Berkeley:
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 Berkeley 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 Berkeley Site to the ENSREG Stress Tests following the events at Fukushima, Japan in March 2011.

Berkeley Site comprises the remaining structures of Berkeley nuclear power station, with two Magnox, gas cooled, graphite moderated, natural uranium reactors and those remaining buildings of the former Berkeley Nuclear Laboratories that still contain small quantities of radioactive materials and contamination.

The reactors are defuelled and there is no fuel remaining on site, therefore there are no requirements for reactivity or criticality control, cooling or ultimate heat sinks. The reactors have been placed into a passive "Safestore" condition, which means that they require minimal services to maintain their long-term physical integrity and there are no safety demands on site services. There are no fuel storage ponds on site.

Intermediate Level Waste (ILW) and Low Level Waste (LLW) are contained partly in purpose built storage facilities and partly in redundant process facilities. It was recognised (prior to the Fukushima event) that the ILW stored in underground concrete vaults is the only radioactive material that would be at significant risk from site-wide flooding from the adjacent river. As a result of As Low as Reasonably Practicable (ALARP) assessment the vaults are protected against the 10^{-4} per annum design basis flood by a purpose built flood barrier and the basements of the reactor Safestores are protected against the 10^{-2} per annum flood.

All the major structures on site have been assessed against the design basis earthquake and found to be robust and to have an acceptable performance.

A Periodic Safety Review of the site was completed in 2009 and the safety cases of the reactor Safestores and all the radioactive waste management facilities have been reviewed against modern standards. It is concluded that the facilities are robust to the challenges of extreme external hazards used in the analyses and will retain their basic integrity for somewhat more severe events and combinations, with no cliff edge effects.

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

Berkeley Site is located on the south-east bank of the Severn Estuary in Gloucestershire, United Kingdom (see map).

The site contains two defuelled "Magnox" reactors.

Magnox Limited is the Site Licence holder for the Berkeley 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).

<u>Reactors</u>

The two Magnox gas cooled, graphite moderated, natural uranium reactors were constructed between 1957 and 1962, and generated power between 1962 and 1989. The thermal power of each reactor was about 590 MW. The dates of first criticality were 29 May 1962 (Reactor 1) and 13 October 1962 (Reactor 2).

Each steel Reactor Pressure Vessel (RPV) contains an irradiated graphite core and its steel core-support structure, with the control rods now detached and resting on the bottom of their channels (total waste volume ~3,150 m^3 graphite moderator and reflector - mainly ILW, 104 m^3 metal (internal reactor structures) ILW. The RPVs are de-pressurised, air filled and vented to atmosphere (total waste volume ~1,584 m^3 metal ILW, 3,300 m^3 metal LLW). Miscellaneous Activated Components (MAC) which were routinely used within the core are located in the fuelling standpipes and stowage holes. The bioshield is still in place and the core, RPV and associated irradiated structures, surrounded by a weather-tight enclosure building, will remain in place throughout the Care and Maintenance period.

During the 1990s the boiler houses were dismantled and the 16 boiler vessels were sealed and laid horizontally on concrete plinths, adjacent to the reactor buildings. One boiler has since been decontaminated, size reduced and removed from site.

Defuelling of both reactors was completed in March 1992. Since that time extensive decommissioning work and modifications have been completed in order to place the reactors into a passive, Safestore condition in anticipation of up to 100 years of Care and Maintenance.

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[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.

Irradiated Fuel Storage Pond

There is no irradiated fuel storage pond. Following despatch of the last irradiated fuel elements from site the fuel pond building was de-planted, decontaminated, demolished to below ground level and backfilled; the work was completed in March 2001.

Former Berkeley Nuclear Laboratories

Berkeley Site includes the remaining buildings of the former Berkeley Nuclear Laboratories that still contain relatively small quantities of radioactive materials and contamination. The shielded cells and caves in the Laboratory were used for destructive examination of irradiated fuel elements from Magnox, AGR and PWR reactors. Bulk quantities of dissected fuel were despatched to BNFL Sellafield after examination but there remains on site quantities of swarf, sludges, contaminated mounts and cladding, etc. The majority of this waste was packaged and consigned to the power station's Active Waste Vaults although some remains stored in containers in the caves.

