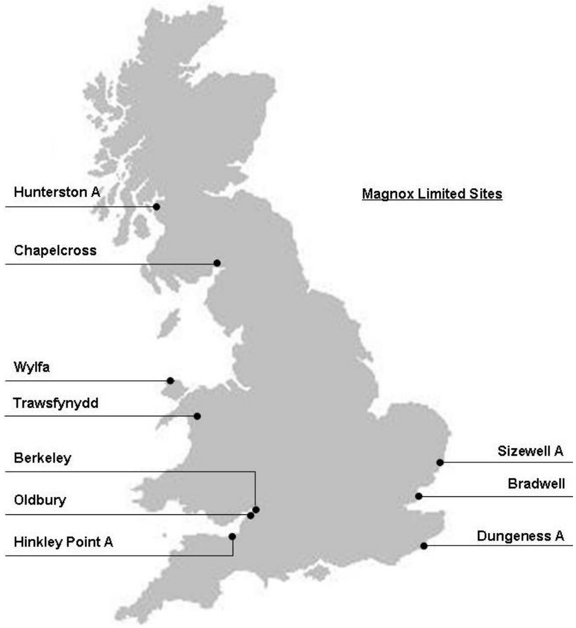
A periodic safety review has recently been carried out for Bradwell site that reviewed the safety cases for all facilities against modern standards. The report identified that the external hazards assessment required update to take account of modern standards and the site has committed to this undertaking.

A series of workshops has been held to identify potential measures to enhance resilience in the event of external hazards or severe accidents, and those being considered for implementation are listed in Table 1. The site will also be supported by enhancements proposed for central emergency support.

1 General data about site/plant

1.1 Brief description of the site characteristics

- location (sea, river)[1]
- number of units;
- license holder



Bradwell site is located on the South side of the Blackwater Estuary in Essex, United Kingdom.

The site contains two "Magnox" reactors, both of which are permanently shut down and fully defuelled. The irradiated fuel storage pond has been verified as fuel-free.

Magnox Limited is the Site Licence holder for Bradwell nuclear licensed site.

1.2 Main characteristics of the unit

- reactor type;
- thermal power;
- date of first criticality;
- existing spent fuel storage (or shared storage).

Reactor 1

Reactor 1 is a Magnox reactor. While operating it contained natural metallic uranium fuel in magnesium alloy cans in a graphite core. The core was cooled by forced circulation of CO_2 gas. The core is contained within a spherical mild steel vessel which is enclosed within a concrete reactor vault which acts as a biological shield. Six boilers are located outside of the concrete reactor vault and connected to the reactor vessel by ducting. The reactor is now vented to atmosphere via a passive unfiltered ventilation system. All means of pressurisation have been disconnected and the primary circuit is maintained in air at nominal atmospheric pressure.

Whilst it was operating, Reactor 1 was capable of producing around 500 MW thermal power.

Reactor 1 achieved first criticality in 1961 and was brought up to load in 1962. It has been permanently shutdown since 2002 and defuelling was completed in 2005.

No cooling of the reactor is required.

Reactor 2

Reactor 2 is the same design and in the same permanently shutdown and defuelled state as Reactor 1.

Reactor 2 achieved first criticality, and was brought up to load in 1962. It has been permanently shutdown since 2002 and defuelling was completed in 2005.

[1] Text and headings which are in a smaller font are relevant extracts from the ENSREG Stress Test documentation and not part of the Stress Test response.

As with Reactor 1, no cooling is required.

Irradiated Fuel Cooling Ponds

There is one pond at Bradwell, constructed of concrete, divided into five bays. All fuel was removed from the pond and transported off-site in fuel flasks by mid-2006, since when the pond has been redundant for the purpose of fuel storage. Prior to this, the pond provided cooling and shielding of irradiated fuel discharged from the reactors.

All bays other than the centre bay have been drained, cleaned and painted. The remaining water in the centre bay provides shielding for an inventory of Magnox sludge, FED (‘fuel element debris’ which comprises metal components which were attached to the cladding of the nuclear fuel rods), concrete and paint debris. At the time of writing, this material is being retrieved, drummed and placed into temporary storage in an empty waste vault.

No cooling is required in the pond.

Radioactive Waste Facilities

Intermediate level waste (ILW) and low level waste (LLW) is contained in purpose built storage facilities:

- Active Waste Vaults: These contain FED, sludges, resins and miscellaneous contaminated items (MCI) (approx 620m^3).
- Low Level Waste Management Facilities: LLW is stored in drums and ISO containers prior to transfer off site for disposal. The facilities also contain modest amounts of ILW within ductile cast iron containers (DCICs) (approx 2m^3).
- Reactor cemetery holes and quarter rooms: These contain MCI and miscellaneous activated components (MAC) (approx 168m^3).

1.3 Systems for providing or supporting main safety functions

In this chapter, all relevant systems should be identified and described, whether they are classified and accordingly qualified as safety systems, or designed for normal operation and classified to non-nuclear safety category. The systems description should include also fixed hook-up points for transportable external power or water supply systems that are planned to be used as last resort during emergencies.

1.3.1 Reactivity control

Systems that are planned to ensure sub-criticality of the reactor core in all shutdown conditions, and sub-criticality of spent fuel in all potential storage conditions. Report should give a thorough understanding of available means to ensure that there is adequate amount of boron or other respective neutron absorber in the coolant in all circumstances, also including the situations after a severe damage of the reactor or the spent fuel.

Both of the reactors at Bradwell have been permanently shutdown since 2002 and fully defuelled since 2005. The control rods are fully inserted and their drive motors and mechanisms disabled. Thus there is no potential for criticality and no requirement to control reactivity in the reactor cores.

1.3.2 Heat transfer from reactor to the ultimate heat sink

Both reactors are in a state of permanent cold shutdown. The reactors are vented to atmosphere via a passive unfiltered ventilation system and are maintained at nominal atmospheric pressure. Air flows into and out of the reactor vessel with atmospheric pressure changes.

There is no appreciable decay heat and hence no requirement for an ultimate heat sink.

1.3.2.1 All existing heat transfer means / chains from the reactor to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system) in different reactor shutdown conditions: hot shutdown, cooling from hot to cold shutdown, cold shutdown with closed primary circuit, and cold shutdown with open primary circuit.

Not applicable for Bradwell site (see above).

1.3.2.2 Lay out information on the heat transfer chains: routing of redundant and diverse heat transfer piping and location of the main equipment. Physical protection of equipment from the internal and external threats.

Not applicable for Bradwell site (see above).

1.3.2.3 Possible time constraints for availability of different heat transfer chains, and possibilities to extend the respective times by external measures (e.g., running out of a water storage and possibilities to refill this storage).

Not applicable for Bradwell site (see above).

1.3.2.4 AC power sources and batteries that could provide the necessary power to each chain (e.g., for driving of pumps and valves, for controlling the systems operation).

Not applicable for Bradwell site (see above).

1.3.2.5 Need and method of cooling equipment that belong to a certain heat transfer chain; special emphasis should be given to verifying true diversity of alternative heat transfer chains (e.g., air cooling, cooling with water from separate sources, potential constraints for providing respective coolant).

Not applicable for Bradwell site (see above).

1.3.3 Heat transfer from spent fuel pools to the ultimate heat sink

The pond has been emptied of fuel and all fuel has been removed from the Site. The pond is redundant for the purpose of fuel storage. All pond bays other than the centre bay have been drained, cleaned and painted. A small volume of water remains in the centre bay to provide shielding for a radioactive inventory as described in Section 1.2.

