Learning From Experience at Fukushima

A UK Regulatory Perspective on Flood Risk Assessment and Management

A. Mayall[1] (Environment Agency, Penrith, Cumbria, UK, andrew.mayall@environment-agency.gov.uk)
T. B. Allmark[2], R. Hill[1], P. J. Ford[2], A. McGoff[1] and D. Fadipe[3]

1. Introduction and objectives

Protection from flooding hazards is a well established part of ensuring safety at nuclear sites in the UK. However it is important to learn lessons from any major incident. The need to ensure the sustained resilience of nuclear sites and their supporting infrastructure in the face of extreme natural hazards, including flooding, was a key lesson from the accident at Fukushima.

The **objectives** of this poster are to summarise:

- how the risks of flooding at nuclear sites are assessed and managed in the UK; and
- how the Environment Agency of England and Wales (EA), Scottish Environment Protection Agency (SEPA) and the Office for Nuclear Regulation (ONR) worked together in learning the lessons from Fukushima for flood risk assessment and management.

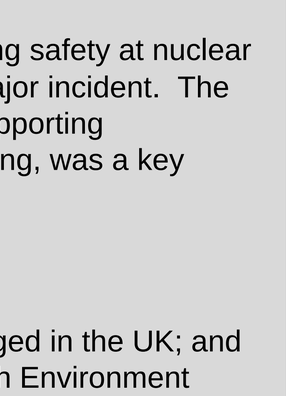
3. National flood risk information

The EA and SEPA both hold strategic flood risk information (e.g. area flood maps, seawater levels etc). Flood Maps show the probability (in zones) of flooding from rivers or the sea which ignore the presence of existing defences. This information can indicate whether there is a likelihood of flooding in the areas where nuclear sites are located or proposed, but does not indicate the risk or potential consequences from flooding at specific facilities. Detailed site specific flood risk assessments, such as those provided as part of planning applications or as part of nuclear site safety cases are required, which take into account detailed knowledge of a site, its flood protection and mitigation, and the impact of climate change etc.

4. Learning from experience

Two regulatory reviews of the Fukushima accident have been carried out in the UK:

- The Chief Nuclear Inspector's (Office for Nuclear Regulation) report on the Implications for the UK nuclear industry (September 2011) (the "Weightman Report"); and
- The European Council requested a review of safety at European nuclear power plants ("stress tests") - a reassessment of the safety margins of nuclear power plants in the light of events which occurred at Fukushima.



There have also been reviews of major flooding events in the UK including the review led by Sir Michael Pitt ("Pitt Review") of the major 2007 floods in the UK. The photograph below shows Mythe water treatment works in Gloucestershire which was badly affected and left 350,000 people without mains water for 17 days.

Recommendations from the Pitt Review covered :

- flood forecasting and mapping and climate change
- improved planning and reducing risk
- emergency response
- maintaining power and water supplies and protecting essential services
- better advice to householders
- recovery

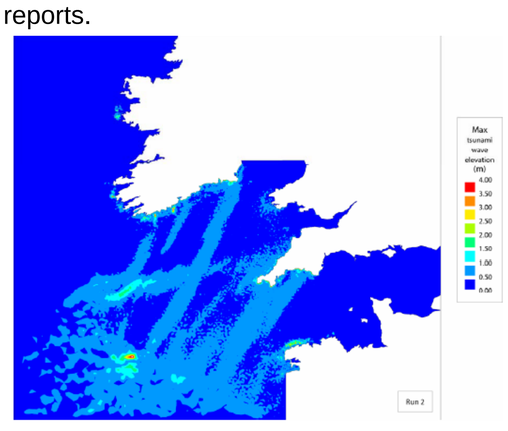
The recommendations led to the UK's largest ever civil emergency exercise in 2011, designed to test the UK's response to a major flood (Exercise Watermark).

5.Key flood hazard issues highlighted by Fukushima

Tsunami

Two studies carried out by UK's Department for Environment, Food and Rural Affairs (Defra) in 2005 and 2006 concluded that the water levels from tsunami in the UK are not expected to be greater than those during a storm surge event; however the waveform, and the impacts, from tsunami and storm surge may be different. Worst case modelling results showed wave elevations on the UK coast from a tsunami originating from an earthquake off the coast of Portugal in the 18th century (the 'Lisbon event') are typically in the range of 1-2m, with localised elevation up to about 4m, for example in parts of Cornwall. These levels are viewed as extreme values for the UK, nevertheless ONR has recommended a review of research on tsunamis that has emerged since the two Defra reports.

The figure shows the maximum free surface elevation using the TELEMAC model for a tsunami source north of the Gorringe Bank (few hundred km SW of Lisbon).



Climate Change

The Fukushima accident re-emphasized the risks to coastal nuclear sites. The predicted rise in sea-levels due to climate change over the next century or more will affect these risks.

The management of future flooding risk given the uncertainty over the scale of sea-level rise will require a **managed adaptive approach**. Options for mitigating the risk should be incorporated into the design and kept available (e.g. a higher seawall). Continuous monitoring of the risk is an important part of this approach. The managed adaptive approach should use the latest credible maximum climate change scenario for the site, for example those provided by UK Climate Projections 2009 (UKCP09).