Radioactive Waste Facilities

Intermediate Level Waste (ILW) and Low Level Waste (LLW) are contained partly in purpose built storage facilities and partly in redundant process facilities. The relevant locations are:

- Active Waste Vaults: a purpose built ILW storage facility in the form of underground chambers made from reinforced concrete. The vaults contain graphite and magnesium alloy fittings removed from fuel elements, canned sludges and resins and miscellaneous waste (total waste volume approximately 1,700 m^3).
- Caesium Removal Plant (CRP): a redundant facility containing contaminated resin and sludge waste within stainless steel process tanks (total waste volume approximately 23 m^3).
- Shielded Area Facilities (E22 – E25): a redundant facility where solid ILW is stored in stainless steel cans within heavily shielded caves (total volume approximately 12 m^3). Also, the interim storage location for drummed desiccant waste and drummed sludge waste (total waste volume approximately 17 m^3).
- Active Effluent Treatment Plants (AETP): treatment facilities that have been mostly post-operatively cleaned out and contain relatively small quantities of residual contamination within pipes and vessels.
- Low Level Waste Building: an operational facility where LLW is held pending packaging and transfer to the national Low Level Waste disposal facility.

The condition of all the above facilities was assessed as part of the 2009 Periodic Safety Review and was judged to be fit for purpose until the next ten-yearly review and beyond, with no cliff edges, provided on-going inspection and maintenance regimes are continued. Appropriate inspection and maintenance regimes are specified in the Site's Maintenance Schedules. The Berkeley Asset Management Plan is used as a forward flag to prompt future asset inspection/possible replacement.

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.

The reactors are both fully defuelled and the control rods that were present at shutdown are still in the core; detached and resting on the bottom of their channels. There is therefore no possibility of criticality in the reactor Safestores.

Small quantities of fissile material (irradiated fuel swarf, defuelled cladding) are present in the ILW stored on site. A criticality study has concluded that there is now insufficient fissile material anywhere on the Site for criticality to be possible in any configuration.

1.3.2 Heat transfer from reactor to the 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.

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.

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).

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).

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).

This section is not applicable for Berkeley as both reactors are fully defuelled. There is no appreciable decay heat to be removed and therefore no requirement for an ultimate heat sink.

1.3.3 Heat transfer from spent fuel pools to the 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).

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.

This section is not applicable for Berkeley as there is no longer a spent fuel storage pond.

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

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).

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.

This section is not applicable for Berkeley as both reactors are fully defuelled. There is no appreciable decay heat to be removed and therefore no requirement for an ultimate heat sink.

The reactor building provides a weather-proof barrier to the reinforced concrete bioshield that encloses the steel pressure vessel (now vented to atmosphere) but there is no pressure retaining containment building.

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.

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.

There is no commercial electrical generation or transmission plant left on site. The normal electrical supply to the Site is from the District Network Operator (DNO) by means of two 11 kV feeders run as a ring serving both Berkeley Site and the adjacent Berkeley Centre (de-licensed parts of the former Berkeley Laboratories). These feeders run directly from a 33/11 kV sub-station. The majority of the route is overhead until it reaches the Berkeley Site boundary from where it is run underground.

The 11 kV ring main switch unit and metering equipment is the property of the DNO. The DNO is solely responsible for the operation and maintenance of this equipment and access is afforded to this equipment at all times.

The system handover point is the outgoing cable terminations on the metering circuit breaker, with the DNO being responsible up to the terminating studs and the site being responsible for the cable from the metering circuit breaker to the incoming isolator of the Berkeley Site 11 kV Main Switchboard.

Any supply abnormality is reported to the DNO. An emergency trip button is provided to enable the emergency isolation of the supply from the DNO.

Voltage dips or short interruptions of the off-site power supply are experienced several times per year. Longer interruptions, sufficient to initiate the automatic starting of the back-up diesel generator, are experienced about once per year.

As indicated above, this level of reliability is not of concern as there is no safety dependence on electrical power.

1.3.5.2 Power distribution inside the plant

1.3.5.2.1 Main cable routings and power distribution switchboards.

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

The site power distribution arrangements have been considerably simplified as a result of decommissioning activities. Large parts of the original electrical distribution systems have been disconnected and where possible removed. Some new distribution cabling has been installed as part of the rationalisation and this is installed to normal UK/EU industrial standards, with no special protection against internal or external hazards. This is acceptable because there is no safety critical demand placed on the site power distribution system.

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

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

Switchboards backed-up by automatically started diesel-generators allow selected equipment to remain operational following extended loss of off-site power. The supported services include ventilation to the Shielded Area caves, the site control room and site telephone system. The diesel-generators are capable of operating for days depending on load. The Active Waste Vaults fire protection system has its own automatically started diesel-generator.