There is no longer any requirement to provide cooling to the pond and hence no requirement for an ultimate heat sink.

1.3.3.1 All existing heat transfer means / chains from the spent fuel pools to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system).

Not applicable for Bradwell site (see above)

1.3.3.2 Respective information on lay out, physical protection, time constraints of use, power sources, and cooling of equipment as explained under 1.3.2.

Not applicable for Bradwell site (see above).

1.3.4 Heat transfer from the reactor containment to the ultimate heat sink

The Magnox reactor design at Bradwell did not employ a containment building as would be the case with modern designs.

In its current lifecycle state, the reactor building envelope serves to provide weather protection to the structures, systems and components within it.

1.3.4.1 All existing heat transfer means / chains from the containment to the primary heat sink (e.g., sea water) and to the secondary heat sinks (e.g., atmosphere or district heating system).

Not applicable for Bradwell site (see above).

1.3.4.2 Respective information on lay out, physical protection, time constraints of use, power sources, and cooling of equipment as explained under 1.3.2.

Not applicable for Bradwell site (see above).

1.3.5 AC power supply

1.3.5.1 Off-site power supply

1.3.5.1.1 Information on reliability of off-site power supply: historical data at least from power cuts and their durations during the plant lifetime.

The reliability of the supply from the Regional Electricity Company (REC) was determined by using historical fault trends which show that a permanent fault affecting one of the duplicate feeds from the off-site primary sub-station is likely to happen less than once per year (in practice, since the site was disconnected from the National Grid in 2007, there have been no unplanned breaks of supply). The loss of one of the duplicate feeds will not disrupt the supply of power to the site.

1.3.5.1.2 Connections of the plant with external power grids: transmission line and potential earth cable routings with their connection points, physical protection, and design against internal and external hazards.

The off-site electrical supplies are obtained from the Regional Electricity Company (REC) utilising twin 11kV feeds from an off-site primary sub-station which run underground to the site. The sub-station itself is supplied by two diverse supplies. The off-site supply connects to an 11kV main site switchboard. Both the supply from the REC and the on-site circuits have protection devices including overcurrent protection, earth fault protection, trip relays and intertrip relays.

1.3.5.2 Power distribution inside the plant

The on-site electrical supplies are distributed by the Electrical Overlay System, which uses an 11kV switchboard located in the main on-site substation. This switchboard has provision for eight vacuum circuit breakers, two for the 11kV incoming supplies, five currently used for outgoing supplies and one spare. The five outgoing supplies feed individual 11kV/415V package sub-stations, located at various points around site.

Under normal conditions the two 11kV incomers are both energised, as are all five of the package substations, outgoing supplies are operated in accordance with plant requirements and the spare circuit is selected to cable earth. Mechanical interlocks are fitted as an integral part of the switchgear to prevent mal-operation.

The low voltage system used for instrument supplies is fed from unearthed three-phase fuse boards.

1.3.5.2.1 Main cable routings and power distribution switchboards.

Addressed in the text above.

1.3.5.2.2 Lay-out, location, and physical protection against internal and external hazards.

Addressed in the text above.

1.3.5.3 Main ordinary on-site source for back-up power supply

The post-defuelling safety case demonstrated that following the removal of fuel from the Site, the backup electrical supply was no longer required. Local UPS-type devices remain, however, for security systems and some alarm systems.

1.3.5.3.1 On-site sources that serve as first back-up if offsite power is lost.

Not applicable for Bradwell site (see above).

1.3.5.3.2 Redundancy, separation of redundant sources by structures or distance, and their physical protection against internal and external hazards.

Not applicable for Bradwell site (see above).

1.3.5.3.3 Time constraints for availability of these sources and external measures to extend the time of use (e.g., fuel tank capacity).

Not applicable for Bradwell site (see above).

1.3.5.4 Diverse permanently installed on-site sources for back-up power supply

As stated in Section 1.3.5.3, there is no longer a requirement for a backup power supply for the Site.

1.3.5.4.1 All diverse sources that can be used for the same tasks as the main back-up sources, or for more limited dedicated purposes (e.g., for decay heat removal from reactor when the primary system is intact, for operation of systems that protect containment integrity after core meltdown).

Not applicable for Bradwell site (see above).

1.3.5.4.2 Respective information on location, physical protection and time constraints as explained under 1.3.5.3.

Not applicable for Bradwell site (see above).

1.3.5.5 Other power sources that are planned and kept in preparedness for use as last resort means to prevent a serious accident damaging reactor or spent fuel.

This is not applicable for Bradwell Site as both reactors are permanently shutdown and defuelled and the irradiated fuel storage pond has been permanently emptied of fuel.

1.3.5.5.1 Potential dedicated connections to neighbouring units or to nearby other power plants.

Not applicable for Bradwell site (see above).

1.3.5.5.2 Possibilities to hook-up transportable power sources to supply certain safety systems.

Not applicable for Bradwell site (see above).

1.3.5.5.3 Information on each power source: power capacity, voltage level and other relevant constraints.

Not applicable for Bradwell site (see above).

1.3.5.5.4 Preparedness to take the source in use: need for special personnel, procedures and training, connection time, contract arrangements if not in ownership of the Licensee, vulnerability of source and its connection to external hazards and weather conditions.

Not applicable for Bradwell site (see above).

1.3.6 Batteries for DC power supply

As stated in Section 1.3.5.3 a backup electrical supply is no longer required by the site.

1.3.6.1 Description of separate battery banks that could be used to supply safety relevant consumers: capacity and time to exhaust batteries in different operational situations.

Not applicable for Bradwell site (see above).

1.3.6.2 Consumers served by each battery bank: driving of valve motors, control systems, measuring devices, etc.

Not applicable for Bradwell site (see above).

1.3.6.3 Physical location and separation of battery banks and their protection from internal and external hazards.

Not applicable for Bradwell site (see above).

1.3.6.4 Alternative possibilities for recharging each battery bank.

Not applicable for Bradwell site (see above).

1.4 Significant differences between units

This chapter is relevant only for sites with multiple NPP units of similar type. In case some site has units of completely different design (e.g., PWR's and BWR's or plants of different generation), design information of each unit is presented separately.

Reactor 1 and 2 are of the same design. There have been no significant modifications to the design between the two reactors since construction.

1.5 Scope and main results of Probabilistic Safety Assessments

Scope of the PSA is explained both for level 1 addressing core meltdown frequency and for level 2 addressing frequency of large radioactive release as consequence of containment failure. At each level, and depending on the scope of the existing PSA, the results and respective risk contributions are presented for different initiating events such as random internal equipment failures, fires, internal and external floods, extreme weather conditions, seismic hazards. Information is presented also on PSA's conducted for different initiating conditions: full power, small power, or shut down.

As both reactors are permanently shutdown and defuelled, there is no possibility of a core meltdown.

The latest probabilistic safety assessment (PSA) for the site was undertaken in support of the Rebaselined (Post Defuelling) Safety Case (RPDSC) for the site. It assessed the risk of death per reactor year for the public as 6.2×10^{-8} and for an individual worker as 2.9×10^{-6}. The worker value was dominated by a scenario which involved no release of material. Risks to both workers and members of the public fall in the Broadly Acceptable Region.

PSA was not carried out on any fault sequence groups which concern the reactors or primary circuit as they were all found to result in doses to public and workers which were below the assessment screening criteria. PSA was carried out on only one fault sequence concerning the fuel storage pond which is no longer a credible fault following emptying and draining of the vast majority of the pond.