Flooding safety cases are periodically reviewed (at least every 10 years) as part of the Periodic Safety Review (PSR) process and where necessary site and operational improvements are made. The rate of change in flood hazard due to climate change is such that there is time to develop and implement solutions on the periodic safety review timeframe.

2. Who does what on and around nuclear sites?

Nuclear site operators (licensees) are responsible for managing their sites to ensure that flooding hazards do not cause unacceptable risks to nuclear safety or operational effectiveness. Responsibility for controlling and regulating flood hazard around nuclear sites is also vested in various regulators, national and local planning authorities and local landowners.

Main responsibilities of ONR:

- Regulation of nuclear safety on nuclear licensed sites, including the on and off-site safety implications associated with hazards arising from flood and coastal erosion.
- Statutory consultee on planning applications for new nuclear sites. Consultee on other planning applications related to nuclear sites.

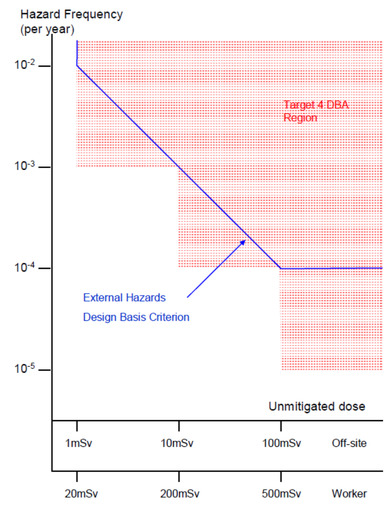
Main responsibilities of the UK environment agencies:

- Principal flood risk management authorities with a strategic overview role. Working with others who have policy or executive responsibilities such as government, local authorities, internal drainage boards etc.
- Forecasting and mapping flood risk, flood warnings, advising on development on and around flood-plains.
- Statutory consultees on planning applications associated with nuclear licensed sites.

Nuclear safety and flood hazard

Still seawater levels, precipitation, storm surge, tides, tsunami and river flows can all contribute to flooding hazard and many of these will be affected by climate change. Local topography, bathymetry and shoreline management can all influence the nature of the hazard.

The ONR expects that all nuclear sites are capable of remaining safe during an extreme (i.e. 1 in 10,000-year or 10^{-4}/y) flooding event (the design basis flood). There should also not be a disproportionate increase in risk for more extreme events. (see figure from ONR Technical Assessment Guide 13).



Typical flood protection includes:
-sea-walls (see below left)/shingle banks/sand dunes;
-site platform level;
-site drainage and site topography;
-local protection such as damboards, berms (see below right showing berm around Fort Calhoun NPP in 2011); and
-building base height.

Nuclear site licensees work with local Shoreline Management Groups, to understand and manage coastal change and subscribe to the weather and flood warning services provided by the environment agencies and the UK Meteorological Office.

Planning for new nuclear power plants in England and Wales

Planning submissions for new sites must be supported by a Flood Risk Assessment. Both ONR and EA are consulted on flood risk assessment and management as part of the planning approval process.

6. Key conclusions

- The accident reinforced the need for nuclear site safety cases and planning submissions to take rigorous account of the potential impact of tsunamis and other flooding hazards, and the impacts of climate change upon those hazards – see 'Weightman report' Recommendation IR-10: *The UK nuclear industry should initiate a review of flooding studies, including from tsunamis, in light of the Japanese experience, to confirm the design basis and margins for flooding at UK nuclear sites, and whether there is a need to improve further site-specific flood risk assessments as part of the periodic safety review programme, and for any new reactors. This should include sea-level protection.* Supporting off-site infrastructure is also at risk from natural hazards and nuclear sites need to ensure adequate self sufficiency in the event of its loss.
- Strategic level assessments carried out by EA suggest that potential new sites identified in the National Policy Statement for nuclear power plants in England and Wales could potentially be protected from flooding. The events at Fukushima have not changed this advice which reflects that site specific flood risk assessments will be required if development proposals come forward.
- Nuclear reactor vendors need to take into account the learning from Fukushima regarding flood hazards. The ONR and the EA required vendors to take account of learning from Fukushima in their designs as part of the Generic Design Assessment.
- The ONR concluded that the UK approach to identifying the design basis is sound for external hazards but that a review should be carried out of the guidance on external hazards to see whether any additional guidance is necessary. The EA and ONR are also developing guidance and principles for the assessment and management of flood risk in the context of new nuclear power plants.
- The EA, SEPA and ONR have taken steps to establish a joint expert group to do an independent review of flood and coastal risk assessments for nuclear sites.

1 – Environment Agency
2 – Office for Nuclear Regulation
3- Scottish Environment Protection Agency
The authors would like to thank EDF NGL and Defra for permission to use their photos/figures.

Office for Nuclear Regulation
An agency of HSE

SEPA
Scottish Environment Protection Agency

Environment Agency