The site Emergency Control Centre and the Access Control Point are each provided with an auto-start back-up diesel generator. However the working arrangements are such that the emergency control function can be moved to another location if the site becomes untenable, for instance as a result of flooding (see section 6). Each auto-start diesel generator has a fuel tank capable of supporting operation for approximately one to two days depending on load. A diesel storage tank is available for replenishing fuel supplies.

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

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).

The back-up diesel-generators are physically distributed across the site and are interchangeable with a spare unit. There are no special measures to extend the time of use.

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

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).

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

There are no diverse permanently installed on-site sources for back-up power supply. This is acceptable because there is no safety critical demand placed on the site power distribution system.

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.

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

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

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

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

None of the electrical supplies is essential for nuclear or radiological safety, even for extended periods of loss.

1.3.6 Batteries for DC power supply

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.

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

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

1.3.6.4 Alternative possibilities for recharging each battery bank.

There are no DC consumers essential for nuclear or radiological safety that require battery backing.

Fire protection and the public branch exchange telephone systems have their own battery backed uninterruptable DC power supplies.

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 Safestores 1 and 2 are essentially identical.

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 shutdown.

A detailed probabilistic safety analysis (PSA) has not been conducted for Berkeley Site.

Following shut down of the reactors in 1989 and completion of de-fuelling in 1992, most of the potential faults that relate to an operating nuclear power station are no longer applicable at the Berkeley Site.

The most significant sources of hazard have been entirely removed (i.e. potentially critical core, fuel storage ponds, bulk quantities of irradiated fuel, pressurised components, hot gas and steam) and the reactors are now in formal Safestore condition. Thus, the total risk and hazard from the site has been reduced by orders of magnitude compared to its former operational state.

A thorough deterministic safety assessment has recently been completed, which has demonstrated that all radioactive materials are robustly contained and shielded and are provided with means to monitor the on-going performance of the containment and shielding at a satisfactory level in face of normal deterioration processes. The assessment specifically considered natural hazards (e.g. earthquake, flooding, tsunami) and internal faults and hazards.

The assessment demonstrates that the risk presented by the storage of residual Intermediate and Low Level Waste on the Berkeley Site is within the broadly acceptable range when assessed against Magnox Limited and Regulatory criteria and is As Low as Reasonably Practicable (ALARP), taking account of all reasonably foreseeable faults and hazards.

The safety assessment has shown that there is no requirement for prompt operator action or for formal protective safety measures to prevent or mitigate any reasonably foreseeable fault or hazard. Sufficient engineered safety measures and procedures are provided to ensure that all radioactive materials stored within the facilities will remain appropriately shielded and contained. A fire detection and argon suppression system is retained as an ALARP Safety Measure for the quiescent storage of ILW in Vaults 1 and 2.

This safety assessment will remain valid as long as the buildings and equipment of the radioactive waste facilities are maintained (and repaired as necessary) in accordance with the specified maintenance schedules. Planned facility inspections and future Periodic Safety Reviews will demonstrate continued integrity of the shielding and containment structures and satisfactory operation of monitoring systems.

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.

Seismic hazards were not included within the original design basis for the Berkeley Power Station or the Berkeley Nuclear Laboratories. The capability of these facilities to withstand seismic events was first evaluated as part of their Long Term Safety Reviews carried out during the late 1980s, with further assessment for the key structures on the Berkeley Site being carried out as part of the recent Periodic Safety Review to August 2009.

The current design basis earthquake for the Berkeley Site is defined by the envelope of the Principia Mechanica Limited (PML) hard site United Kingdom (UK) design response spectrum anchored to a horizontal zero period acceleration of 0.1g and a UK generic uniform risk spectrum with a probability of exceedance of 10^{-4} per annum. The PML spectrum determines the overall spectral magnitude at low frequencies. The uniform risk spectrum dominates at higher frequencies. The horizontal free-field peak ground acceleration associated with the design basis event is approximately 0.16g.

This design basis seismic event was selected to bound the expected 10^{-4} per annum exceedance frequency event at the Berkeley site.

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.

No site specific seismic hazard study has been undertaken for the Berkeley site.

The uniform risk spectrum component of the design basis earthquake for the Berkeley site was derived from a probabilistic seismic hazard assessment whose input seismic source parameter distributions (b-value, activity rate, maximum magnitude, depth etc.) represent the characteristics of seismicity within the UK region as a whole. The seismic source is taken to be a 500 km square zone centred around a generic site. In the absence of sufficient UK-specific strong motion records, ground motion spectral attenuation relationships were derived by regression analysis of earthquake records from regions elsewhere in the world considered to share tectonic similarity with the UK. The response spectrum used in the definition of the design basis event is that assessed to have a uniform probability of exceedance of 10^{-4} per annum.