No significant risk to the public was identified. The most onerous fault sequence identified, leading to a potential dose to a member of the public of 4 mSv, results from a postulated ignition of Fuel Element Debris (FED) after a fire in a waste vault. Systems and procedures are in place to prevent this occurring.

Following the Fukushima event a series of workshops has been held to consider the robustness of the site against internal and external hazards, and to look at the site emergency preparedness arrangements. Some areas for consideration were identified and these are currently being assessed. The area for consideration relevant to this section is given below:

Consideration BWA 1: Consideration will be given to the fire safety case for ILW storage facilities to identify any appropriate enhancements to the level of resilience.

2 Earthquakes

2.1 Design basis

2.1.1 Earthquake against which the plant is designed

2.1.1.1 Characteristics of the design basis earthquake (DBE)

Level of DBE expressed in terms of maximum horizontal peak ground acceleration (PGA). If no DBE was specified in the original design due to the very low seismicity of the site, PGA that was used to demonstrate the robustness of the as built design.

First Assessment

The potential for seismic hazards to affect Bradwell site was not assessed as part of the original design basis. The capability of the site to withstand seismic activity was first evaluated as part of the Long Term Safety Review (LTSR) carried out during the mid-1980s.

The assessment used a ‘target’ peak horizontal ground acceleration in the free field of 0.1g. This design basis seismic event was selected to bound the expected 10^{-3} per annum exceedance frequency event at Bradwell site.

Latest Assessment

The latest external hazards assessment for Bradwell site utilises a seismic assessment produced in 1992. The design basis seismic event was defined by the 10^{-4} per annum exceedence frequency site specific Uniform Risk Spectrum (URS). The peak horizontal ground acceleration in the free field corresponded to 0.261g.

2.1.1.2 Methodology used to evaluate the design basis earthquake

Expected frequency of DBE, statistical analysis of historical data, geological information on site, safety margin.

The 1992 seismic assessment used a site specific URS, developed in the horizontal and vertical directions for a 10^{-4} per annum exceedence frequency earthquake. Three statistically independent input time histories which matched the target response spectra of the URS were synthesised. Time history generation was based on frequencies above 1 Hz. The time histories were matched to a 5% damping response spectrum.

2.1.1.3 Conclusion on the adequacy of the design basis for the earthquake

Reassessment of the validity of earlier information taking into account the current state-of-the-art knowledge.

The UK is a region of relatively low-level and diffuse seismic activity. No specific geological or tectonic features have been identified that would suggest that earthquakes larger than those considered in the studies underpinning the Bradwell design basis event are credible.

The current external hazards assessment concludes that the risks posed by design basis seismic activity are ALARP.

2.1.2 Provisions to protect the plant against the design basis earthquake

2.1.2.1 Systems Structures and Components (SSCs)

Identification of systems, structures and components (SSCs) that are required for achieving safe shut down state and are most endangered during an earthquake. Evaluation of their robustness in connection with DBE and assessment of potential safety margin.

As both reactors are permanently shutdown and defuelled, no systems, structures and components (SSCs) are required to achieve a safe shutdown state after an earthquake.

There is no scenario for significant radioactive release (>1mSv public, >20mSv worker) in the event of any seismically induced damage to the reactors.

2.1.2.2 Main operating contingencies in case of damage that could be caused by an earthquake and could threaten achieving safe shut down state.

The reactors are already in permanent, cold shutdown state. No contingency plans for achieving a safe shutdown state are required in the event of an earthquake.

The following key actions, however, would be invoked:

- Establish Command and Control of the event

  Man the site Emergency Control Centre, or if not tenable establish an alternate command post.

- Carry out plant inspections and prioritise repair of damaged plant

  Access for post-seismic plant inspection would be subject to expert assessment of the structural condition of the buildings and would be conditioned by radiological surveys.

2.1.2.3 Protection against indirect effects of the earthquake

2.1.2.3.1 Assessment of potential failures of heavy structures, pressure retaining devices, rotating equipment, or systems containing large amount of liquid that are not designed to withstand DBE and that might threaten heat transfer to ultimate heat sink by mechanical interaction or through internal flood.

As the site no longer contains fuel, there is no requirement for heat transfer to an ultimate heat sink.

2.1.2.3.2 Loss of external power supply that could impair the impact of seismically induced internal damage at the plant.

As the site no longer contains fuel, there is no requirement for heat transfer to an ultimate heat sink.

2.1.2.3.3 Situation outside the plant, including preventing or delaying access of personnel and equipment to the site.

Delay to access of personnel and equipment to the site could occur, particularly in the event of damage to local roads. It is noted that there are no bridges on the roads between the site and the nearest towns. The most significant hindrance posed by the site becoming cut-off is likely to involve evacuation of casualties from the site. However, this would still be possible by air even if the site could not be accessed by the approach road.

2.1.2.3.4 Other indirect effects (e.g. fire, explosion).

The most onerous fault sequence associated with the site is fire or explosion in a waste vault. The off-site consequence is such that there is no resulting requirement for off-site countermeasures beyond sheltering.

2.1.3 Compliance of the plant with its current licensing basis

2.1.3.1 Processes to ensure SSCs remain in faultless condition

Licensee's processes to ensure that plant systems, structures, and components that are needed for achieving safe shut down after earthquake, or that might cause indirect effects discussed under 2.1.2.3 remain in faultless condition.

As both reactors are permanently shutdown and defuelled, no systems, structures and components (SSCs) are required to achieve a safe shutdown state after an earthquake.

The plant is subject to routine maintenance, inspection and testing as required by the Nuclear Maintenance Schedule, which lists those ongoing activities that are necessary to support the site safety case. This is implemented in accordance with Management Control Procedure (MCP) 19 [Bradwell Site, Management of Maintenance]. Specific procedures include S-268 [Inspection and Assessment of Nuclear Safety Related Civil Structures to Comply with Site Licence Condition 28], whose scope specifically includes all significant civil structures and specifically includes structures claimed for seismic support.

As necessary, the plant and safety case is modified or updated in accord with MCP 99 [Bradwell Site, Unified Arrangements for Regulatory Compliance in Projects during Defuelling and/or Decommissioning].

2.1.3.2 Processes for mobile equipment and supplies

Licensee's processes to ensure that mobile equipment and supplies that are planned to be available after an earthquake are in continuous preparedness to be used.

There is no requirement for mobile equipment and supplies to be available for use in the event of seismic activity.

2.1.3.3 Potential deviations from licensing

Potential deviations from licensing basis and actions to address those deviations.

At 10-yearly intervals, and in response to significant operating events, the safety of the plant is reviewed in a periodic safety review (PSR). This reviews the plant against modern standards, operating experience and the effect of ageing.

A PSR has recently been carried out for Bradwell site that reviewed the safety cases for all facilities against modern standards. The report identified that the external hazards assessment required update to take account of the latest changes to modern standards and the site has committed to this undertaking.

2.2 Evaluation of safety margins

2.2.1 Range of earthquake leading to severe fuel damage

Weak points and cliff edge effects: estimation of PGA that would result in damage to the weakest part of heat transfer chain, and consequently cause a situation where the reactor integrity or spent fuel integrity would be seriously challenged.

As no fuel remains on the site, there is no scenario which can lead to severe fuel damage.

2.2.2 Range of earthquake leading to loss of containment integrity

Estimation of PGA that would result in loss of integrity of the reactor containment.