The PML UK design response spectra are piece-wise linear (on a standard tripartite plot) response spectra derived by statistical analysis of strong motion earthquake records from elsewhere in the world conforming to the profile of expected UK events. This is again necessitated by a lack of suitable UK-specific strong motion records. These design spectra may be anchored to any zero period acceleration. For the purpose of defining the design basis event the spectrum has been anchored to a zero period acceleration of 0.1g in recognition of the international regulatory significance of that value.

The design basis earthquake is defined as the upper envelope of these two spectral components.

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 as a whole 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 Berkeley design basis event (average maximum magnitude $6.5M_S$) are credible. Examination of the pattern of historical UK seismicity indicates that Berkeley is situated in a region of low to moderate earthquake activity by UK standards. The use of a UK generic uniform risk spectrum within the definition of the design basis event is, therefore, considered reasonable in lieu of a site-specific hazard assessment.

Knowledge of UK seismicity has increased somewhat since the design basis was established and methods for seismic hazard analysis continue to advance. Nevertheless, it is considered that the design basis earthquake is an adequate representation of the prevailing seismic hazard for the Berkeley site at a 10^{-4} per annum exceedance frequency.

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 (SSC) that are required for achieving safe shutdown state and are most endangered during an earthquake. Evaluation of their robustness in connection with DBE and assessment of potential safety margin.

There is no requirement for control of reactivity or decay-heat removal. Therefore, there are no systems, structures or components that are required to achieve a safe shutdown state or which need to be claimed to remain available following an earthquake.

For Berkeley the post-seismic demand is for the various passive structures to maintain effective containment of the radioactivity stored within them. Seismic assessments were undertaken as part of the Periodic Safety Review (PSR) implementation and Safestore preparation works:

It was concluded that the reactor buildings have a seismic withstand in excess of 0.125g which includes the effects of corrosion over the Safestore period. Similarly, the Active Waste Vaults, CRP building and Shielded Area caves are all shown to be robust structures that are unlikely to suffer a substantial loss of containment when assessed against the design basis earthquake.

Conservative assessments of the post-seismic radiological consequences are included in the consolidated Radioactive Waste Safety Case for Berkeley Site ILW storage facilities. The site risk from the design basis earthquake is shown to be well within the broadly acceptable range when assessed against Regulatory criteria and is ALARP.

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

Operations to be carried out following an earthquake consistent with the design basis event would initially be determined by the shift charge engineer / site emergency controller in accordance with the site Emergency Handbook procedures. Actions will depend upon the state of the plant and system availability. As there are no nuclear or radiological safety essential tasks to be accomplished in the short-term, evacuation of all persons on the site to a place of safety and rescue of possible casualties would be the primary concern.

The following key actions would be invoked in the longer-term:

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. For the Berkeley Site none of this would be on an urgent time-scale and it is expected that Company and other resources are likely to be concentrated on other sites.

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.

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

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

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

The Berkeley site has no pressure retaining devices, large rotating equipment, or systems containing a large amount of liquid, whose failure could lead to additional seismically induced damage.

The boilers have been laid on their side in a stable configuration and all structures containing artificial radioactivity are assessed to be resistant to collapse.

There is no requirement for an ultimate heat sink, therefore, loss of external power or difficulties in accessing the Site following a design basis earthquake can be tolerated.

The Site has no gas main or stores of flammable or explosive materials and no on-going hot processes, so there is no risk of fire or explosion as a result of earthquake. The risk of fire in the Active Waste vaults as a consequence of earthquake has been specifically assessed and excluded.

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 shutdown after earthquake, or that might cause indirect effects discussed under 2.1.2.3 remain in faultless condition.

The plant is subject to routine maintenance, inspection and testing as required by the Nuclear Maintenance Schedule, which lists those activities that are necessary to support the on-going site safety case. This is implemented in accordance with MCP 19 “Management of Maintenance Work” and MCP 13 “Surveillance and Routine Testing of Plant Items and Systems”. 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. Any changes to the plant or the safety case are controlled via MCP 99.

The ability of the facilities to continue to meet their integrity requirements is demonstrated by the arrangements to carry out civil inspections in accordance with Licence Condition 28 arrangements. Planned System Engineering walk-down reports are completed to a given programme.

At 10-yearly intervals, and in response to significant operating events, the safety of the plant is reviewed in a Periodic Safety Review. This reviews the plant against modern standards, operating experience and the effect of ageing. A PSR was completed in 2009 and identified enhancements have been implemented

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.

For the Berkeley Site there is no particular mobile equipment or supplies that are planned to be available after an earthquake.

2.1.3.3 Potential deviations from licensing basis

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

There are no potential deviations from the licensing basis.

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.

Not applicable for Berkeley as there is no significant quantity of spent fuel on Site.

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.

Not applicable for Berkeley as there is no containment structure. The integrity of the reactor buildings and radioactive waste facilities is addressed in Section 2.1.2.

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.

The relatively low magnitudes together with the anticipated mechanisms of UK earthquakes indicate that the potential for a significant tsunami resulting from a local earthquake is very low. Furthermore, the potential for local land-slips into water or slippage of the river/sea bed leading to a local tsunami affecting the Berkeley site is also considered to be negligible. A more significant tsunami could credibly result from a distant earthquake. In that case, however, the ground motion at the Berkeley site resulting from the earthquake would not be damaging. Thus, the potential for significant earthquake damage combined with significant tsunami-induced damage can be discounted.

There are no nearby large bodies of stored water or water-retaining structures that are above the level of the Berkeley site. There are, therefore, no bodies of water that could be breached leading to Site flooding following a design basis earthquake.

There are no significant quantities of water stored on-site so localised flooding that could arise from failure of on-site tanks or pipework can also be discounted.

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.

There is not considered to be any need to increase the robustness of the Berkeley Site plant and equipment against earthquakes. The assessed risk from the consequences of the design basis earthquake is not sufficiently high to warrant expenditure on any practicable measures of improvement (i.e. the plant is considered already to meet ALARP criteria).

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.

Berkeley Site is located on the east bank of the River Severn. The site is generally flat and level, at an elevation of about 10 m AOD (Above Ordnance Datum). In the vicinity of the site the river is tidal and the still water level is determined by a combination of fluvial flow, tidal variation and storm surge.

Flooding from the Severn estuary was assessed for the Berkeley Site in 2006 taking into account the possible effects of climate change. It is predicted that the 10^{-4} per year peak flood level is 10.69 m AOD and the 10^{-3} per year flood level is 10.20 m AOD. These values will not alter significantly as a result of climate change or other mechanisms during the next several years.

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.

The design basis flood (or lesser floods) would be associated with a storm surge coincident with a single tide cycle; therefore the inundation would be a single event lasting only a few hours. For the Berkeley location, the storm surge element of such a flood would result from a severe North Atlantic depression which would be signalled a few days in advance, combined with the tide cycle that is fully predictable. The site would therefore have adequate time to implement the site arrangements prior to the event.

Tsunami was assessed for UK coastal locations in 2006. The peak wave level associated with the potential impact envelope in, the Bristol Channel, from a “Lisbon-type” tsunami is less than 0.5m and the wave period is about 20 minutes. Since Tsunami would not be expected to occur in conjunction with other extreme conditions on site it does not present a significant threat to any Berkeley Site facilities.

The historically recorded Bristol Channel Floods of January 1607 have been assessed in light of current knowledge. It is concluded that the event is consistent with a wind driven storm surge superimposed on an extreme spring tide. The reconstruction of the 1607 floods reflects an event with a return period in the range 500 to 1,000 years, consistent with it being the most catastrophic event known for the region, probably over at least 500 years. Such a flood occurring today is judged to be bounded by a 10^{-3} per year flood event and the ILW waste vaults would be protected as described in Section 3.1.1.3.

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

3.1.1.3 Conclusion on the adequacy of protection against external flooding

Each of the Berkeley Site facilities has been assessed for the effects of the potential 10^{-4} per year site-wide flood level of 10.69 m AOD.

The roofs of the Active Waste Vaults are at approximately 10.1 m AOD which is similar to the general ground level of the site. In the absence of flood protection the vaults would be flooded in a 10^{-3} per year event. The erection of a proprietary flood barrier 0.9 m high has been sufficient to protect the vaults against the 10^{-4} per year flood and beyond. The flood barrier has sections that are left open to allow access for maintenance and inspection. The barrier can be manually closed at short notice using modular sections stored nearby.

Flooding of the Safestore basements and the void beneath the Reactors was assessed in the Safestore Safety Case. Radiological consequences are so low as not to justify on an ALARP basis any measures to protect against the design basis flood. Flood water would be of sufficiently low specific activity that it could be pumped into storm drains after the flood has passed. The only significant issue from having the Safestores flooded is the potential for increased corrosion of vessel supports over the long period following contact with salt water. For this reason the Safestore has been protected against the 10^{-2} per annum site flood by raising the threshold level to at least 10.15 m AOD.

The consequences of flooding any of the other facilities on site are considered to be low.

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 to the plant.