This section is not applicable to Bradwell site as the reactor design did not employ a containment building (see Section 1.3.4).

2.2.3 Earthquake exceeding the design basis earthquake for the plant and consequent flooding exceeding design basis flood

Possibility of external floods caused by an earthquake and potential impacts on the safety of the plant. Evaluation of the geographical factors and the physical possibility of an earthquake to cause an external flood on site, e.g. a dam failure upstream of the river that flows past the site.

It has been determined that there is no credible risk of tsunami at Bradwell site (see Section 3.1.1.1).

With tsunami discounted, any flooding as a result of seismic activity would be no more severe than the design basis flood described in Section 3.1.1.1.

2.2.4 Potential need to increase robustness of the plant against earthquakes

Consideration of measures, which could be envisaged to increase plant robustness against seismic phenomena and would enhance plant safety.

Due to the absence of fuel on Site and limited potential for release of radioactive material, it is anticipated that it is not reasonably practicable to provide additional protection against seismic events.

3 Flooding

3.1 Design basis

3.1.1 Flooding against which the plant is designed

3.1.1.1 Characteristics of the design basis flood (DBF)

Maximum height of flood postulated in design of the plant and maximum postulated rate of water level rising. If no DBF was postulated, evaluation of flood height that would seriously challenge the function of electrical power systems or the heat transfer to the ultimate heat sink.

Site Characteristics

The Site is located on the south bank of the Blackwater Estuary. The Site lies at +5.5m above Ordnance Datum (OD) and is protected by a sea wall which rises to a height of +5m OD to the east of the Site and +4.8m OD to the west. The Site is further protected by a gulley behind the sea wall which would drain to either side of the Site any water accumulated by waves overtopping the wall. The gulley is 40m wide and has depth to almost 0m OD.

First Assessment

The potential for flooding from external sources to affect the Bradwell site was not assessed as part of the original design basis. The capability of the site to withstand flooding events was first evaluated as part of the Long Term Safety Review (LTSR) carried out during the mid-1980s.

The 10^{-3} per annum exceedance frequency tidal height at the site was determined to be +4.8m OD, with the potential for wave crests 0.75m above this level. Wave crests could overtop the sea wall by up to 0.55m. However, any water would drain away in the gulley. The tidal level would not overtop the sea wall. The 10^{-4} per annum exceedance frequency tidal height was not assessed for the Bradwell site due to unavailability of data at the time.

Latest Assessment

The latest flooding assessment for the Bradwell site was produced in 2010. The re-assessed flood levels for 2010 at exceedence frequencies of 10^{-2}, 10^{-3} and 10^{-4} per annum were +4.48m OD, +4.98m OD and +5.48m OD respectively. The 10^{-4} per annum exceedence frequency flood could result in minimal water ingress on the site, but this could be prevented by simple barrier methods. Instruction to protect potentially affected plant in such a way is contained within the site flooding plan as described in Section 3.1.2.

The flooding assessment also concluded that there was no credible tsunami risk to the Bradwell site based on its location on the south east coast of the UK.

There are no off-site water retaining structures (dams, reservoirs etc) whose failure could credibly lead to site flooding.

3.1.1.2 Methodology used to evaluate the design basis flood.

Reassessment of the maximum height of flood considered possible on site, in view of the historical data and the best available knowledge on the physical phenomena that have a potential to increase the height of flood. Expected frequency of the DBF and the information used as basis for reassessment.

For the latest flooding assessment, flood levels were re-assessed based on the latest data regarding sea level rise for locations both north (Felixstowe) and south (Sheerness and Dover) of the Site. The mean sea level data had to be adjusted to remove the influence of the metonic cycle (based on the lunar cycle) which affects tidal amplitude. This resulted in a mean annual sea level rise of 2.8mm/yr.

The mean annual sea level rise was then used to adjust the original data provided by the Anglia Water Authority for the LTSR.

Assessment of tsunami risks to the UK was based on a report published by the Department for Environment, Food and Rural Affairs (Defra) in 2005 which considered credible tsunami sources in waters around the UK.

3.1.1.3 Conclusion on the adequacy of protection against external flooding

It is concluded that flooding in the short term provides insignificant risk to the site, particularly in view of the fact the site is permanently defuelled. Even a 10^{-4} per annum exceedance frequency flood would not inundate the site. Power supplies are not at ground level and will not be threatened.

Though the effects of kinetic energy and momentum of flood water have not been specifically discussed in the flooding assessment, it is not believed that this would affect the structural integrity of the reactor buildings which are massive structures or the active waste vaults which are below ground level.

The current external hazards assessment concludes that the radiological consequences of design basis flooding are not significant and that risks are ALARP.

3.1.2 Provisions to protect the plant against the design basis flood

3.1.2.1 Systems Structures and Components (SSCs)

Identification of systems, structures and components (SSCs) that are required for achieving and maintaining safe shut down state and are most endangered when flood is increasing.

No systems, structures or components are required for achieving or maintaining a safe shutdown state because the reactors are defuelled.

3.1.2.2 Main design and construction provisions

Main design and construction provisions to prevent flood impact on the plant

The principal design and construction provisions in place to protect the plant from design basis flood are the sea wall and the gulley (see

Section 3.1.1.1). However, the level of the site should prevent inundation due to flood up to a 10^{-4} per annum exceedence frequency event.

3.1.2.3 Main operating provisions

Main operating provisions to prevent flood impact to the plant.

The site flooding plan in MCP 26/003 Chapter 2 [Bradwell Site, Flood Plan] assumes that the site would receive at least 9 hours warning of an exceptional tide. Actions to be taken include:

- Forming flood defences around any vulnerable plant
- Placing sandbags around reactor basement hatches and ensuring they are closed

3.1.2.4 Situation outside the plant.

Situation outside the plant, including preventing or delaying access of personnel and equipment to the site.

Though prevention of access to the site has not been assessed in the safety case, personnel and equipment from off-site will not be required to prevent compromise of nuclear safety as all fuel has been removed from the site.

3.1.3 Plant compliance with its current licensing basis

3.1.3.1 Processes to ensure SSCs remain in faultless condition

Licensee's processes to ensure that plant systems, structures, and components that are needed for achieving and maintaining the safe shut down state, as well as systems and structures designed for flood protection remain in faultless condition.

As both reactors are permanently shutdown and defuelled, no systems, structures and components (SSCs) are required to achieve a safe shutdown state after an earthquake.

In general, plant is subject to routine maintenance, inspection and testing as required by the Nuclear Maintenance Schedule, which lists those ongoing activities that are necessary to support the site safety case. This is implemented in accordance with MCP 19 [Bradwell Site, Management of Maintenance]. Specific procedures include S-268 [Inspection and Assessment of Nuclear Safety Related Civil Structures to Comply with Site Licence Condition 28], whose scope specifically includes "sea and river flood defences that protect the licensed site from flooding.

As necessary, the plant and safety case is modified or updated in accord with MCP 99 [Bradwell Site, Unified Arrangements for Regulatory Compliance in Projects during Defuelling and/or Decommissioning].

3.1.3.2 Processes for mobile equipment and supplies

Licensee's processes to ensure that mobile equipment and supplies that are planned for use in connection with flooding are in continuous preparedness to be used.

There is no requirement for mobile equipment and supplies to be available for use in the event of flooding within design basis.

3.1.3.3 Potential deviations from licensing basis

Potential deviations from licensing basis and actions to address those deviations.