Specific flood protection measures have been taken only in respect of the reactor Safestores and the Active Waste Vaults, as described in section 3.1.1.3.

3.1.2.3 Main operating provisions

Main operating provisions to prevent flood impact to the plant.

As noted in section 3.1.1.3, the Active Waste Vaults flood barrier has sections that are normally left open to allow access for maintenance and inspection. To complete the flood protection the openings in the barrier must be manually closed using modular sections stored nearby.

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

Low lying parts of the single access road to the Berkeley Site are susceptible to occasional flooding (typically once or twice a year for a few hours) but to date this has not been to sufficient depth to prevent vehicle access.

If the site were flooded up to the design basis level the entire surrounding area would also be flooded and for a few hours access to the site would only be possible by boat. Those persons present on site would easily be able to take refuge in buildings with a floor above ground level. As such an event is foreseeable (see section 3.1.1.2) it is likely that only a skeleton staff would be on site.

There are no short-term operator actions necessary to control or limit radiological releases as the facilities are essentially passive safe.

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.

There is no need to achieve and maintain the safe shutdown state as the reactors are defuelled.

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.

Procedures for confirming that all parts of the Active Waste Vaults flood barrier are present and serviceable are included in site maintenance schedules.

3.1.3.3 Potential deviations from licensing basis

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

There are no potential deviations from the licensing basis with regard to the design basis flood.

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.

Not applicable for Berkeley Site as there is no ultimate heat sink requirement.

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 Periodic Safety Review 2009 and the Consolidated Safety Case for Berkeley Site Radioactive Waste Facilities (2010) considered the effects of flooding and ALARP assessments were made for the potentially significantly affected facilities, i.e. the Reactor Safestores and the Active Waste Vaults. As a result of these assessments it was decided to implement flood protection of the Active Waste Vaults against a 10^{-4} per annum site flood and to provide protection of the Reactor Safestores against a 10^{-2} per annum flood.

4 Extreme weather conditions

4.1 Design basis

4.1.1 Reassessment of weather conditions used as design basis

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.

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.

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.

Consideration of the impact of more severe weather than that likely to have been used for the original design does not lead to concern – see section 4.1.1.3 below.

4.1.1.3 Assessment of frequency

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

Extreme weather includes wind, snow and ice, high and low air and sea temperature, humidity and precipitation. Lightning strike is also considered.

Wind: The threat from extreme winds arises from the possibility that items such as roofing sheets or wall cladding could be released by the wind. This affects the weather tightness of buildings and can produce wind-blown missiles. It is possible that ventilation systems may be disrupted if vent stacks are damaged. No significant radiological release would occur as a result of short-term loss of building weather tightness and entry of rainwater or by interruption of ventilation provisions. Following any extreme weather episode the site would be assessed and repairs effected. It is judged that there will be no radiological consequence as a result of wind-blown missiles because all of the remaining ILW activity sources are within relatively massive structures compared with any wind-blown missile that could strike them.

Snow and Ice: Snow and ice could present a threat to the containment and shielding of the radioactive waste through the effects of structural overload. Snow and ice could also restrict access to the site. Assessments have concluded that the ILW is contained within robust structures that will not be disrupted by outer building damage. None of the facilities require human intervention on a time scale that would be prejudiced by temporarily restricted access to site.

Humidity and Precipitation: Humidity and precipitation presents a potential threat to the containment and shielding of radioactive waste through the effects of corrosion or through transport of activity by water movement. Heavy rainfall that overloads the capacity of site drainage can also lead to flooding of basement areas. Rainwater entry will be within the capacity of secondary containment systems and on a scale limited enough to allow for remedial action to be taken. The preventative measures required to maintain the water tightness of buildings are supported through civil structure inspection and maintenance.

Temperature: Extremes of ambient temperature will not affect the contents of any ILW storage locations as they are in shielded containment structures in which conditions will only change very slowly. None of the facilities are dependent on services that might be disrupted by extreme high or low ambient temperature. No facilities require cooling water that might be affected by freezing water temperatures.

Lightning Strike: None of the facilities are of a construction type that would be vulnerable to fire or major structural damage as a result of lightning strike. Lightning strike could disrupt electrical supplies or even damage electrical equipment within buildings. However, loss of services is a tolerable event for all facilities. All buildings are provided with lighting protection in accordance with BS6651:1992 or the later BSEN62305:2006, which will provide adequate protection. Remedial and upgrading work on the lightning protection for all buildings was completed in March 2011.

4.1.1.4 Potential combinations of weather conditions

Consideration of potential combination of weather conditions.

Combinations of extreme weather at the 10^{-4} per year level have not been considered. Some combinations at less severe, more frequent events have been considered as part of the design.

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.

Not applicable for Berkeley Site as there is no ultimate heat sink requirement.

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.

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.

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.

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.

5.1.1.2.2 Battery capacity, duration and possibilities to recharge batteries.

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

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

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.

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 Berkeley Site as the reactors are defuelled and there is no ultimate heat sink requirement.

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

Not applicable for Berkeley Site as the reactors are defuelled and there is no ultimate heat sink requirement.

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.

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)

5.1.3.2.1 Availability of an alternate heat sink

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

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.

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).

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.

5.1.3.4.2 External actions foreseen to prevent fuel degradation.

Not applicable for Berkeley Site as the reactors are defuelled and there is no ultimate heat sink requirement.

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 Berkeley Site as the reactors are defuelled and there is no ultimate heat sink requirement.

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.

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

5.2.1 Loss of electrical power

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

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

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

5.2.3 Loss of the ultimate heat sink

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

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 Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

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.

6.1.1 Organisation of the licensee to manage the accident

6.1.1.1 Staffing and shift management in normal operation

Berkeley Site is currently undergoing decommissioning activates 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

Arrangements are in place for the management of emergencies at Berkeley Site. The Emergency Handbook documents the site emergency arrangements and the arrangements for collaboration with external organisations, including the Regulators (ONR and Environment Agency), the emergency services, local government and central government. The document is approved by the ONR and changes cannot be made to it without consultation. The on-site arrangements allow for the establishment of an Emergency Control Centre (ECC) staffed by at least an Emergency Controller, and Assistant Emergency Controller, an Emergency Administration Officer, an Emergency Health Physicist, an Emergency Technical Officer and an Emergency Communications Officer. In addition the Control Room, an Access Control Point and a Response Team are established. Members of these teams are on an emergency call-out rota using a telephone voicemail system based upon a stand-alone off site server. Additional telecommunications can be made independently through BT or mobile networks.

6.1.1.3 Measures taken to enable optimum intervention by personnel

The arrangements described above allow for the intervention of personnel to assess and mitigate emergency situations.

6.1.1.4 Use of off-site technical support for accident management

In the event of a site incident or off-site nuclear emergency being declared the Central Emergency Support Centre (CESC) is set up in another part of Gloucestershire.

This dedicated facility is manned by a Controller, a Health Physicist and a Technical Officer each with a support team on a one-hour call out rota.

The remit of the CESC is to:

(i) Relieve the affected station of the responsibility for liaison with outside bodies on off-site issues in as short a time as possible after an accident.

(ii) Take over for the affected site at an early stage the task of directing the off-site monitoring teams and assessing their results.

(iii) Provide the requisite technical advice on off-site issues to all stakeholders in the Strategy Coordination Centre (SCC) and those agencies represented in the CESC.

(iv) Provide regular authoritative company briefings for the media on all aspects of the emergency.

(v) Co-ordinate advice and support from within the affected company and other parts of the nuclear industry to the affected station.

(vi) Centrally manage the collation of all relevant information relating to the event (using appropriate means).

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.

6.1.1.5 Procedures, training and exercises

The procedures set out in the Berkeley Site Emergency Handbook are frequently exercised by members of the Emergency Response Team and are used as part of the training for new members. Once per year there is a Demonstration Exercise, observed by the Regulators, which involves external agencies such as local fire, police and ambulance services.

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.)

As there is limited need for the provision of fuel and other supplies there are no special arrangements for their management.

6.1.2.3 Management of radioactive releases, provisions to limit them

There are no management actions required to control the foreseeable radioactive release scenarios.

6.1.2.4 Communication and information systems (internal and external).

In the event of an accident 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 Coordinating Centre (SCC), the Central Emergency Support Centre (CESC) and the responding emergency services.

The Magnox telephone system is designed to be resilient and function through any single point failure. Two telephone exchanges are physically separated and connect to the Public Switched Telephone Network (PSTN) via diverse routes. Phones in the key response centres (e.g. Emergency Control Centre) are divided between the two exchanges so that failure of an exchange will not leave the room without at least some working phones. The telephone exchanges are connected to robust electrical supplies and have battery backup with a design period of not less than 300 minutes.

Equipment is provided for radiological monitoring (see section 2.1.3.2).

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.

There are no operator actions necessary to control or limit radiological releases as the facilities are essentially passive safe. Therefore the inability to access the site for a period of time (e.g. 24 hours) would not be critical - see section 3.1.2.4.