At 10-yearly intervals, and in response to significant operating events, the safety of the plant is reviewed in a PSR. This reviews the plant against modern standards, operating experience and the effect of ageing. Enhancements identified to date in response to operating experience elsewhere have been implemented.

A PSR has recently been carried out for Bradwell site that reviewed the safety cases for all facilities against modern standards. The report identified that the external hazards assessment required update to take account of the latest changes to modern standards and the site has committed to this undertaking.

3.2 Evaluation of safety margins

3.2.1 Estimation of safety margin against flooding

Estimation of difference between maximum height of flood considered possible on site and the height of flood that would seriously challenge the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink.

As stated in Section 1.2, there is no fuel remaining on the Site. There is therefore no requirement for transfer of heat from the reactors or pond to an ultimate heat sink.

The 10^{-4} per annum exceedance frequency flood, as assessed for 2010, could potentially challenge the supply of power to the active waste vault ventilation system but it would remain safe with a margin of more than 0.5m in the event of a 10^{-3} per annum exceedance frequency flood.

3.2.2 Potential need to increase robustness of the plant against flooding

Consideration of measures, which could be envisaged to increase plant robustness against flooding and would enhance plant safety.

The only item of plant of safety significance which could be challenged by flood is the active waste vault ventilation system, to which electrical supplies could be lost. Given the low consequence and low probability of failure, it is considered that the site is sufficiently robust against flooding and that risks are ALARP.

4 Extreme weather conditions

4.1 Design basis

4.1.1 Reassessment of weather conditions used as design basis

The original design of the plant would have been in accordance with construction standards of the day (mid-1950s); likely to have been based on extreme weather return periods in the order of 1 in 50 to 1 in 100 years.

Extreme Wind Loading

The latest external hazards assessment was based on a 10^{-4} per annum exceedence frequency wind speed of 61 m/s, a 10^{-3} per annum exceedence frequency average hourly wind speed of 31.6 m/s and a 3 second maximum gust of 54.6m/s. With regard to climate change predictions the 10^{-4} per annum exceedence frequency wind speed and theoretical maximum gust speeds are assumed to remain unchanged.

The reactor building is assessed against a 10^{-3} per annum exceedence frequency wind load. With no fuel in the remaining in the reactors, any consequential damage to the reactor buildings from wind loading will have negligible impact on nuclear safety.

The only part of the pond building to protrude far enough above ground level to experience non-negligible loads is the flask handling bay which is approximately 26’ high. In the absence of a detailed assessment, the possibility of some damage to the flask handling bay building cannot be ruled out, for wind speeds with an exceedence frequency of around 10^{-3} per annum. However, with no fuel remaining to be handled, such an occurrence is considered to have negligible impact on nuclear safety.

Due to their location and construction, the waste storage vaults are either subject to negligible wind loading or are expected to resist the 10^{-4} per annum exceedence frequency wind without significant damage. With no fuel on site, any consequential damage to the radioactive waste management facilities from wind loading will have negligible impact on nuclear safety.

Extreme Snow Loading

As with extreme wind loading above, any building roof damage in the case of waste management facilities and pond are not considered to be significant, and designation of the reactor building roof against the 10^{-3} per annum exceedence frequency extreme snow loading is included on an ALARP basis only.

Extreme Temperatures

Extreme temperature conditions can occur during longer periods of abnormal weather but they arise slowly and predictably over a length of time. Whilst Bradwell is an exposed site, it is not subjected to extreme weather conditions and any extreme hot or cold periods are not usually prolonged and have not significantly affected the safe running of the plant.

Station records indicate that maximum and minimum temperatures recorded on site have been +32ºC and -9ºC. The maximum 10^{-3} per annum exceedence frequency dry bulb temperature at Bradwell is predicted to be 39.1ºC, and the minimum temperature –16ºC. Temperatures at an exceedence frequency of 10^{-4} per annum are not available.

With no fuel on site, any consequential damage to the plant from extreme temperatures will have negligible impact on nuclear safety.

Precipitation

The current prediction for 10^{-4} per annum exceedence frequency rainfall is a theoretical water level on-site of 0.28m. However, this value is based on a number of conservatisms and does not take account of the influence of off-site water run-off. It is concluded that in practise the level would be much less than 0.28m and could not be sustained for a significant period. Resulting radiological risks are considered to be insignificant and ALARP.

Lightning

Lightning presents a hazard to electronic systems but due to the defuelled state of the site this hazard is considered to be negligible. The site has installed lightning conductor systems under building regulations and this provision is considered to be adequate.

4.1.1.1 Characteristics of design basis extreme weather conditions

Verification of weather conditions that were used as design basis for various plant systems, structures and components: maximum temperature, minimum temperature, various type of storms, heavy rainfall, high winds, etc.

Addressed in the text above.

4.1.1.2 Postulation of design basis characteristics

Postulation of proper specifications for extreme weather conditions if not included in the original design basis.

Addressed in the text above.

4.1.1.3 Assessment of frequency

Assessment of the expected frequency of the originally postulated or the redefined design basis conditions.

Addressed in the text above.

4.1.1.4 Potential combinations of weather conditions

Consideration of potential combination of weather conditions.

Combinations of weather have not been considered for the site, but with no fuel on site, any adverse weather combinations will have negligible impact on nuclear safety.

4.2 Evaluation of safety margins

4.2.1 Estimation of safety margin against extreme weather conditions

Analysis of potential impact of different extreme weather conditions to the reliable operation of the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink. Estimation of difference between the design basis conditions and the cliff edge type limits, i.e. limits that would seriously challenge the reliability of heat transfer.

As stated in Section 1.2, there is no fuel remaining on the Site. There is therefore no requirement for transfer of heat from the reactors or pond to an ultimate heat sink. Structural damage to reactor buildings, the pond building or waste management facilities have been assessed to present negligible nuclear safety consequence.

4.2.2 Potential need to increase robustness of the plant against extreme weather conditions

Consideration of measures, which could be envisaged to increase plant robustness against extreme weather conditions and would enhance plant safety.

No requirement to increase robustness of the plant against extreme weather conditions has been identified.

5 Loss of electrical power and loss of ultimate heat sink

5.1 Nuclear power reactors

For writing chapter 5, it is suggested that detailed systems information given in chapter 1.3. is used as reference and the emphasis is in consecutive measures that could be attempted to provide necessary power supply and decay heat removal from the reactor and from the spent fuel. Chapter 5 should focus on prevention of severe damage of the reactor and of the spent fuel, including all last resort means and evaluation of time available to prevent severe damage in various circumstances. As opposite, the chapter 6 should focus on mitigation, i.e. the actions to be taken after severe reactor or spent fuel damage as needed to prevent large radioactive releases. Main focus in chapter 6 should thus be in protection of containment integrity.

As stated in Section 1.2 both reactors are permanently shutdown and defuelled and all fuel has been removed from the site. There is no longer a requirement for heat transfer to an ultimate heat sink or for any control of reactivity in the core. Though some alarms and detectors are still dependent on electrical power for their operation, no release of radioactive material will directly result from a loss of power.

5.1.1 Loss of electrical power

5.1.1.1 Loss of off-site power

5.1.1.1.1 Design provisions taking into account this situation: back-up power sources provided, capacity and preparedness to take them in operation.

Not applicable for Bradwell site (see Section 5.1).

5.1.1.1.2 Autonomy of the on-site power sources and provisions taken to prolong the time of on-site AC power supply.

Not applicable for Bradwell site (see Section 5.1).