6.1.3.2 Loss of communication facilities / systems

The Company has robust communications systems featuring diversity and redundancy, particularly at operating sites. These include:

- A resilient Company Wide Area Network
- Telephones that are independent of the Company exchanges with direct (copper) links to the 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.

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 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 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, including breathing apparatus, 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 are no operator actions necessary to control or limit radiological releases as the facilities are essentially passive safe. Therefore the inability to access the Site Control Room for a period of time (e.g. 24 hours) would not be critical.

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.

The Site Emergency Control Centre depends on only basic materials (e.g. charts and maps) for its essential functions and can be relocated if necessary.

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

The accident 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

No power supplies are necessary to control or limit radiological releases as the facilities are essentially passive safe.

6.1.3.8 Potential failure of instrumentation

There is no installed instrumentation that is essential to the control of the plant.

Portable radiometric instrumentation, which would be used for the assessment of radiological releases, is kept in an emergency response vehicle located on-site. Replacement of failed instrumentation or alternative monitoring arrangements would be organised through the Central Emergency Support Centre.

6.1.3.9 Potential effects from the other neighbouring installations at site.

Berkeley Site is surrounded by farmland for several kilometres and by the River Severn to the west. There are no neighbouring installations, or river traffic, that pose any threat to the Site.

6.1.4 Measures which can be envisaged to enhance accident management capabilities

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 below and in Table 1. The site will also be supported by enhancements proposed for central emergency support.

Consideration BKA 1: Consideration will be given to enhancing the availability of beyond design basis equipment.

Consideration BKA 2: Consideration will be given to providing further equipment to facilitate operator access around the Site.

Consideration BKA 3: Consideration will be given to enhancing site arrangements for command, control and communications.

Consideration BKA 4: Consideration will be given to updating and enhancing severe accident management guidance.

Consideration BKA 5: Consideration will be given to the fire safety case for ILW storage facilities to identify any appropriate enhancements to the level of resilience.

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

Not applicable for Berkeley Site as the reactors are defuelled.

6.2.1 Elimination of fuel damage / meltdown in high pressure

6.2.1.1 Design provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.1.2 Operational provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.2 Management of hydrogen risks inside the containment

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

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.2.2 Operational provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.3 Prevention of overpressure of the containment

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 Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.3.2 Operational and organisational provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.4 Prevention of re-criticality

6.2.4.1 Design provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.4.2 Operational provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.5 Prevention of base-mat melt through

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

Not applicable for Berkeley Site as the reactors are defuelled.

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

Not applicable for Berkeley Site as the reactors are defuelled.

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

Not applicable for Berkeley Site as the reactors are defuelled.

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

6.2.6.1 Design provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.6.2 Operational provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.2.7 Measuring and control instrumentation needed for protecting containment integrity

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

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

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

6.3 Accident management measures to restrict the radioactive releases

6.3.1 Radioactive releases after loss of containment integrity

6.3.1.1 Design provisions

6.3.1.2 Operational provisions

Not applicable for Berkeley Site as the reactors are defuelled and there is no fuel storage pool.

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

6.3.2.1 Hydrogen management

6.3.2.2 Providing adequate shielding against radiation.

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

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

6.3.2.5 Availability and habitability of the control room

None of the above is applicable for Berkeley Site as there is no spent fuel and no fuel storage pool.

Very low levels of hydrogen are generated in the Active Waste Vaults 1 and 2 by corrosion of Magnox Fuel Element Debris. Hydrogen concentrations are managed by an active ventilation system. Lack of forced ventilation can be tolerated for a period of approximately 100 days before impacting on safety.

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
AETP	Active Effluent Treatment Plant
AGR	Advanced Gas-Cooled Reactor
AOD	Above Ordnance Datum
ALARP	As Low As Reasonably Practicable
CESC	Central Emergency Support Centre
CRP	Caesium Removal Plant
DBE	Design Basis Earthquake
DBF	Design Basis Flood
DNO	District Network Operator
ECC	Emergency Control Centre
ENSREG	European Nuclear Safety Regulators Group
ILW	Intermediate Level Waste
LLW	Low Level Waste
MAC	Miscellaneous Activated Components
MCP	Management Control Procedure
ONR	Office for Nuclear Regulation
PGA	Peak Ground Acceleration
PML	Principia Mechanica Limited
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
PSTN	Public Switched Telephone Network
PWR	Pressurised Water Reactor
REPPIR	Radiation Emergency Preparedness and Public Information Regulations
SCC	Strategic Coordination Centre
SSC	Systems Structures and Components
UK	United Kingdom

Table 1: Considerations Identified for Berkeley Site

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

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