5.1.1.2 Loss of off-site power and loss of the ordinary back-up AC power source

5.1.1.2.1 Design provisions taking into account this situation: diverse permanently installed AC power sources and/or means to timely provide other diverse AC power sources, capacity and preparedness to take them in operation.

Not applicable for Bradwell site (see Section 5.1).

5.1.1.2.2 Battery capacity, duration and possibilities to recharge batteries.

Not applicable for Bradwell site (see Section 5.1).

5.1.1.3 Loss of off-site power and loss of the ordinary back-up AC power sources, and loss of permanently installed diverse back-up AC power sources

5.1.1.3.1 Battery capacity, duration and possibilities to recharge batteries in this situation

Not applicable for Bradwell site (see Section 5.1).

5.1.1.3.2 Actions foreseen to arrange exceptional AC power supply from transportable or dedicated off-site source

Not applicable for Bradwell site (see Section 5.1).

5.1.1.3.3 Competence of shift staff to make necessary electrical connections and time needed for those actions. Time needed by experts to make the necessary connections.

Not applicable for Bradwell site (see Section 5.1).

5.1.1.3.4 Time available to provide AC power and to restore core cooling before fuel damage: consideration of various examples of time delay from reactor shut down and loss of normal reactor core cooling condition (e.g., start of water loss from the primary circuit).

Not applicable for Bradwell site (see Section 5.1).

5.1.2 Measures which can be envisaged to increase robustness of the plant in case of loss of electrical power

Not applicable for Bradwell site (see Section 5.1).

5.1.3 Loss of the ultimate heat sink

5.1.3.1 Design provisions to prevent the loss of the primary ultimate heat sink

Design provisions to prevent the loss of the primary ultimate heat sink, such as alternative inlets for sea water or systems to protect main water inlet from blocking.

Not applicable for Bradwell site (see Section 5.1).

5.1.3.2 Effects of loss of the primary ultimate heat sink

Loss of the primary ultimate heat sink (e.g., loss of access to cooling water from the river, lake or sea, or loss of the main cooling tower).

Not applicable for Bradwell site (see Section 5.1).

5.1.3.2.1 Availability of an alternate heat sink

Not applicable for Bradwell site (see Section 5.1).

5.1.3.2.2 Possible time constraints for availability of alternate heat sink and possibilities to increase the available time.

Not applicable for Bradwell site (see Section 5.1).

5.1.3.3 Loss of the primary ultimate heat sink and the alternate heat sink

5.1.3.3.1 External actions foreseen to prevent fuel degradation.

Not applicable for Bradwell site (see Section 5.1).

5.1.3.3.2 Time available to recover one of the lost heat sinks or to initiate external actions and to restore core cooling before fuel damage: consideration of situations with various time delays from reactor shut down to loss of normal reactor core cooling state (e.g., start of water loss from the primary circuit).

Not applicable for Bradwell site (see Section 5.1).

5.1.3.4 Loss of the primary ultimate heat sink, combined with station black out (i.e. loss of off-site power and ordinary on-site back-up power source).

5.1.3.4.1 Time of autonomy of the site before start of water loss from the primary circuit starts.

Not applicable for Bradwell site (see Section 5.1).

5.1.3.4.2 External actions foreseen to prevent fuel degradation.

Not applicable for Bradwell site (see Section 5.1).

5.1.4 Measures which can be envisaged to increase robustness of the plant in case of loss of ultimate heat sink

Not applicable for Bradwell site as there is no ultimate heat sink requirement (see Section 5.1).

5.2 Spent fuel storage pools

Where relevant, equivalent information is provided for the spent fuel storage pools as explained in chapter 5.1 for nuclear power reactors.

As stated in Section 1.3.3, the fuel storage pond has been permanently emptied of fuel. There is no longer a requirement for heat transfer to an ultimate heat sink. Though some alarms and detectors are still dependent on electrical power for their operation, no significant release of radioactive material will result from a loss of power.

5.2.1 Loss of electrical power

Not applicable for Bradwell site (see Section 5.1).

5.2.2 Measures which can be envisaged to increase robustness of the plant in case of loss of electrical power

Not applicable for Bradwell site (see Section 5.1).

5.2.3 Loss of the ultimate heat sink

Not applicable for Bradwell site (see Section 5.1).

5.2.4 Measures which can be envisaged to increase robustness of the plant in case of loss of ultimate heat sink

Not applicable for Bradwell site (see Section 5.1).

6 Severe accident management

6.1 Organisation and arrangements of the licensee to manage accidents

Chapter 6.1 should cover organization and management measures for all type of accidents, starting from design basis accidents where the plant can be brought to safe shut down without any significant nuclear fuel damage and up to severe accidents involving core meltdown or damage of the spent nuclear fuel in the storage pool.

Because Bradwell is fuel-free, it is not possible for a severe accident involving core meltdown or damage of spent nuclear fuel to occur on the site.

6.1.1 Organisation of the licensee to manage the accident

6.1.1.1 Staffing and shift management in normal operation

As Bradwell is currently undergoing decommissioning activities to prepare the site for entry into care and maintenance, the staffing levels over and above the basic complement required for compliance are dependent on the projects being carried out at the time.

6.1.1.2 Plans for strengthening the site organisation for accident management

In the event of an incident on-site, the site acts in accordance with the Bradwell Emergency Handbook.

If an incident occurs, an Emergency Control Centre (ECC) will be set up with information, maps and communications equipment necessary to control the emergency. ECC staff will include the following key personnel available on a 24 hour standby rota:

- Emergency Controller
- Emergency Health Physicist
- Emergency Technical Advisor
- Emergency Administrative Officer

The Emergency Controller (EC) will declare and initiate the emergency response and take command and control of all on-site and off-site activities. Out of hours, the Shift Leader will assume the role of EC until relieved by the Duty Emergency Controller. Personnel who may act as EC are authorised in writing.

The EC will coordinate efforts with the company and with external agencies to ensure protection of security, public, personnel, plant and environment. The EC will initiate the activities of Site Emergency Teams and supervise them through the Shift Leader and Emergency Officers, The EC will ensure that sufficient manpower, equipment and materials are available for effective operation of the Emergency Organisation.

The Emergency Health Physicist will advise the EC on radiological aspects of the emergency.

The Emergency Technical Advisor will advise the EC on aspects of plant safety.

The Emergency Administrative Officer will advise the EC on administrative matters and will be responsible for the site muster.

An Access Controller will direct the location and recovery of casualties. The Shift Leader will act as Access Controller.

6.1.1.3 Measures taken to enable optimum intervention by personnel

As stated in Section 6.1.1.2, the EC will ensure that sufficient manpower, equipment and materials are available for effective operation of the Emergency Organisation.

An adequate number of trained personnel are available on-site or on standby at all times to perform, concurrently:

- Access Control
- Initial response to the incident
- Liaison with emergency services

An adequate supply of emergency equipment, protective clothing, communications equipment and health physics instruments is available in special stores and maintained in accordance with written schedules.

6.1.1.4 Use of off-site technical support for accident management

<u>Central Emergency Support Centre</u>

In the event of a site incident or off-site nuclear emergency being declared the Central Emergency Support Centre (CESC) is set up in Gloucestershire. This dedicated facility is manned by a Controller, a Health Physicist and a Technical Support Team Leader each with a support team on a one-hour call out rota.

The CESC Controller has the full backing of the Company to take whatever steps are necessary, including using any resources required, to control the situation.

The Technical Support Team in the CESC has access to the Company Drawing Office so can obtain and print systems diagrams and a range of experts to help analyse the issues on-site and formulate recovery plans.

The CESC also has access to Procurement and the Supply Chain to obtain any goods or services required in the recovery.

The CESC manages the links to the local and national responding organisations.

The CESC takes over the management of the off-site survey and the formulation of Company advice.

The CESC mobilises and coordinates the resources of the whole Company and cooperation from other nuclear companies.

<u>Other Company Sites</u>

In the event of an emergency, shift engineers and shift charge engineers on duty at other Company sites will be called upon for assistance. They will provide additional personnel and equipment, including off-site survey teams, either in accordance with the predetermined response or as requested by the CESC.

6.1.1.5 Procedures, training and exercises

Site Licence Condition (LC) 11 requires the site to put emergency arrangements in place. Compliance with LC 11 is ensured through application of MCP 26 [Bradwell Site, Contingency and Emergency Arrangements]. Requirements for training staff are managed through the MCP 10 Interface Document [Interface to Company MCP/10 Training].

Personnel with specific duties in emergency situations are also trained as necessary in:

- Emergency procedures
- Use of equipment and facilities
- Communication routes
- Command and control activities
- Nuclear and environmental hazards
- First aid
- Search
- Radiological protection
- Access control procedures

Site emergency arrangements are demonstrated to be adequate on an annual basis through a demonstration exercise for the Office for Nuclear Regulation (ONR). Regular practice exercises also take place.

6.1.2 Possibility to use existing equipment

6.1.2.1 Provisions to use mobile devices (availability of such devices, time to bring them on site and put them in operation)

The Company shares a Beyond Design Basis Accident Container set in a central location in the UK that can be transported to any affected site. These containers are equipped with Command and Control, fire fighting, reactor cooling and contamination control materials.

6.1.2.2 Provisions for and management of supplies (fuel for diesel generators, water, etc.)

There is no requirement for provision of supplies to Bradwell site in the event of an emergency or incident.

6.1.2.3 Management of radioactive releases, provisions to limit them

As there is only potential for a limited release from the stored radioactive waste there are no special provisions deemed necessary.

6.1.2.4 Communication and information systems (internal and external).

In the event of an incident or natural disaster at a power station there is a need to be able to promulgate an alert and then to pass information into and out of the site. Particularly important communications paths are those between the site, the Strategic Coordination Centre (SCC), the Central Emergency Support Centre (CESC) and the responding emergency services.

The telephone system at Bradwell is designed to be resilient. Phones in the key response centres are divided between the site exchange and direct external lines so that failure of the exchange will not leave the room without at least some working phones. The telephone exchange is connected to a battery backup with a design period of not less than 300 minutes.

6.1.3 Evaluation of factors that may impede accident management and respective contingencies

6.1.3.1 Extensive destruction of infrastructure or flooding around the installation that hinders access to the site.

It is to be considered a plausible scenario that the site could be 'islanded' by flood water since it has only one approach road which is at a slightly lower height than the site itself.

This may affect the ability of responding staff and emergency services to reach the site in a timely manner.

Sites have sufficient people on site at all times to initiate a response to an emergency. Personnel on shift include a person authorised to act as EC with authority to respond as they see fit and first aid capability.

For decommissioning sites, especially defuelled sites such as Bradwell, there is not a requirement for immediate action to prevent a serious nuclear safety hazard. The most significant hindrances posed by the site becoming cut-off are likely to involve evacuation of casualties from the site and access for fire fighting capability. However, casualty evacuation would still be possible by air even if the site could not be accessed by the approach road. Lack of personnel on site in the immediate aftermath of an incident will not result in dramatic deterioration of the state of the plant.

6.1.3.2 Loss of communication facilities / systems

The Company has robust communications systems featuring diversity and redundancy. These include:

- A resilient Company Wide Area Network
- Telephones that are independent of the Company exchanges with direct (copper) links to the Public Switched Telephone Network (PSTN)
- The Nuclear Industry Airwave Service, designed to allow communication with off-site survey vehicles, can be used to make phone calls independent of the local PSTN

Unavailability of all of these communications systems is highly unlikely.

6.1.3.3 Impairment of work performance due to high local dose rates, radioactive contamination and destruction of some facilities on site

In all exposure conditions including accident response, doses to personnel should be below dose limits (normally 20 mSv whole body dose) and must be As Low as Reasonably Practicable (ALARP). In the event of a major accident at a nuclear site the higher REPPIR Emergency Exposures can be applied to informed volunteers. The role of the Health Physicist in the Emergency Control Centre (ECC) is to ensure the safety of all people on site.

Staff that are not responding to an accident will be subject to controls based on doserate, airborne contamination levels and other hazards, and may be evacuated from the site.

The ECC is positioned to minimise the likelihood that it would be damaged in an accident or affected by radiation. It would be subject to tenability checks, the Initial Control Dose limit being 10 mSv over the first 10 hours. After this period the situation would be reassessed in the light of the radiological conditions, availability of replacement staff, etc. The function of the ECC could be transferred to other locations on site should the primary facility be declared untenable, including destruction and blocked access.

On-site survey and emergency team staff controlled from the Access Control Point (ACP) are subject to the normal dose limits but in the event of a major accident the higher REPPIR Emergency Exposures (whole body doses of 100 mSv for operations and 500 mSv for life saving) can be applied to informed volunteers. Health Physics monitoring provides information on the local dose rates allowing response teams to ensure their doses are minimised and Electronic Personal Dosimeters are used to monitor doses and enforce dose limits. If necessary an alternative facility would be nominated and used.

Training is given on the use of appropriate Personal Protective Equipment and undressing / decontamination processes, and use of these would not prevent appropriate remedial work being undertaken.

In some extreme instances high radiation levels could make access to the damage scene unachievable. If this were the case then remote access or the installation of the appropriate level of shielding would be required. If radiation levels remain high then working time would be limited, which could impair the recovery operation particularly if the operations required are time consuming. Under conditions of high local dose rates, contamination and destruction of some facilities the Company would be relying on the site Command and Control structures to manage the event making an accurate assessment of the situation and best use of available resource.

6.1.3.4 Impact on the accessibility and habitability of the main and secondary control rooms, measures to be taken to avoid or manage this situation

There is no requirement for centralised control facilities at Bradwell Site.

Emergency facilities are at or slightly above site datum which makes them potentially vulnerable to the 10^{-4} per annum exceedence frequency flood. Although there are no requirements for backup arrangements they are available in outline and are flexible. Emergency scheme personnel receive Command and Control training which emphasises flexibility of response.

6.1.3.5 Impact on the different premises used by the crisis teams or for which access would be necessary for management of the accident.

Key emergency response centres on site are the Emergency Control Centre (ECC) and Access Control Point (ACP). Bradwell has outline plans on how to cope if the primary facility is unavailable.

For decontamination of returning teams there are a number of options including other shower facilities on site or, in the longer term, use of the emergency services mobile facilities.

6.1.3.6 Feasibility and effectiveness of accident management measures under the conditions of external hazards (earthquakes, floods)

The incident management measures provided at Magnox sites are intended to be flexible. Identified personnel have high levels of authority to utilise any resources available and technical advice is available from off-site facilities.

6.1.3.7 Unavailability of power supply

Unavailability of power supply should not impede incident management. Portable radiometric instrumentation which would be used for the assessment of radiological releases is kept in emergency response vehicles. Alternative forms of communication are available such as NIAS radio and mobile telephones.

6.1.3.8 Potential failure of instrumentation

There are no requirements on permanently installed instrumentation for emergency situations. Portable radiometric instrumentation which would be used for the assessment of radiological releases is kept in emergency response vehicles. Replacement of failed instrumentation or alternative monitoring arrangements would be organised through the CESC.

6.1.3.9 Potential effects from the other neighbouring installations at site.

There are no installations adjacent to Bradwell site which would represent a significant hazard to the site.

6.1.4 Measures which can be envisaged to enhance accident management capabilities

Following the Fukushima event a series of workshops has been held to consider the robustness of the site against internal and external hazards, and to look at the site emergency preparedness arrangements. Some areas for consideration were identified and these are currently being assessed. The areas for consideration relevant to this section are given below:

Consideration BWA 2: Consideration will be given to enhancing the availability of beyond design basis equipment.

Consideration BWA 3: Consideration will be given to providing further equipment to facilitate operator access around the Site.

Consideration BWA 4: Consideration will be given to enhancing on site arrangements for command, control and communications.

Consideration BWA 5: Consideration will be given to updating and enhancing severe accident management guidance.

6.2 Maintaining the containment integrity after occurrence of significant fuel damage (up to core meltdown) in the reactor core

This section is not applicable to Bradwell site as the reactors have been permanently defuelled (see Section 1.3.1).

6.2.1 Elimination of fuel damage / meltdown in high pressure

This section is not applicable to Bradwell site as the reactors have been permanently defuelled (see Section 1.3.1).

6.2.1.1 Design provisions

Not applicable for Bradwell site (see above).

6.2.1.2 Operational provisions

Not applicable for Bradwell site (see above).

6.2.2 Management of hydrogen risks inside the containment

This section is not applicable to Bradwell site as the reactor design did not employ a containment building (see Section 1.3.4).

It should be noted that hydrogen is evolved from corrosion of Magnox FED in the active waste vaults. The vaults have a ventilation system designed to prevent build-up of hydrogen.

6.2.2.1 Design provisions, including consideration of adequacy in view of hydrogen production rate and amount

Not applicable for Bradwell site (see above).

6.2.2.2 Operational provisions

Not applicable for Bradwell site (see above).

6.2.3 Prevention of overpressure of the containment

This section is not applicable to Bradwell site as the reactor design did not employ a containment building (see Section 1.3.4).

6.2.3.1 Design provisions, including means to restrict radioactive releases if prevention of overpressure requires steam / gas relief from containment

Not applicable for Bradwell site (see above).

6.2.3.2 Operational and organisational provisions

Not applicable for Bradwell site (see above).

6.2.4 Prevention of re-criticality

This section is not applicable to Bradwell site as the reactors have been permanently defuelled (see Section 1.3.1).

6.2.4.1 Design provisions

Not applicable for Bradwell site (see above).

6.2.4.2 Operational provisions

Not applicable for Bradwell site (see above).

6.2.5 Prevention of base-mat melt through

This section is not applicable to Bradwell site as the reactors have been permanently defuelled (see Section 1.3.1).

6.2.5.1 Potential design arrangements for retention of the corium in the pressure vessel

Not applicable for Bradwell site (see above).

6.2.5.2 Potential arrangements to cool the corium inside the containment after reactor pressure vessel rupture

Not applicable for Bradwell site (see above).

6.2.5.3 Cliff edge effects related to time delay between reactor shut down and core meltdown

Not applicable for Bradwell site (see above).

6.2.6 Need for and supply of electrical AC and DC power and compressed air to equipment used for protecting containment integrity

This section is not applicable to Bradwell site as the design did not employ a containment building (see Section 1.3.4).

6.2.6.1 Design provisions

Not applicable for Bradwell site (see above).

6.2.6.2 Operational provisions

Not applicable for Bradwell site (see above).

6.2.7 Measuring and control instrumentation needed for protecting containment integrity

This section is not applicable to Bradwell site as the design did not employ a containment building (see Section 1.3.4).

6.2.8 Measures which can be envisaged to enhance capability to maintain containment integrity after occurrence of severe fuel damage

Not applicable as the reactors are defuelled.

6.3 Accident management measures to restrict the radioactive releases

6.3.1 Radioactive releases after loss of containment integrity

This section is not applicable to Bradwell site as the reactor design did not employ a containment building (see Section 1.3.4).

6.3.1.1 Design provisions

Not applicable for Bradwell site (see above).

6.3.1.2 Operational provisions

Not applicable for Bradwell site (see above).

6.3.2 Accident management after uncovering of the top of fuel in the fuel pool

As stated in Section 1.3.3, the pond has been permanently emptied of fuel. Therefore, this section is not applicable to Bradwell site.

6.3.2.1 Hydrogen management

In relation to the fuel pond, this is not applicable for Bradwell site (see above).

6.3.2.2 Providing adequate shielding against radiation

In relation to the fuel pond, this is not applicable for Bradwell site (see above).

6.3.2.3 Restricting releases after severe damage of spent fuel in the fuel storage pools

Not applicable for Bradwell site (see above).

6.3.2.4 Instrumentation needed to monitor the spent fuel state and to manage the accident

Not applicable for Bradwell site (see above).

6.3.2.5 Availability and habitability of the control room

Not applicable for Bradwell site (see above).

6.3.3 Measures which can be envisaged to enhance capability to restrict radioactive releases

There are no measures which can be envisaged that would usefully enhance the capability to restrict radioactive releases.

7 Glossary

ACP	Access Control Point
ALARP	As Low As Reasonably Practicable
CESC	Central Emergency Support Centre
CO_2	Carbon Dioxide
DBE	Design Basis Earthquake
DBF	Design Basis Flood
DCIC	Ductile Cast Iron Container
Defra	Department for Environment, Food and Rural Affairs
EC	Emergency Controller
ECC	Emergency Control Centre
ENSREG	European Nuclear Safety Regulators Group
FED	Fuel Element Debris
ILW	Intermediate Level Waste
ISO	International Standards Organisation
LC	Licence Condition
LLW	Low Level Waste
LTSR	Long Term Safety Review
MAC	Miscellaneous Activated Components
MCI	Miscellaneous Contaminated Items
MCP	Management Control Procedure
OD	Ordnance Datum
ONR	Office for Nuclear Regulation
PGA	Peak Ground Acceleration
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
PSTN	Public Switched Telephone Network
REC	Regional Electricity Company
REPPIR	Radiation Emergency Preparedness and Public Information Regulations
RPDSC	Rebaselined (Post Defuelling) Safety Case
SCC	Strategic Coordination Centre
SSC	Systems Structures and Components
URS	Uniform Risk Spectrum
UK	United Kingdom

Table 1: Considerations Identified for Bradwell Site

This is a consolidated list of the items to be considered arising from the Stress Test review.

Ref:	Section No	Consideration
BWA 1	1.5	Consideration will be given to the fire safety case for ILW storage facilities to identify any appropriate enhancements to the level of resilience.
BWA 2	6.1.4	Consideration will be given to enhancing the availability of beyond design basis equipment.
BWA 3	6.1.4	Consideration will be given to providing further equipment to facilitate operator access around the Site.
BWA 4	6.1.4	Consideration will be given to enhancing on site arrangements for command, control and communications.
BWA 5	6.1.4	Consideration will be given to updating and enhancing severe accident management guidance.