British Energy Generation Ltd

Review of medium to long-term coastal geohazard risks at British Energy sites

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Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Signed
1	0	Draft for comment	22.06.07	PRF
1	1	Incorporating client review comments	28.09.07	PRF

Contents

1 Introduction

1.1 Background

British Energy (BE) owns and operates eight nuclear power stations at a variety of coastal and estuarine locations around the UK. These power stations are: Dungeness B (south Kent), Hartlepool (Tees Estuary), Heysham 1 and 2 (Morecambe Bay), Hinkley Point B (north Somerset), Hunterston B (Firth of Clyde), Sizewell B (Suffolk), and Torness (Firth of Forth). In addition, BE owns land adjacent to these existing developments and beside the decommissioning Bradwell nuclear power station (Blackwater Estuary) that may be developed for new nuclear build (NNB).

Predictions of climate and sea-level change, in so far as they affect risks associated with coastal erosion and flooding, are a matter of significance for the future management of both current and potential future operations. BE has thus commissioned a high-level review of the potential impacts of future climate change and coastal geohazards at the eight locations involved, based on credible worst-case scenarios, covering the period from now until 2105. This is the point at which all operations, including the final decommissioning of any NNB power stations, would be expected to end. This report outlines the findings of that review.

The review itself is preliminary and will need to be repeated at subsequent intervals, to accommodate both the developing understanding of the scientific community and the more detailed findings of site-specific studies. In its current form it does no more than provide an indication of the likely coastal geohazard pressures that are likely be experienced at the individual sites in the period to 2105; subsequent studies will seek to refine the actual site-specific engineering needs and management strategies involved.

For the purpose of the review, and in order to scale the degree of need involved at each site from a conservative baseline, it has been presumed that the NNB site frontages will remain as they are today without any subsequent modification or management. Therefore some of the potential NNB frontages have been presumed to be entirely devoid of flood defence or coastal protection measures, whilst the remainder have been presumed to benefit from existing, sometimes elderly, shoreline works. Although convenient this is an artificial position, the reality being that active management by the operator of these frontages will be coupled to a process of review. Furthermore, whilst existing operational sites already have flood and/or coastal defences in place and are actively engaged in such management, any new developments are likely to need similar engineering structures and the associated management measures. The objective in doing this was to scale the degree of actual need involved and provide an initial judgement on available mitigation options and engineering feasibility.

The review is based on previously published data on the coastal system, previously published and newly generated data on historical coastal behaviour, and projections of future climate and sea-levels. Climate change data was derived from work carried out by the Met Office, the UK Climate Impacts Programme (UKCIP) and DEFRA. The coastal geohazard risk assessment was undertaken using expert judgement, based on a credible worst case scenario.

1.2 Structure of this document

Section 2 of this report provides details of projected climate and sea-level changes over the next 100 years at the eight locations concerned. The potential impacts of coastal geohazard risks for both existing and potential NNB sites are then summarised in Section 3. Risk mitigation strategies are then presented, and their feasibilities assessed for BE's existing and potential NNB sites in Section 4. This section also presents details of the information required to reduce uncertainty over future coastal geohazard risks and risk mitigation strategies.

2 Climate change and coastal hazards

2.1 *Climate change source data*

For the purposes of this assessment it was assumed that the high emissions climate change and sea-level rise scenarios developed by IPCC (2001), applied to the UK-scale by UKCIP (2002), and applied to the various nuclear power station sites by the Met Office (2004, 2007), represented a suitable worse case scenario. There has been recent debate on the predicted timescale for a collapse of ice sheets associated with Antarctica and Greenland. Collapse of the West Antarctic Ice Sheet, for example, is predicted to result in a rise in eustatic (global) sea-level of 5 to 6m. However, there are considerable uncertainties about the timing and mechanisms for collapse (e.g. Rahmstorf 2007). This scenario is considered not to be credible within the next 100 years by DEFRA and its advisors and for this reason the scenario has not been adopted here.

2.2 *Sea-level change and increases in storminess*

Sea-level change involves two components: changes in the *absolute* volume of sea water (*eustatic changes*) which are worldwide and largely associated with the growth and decay of land based ice sheets; and regional changes in the absolute land level due of uplift and subsidence (*isostatic changes*). *Relative sea level change* is the change in the level of the sea relative to the land, taking account of both eustatic and tectonic/isostatic changes. Predictions were available from three sources:

1. UKCIP (August 2006 update): The UK Climate Impacts Programme (UKCIP) high emissions scenario forms the basis of the projections made by the Met Office.

2. Met Office (2007) report to BE: As with the UKCIP input, but including estimates of site-specific isostatic uplift/ subsidence rates and predicted site-specific increases in storm surge heights. These data are summarised in Table 2.1.

3. DEFRA (October 2006): DEFRA predictions are linked to the IPCC (2001) high emissions scenario. They provide a continuous predictive curve for the next 100 years and as such are, in some cases, more useful than the step-wise predictions provided by UKCIP. The projections derived by this method do

not differ from UKCIP or the Met Office by more than ±15cm in the worst case scenario for the mid-point of the 2080s period.

Table 2.1. Sea-level and 1:50 year surge height change for the 2080s (Met Office, 2007: Worst Case Scenario)

Site	Existing 1:50 yr surge height (m OD)	2080s 1:50 yr surge height change + relative sea-level rise (m)	2080s 1:50 yr surge height change + relative sea-level rise (m OD)
Bradwell	4.24	1.67	5.91
Dungeness	5.05	1.22	6.27
Hartlepool	3.7	1.07	4.77
Heysham	6.56	0.90	7.46
Hinkley Point	7.19	0.88	8.07
Hunterston	3.56	0.99	4.55
Sizewell	3.00	1.70	4.70
Torness	3.43	0.94	4.37

Note: mean sea-level for each site will be different and is not 0m OD. 2080s predictions are taken to be broadly applicable to 2105. Factors contributing to relative sea-level rise are shown in Figure 2.1.

The projected surge height change figures calculated by the Met Office (2007) were derived from five sources: global sea-level rise, localised isostatic land-level changes, increased 1:50 yr event storm surge height, and uncertainty in the global sea-level rise factor and other localised effects. Using the worst-case scenario for the 2080s at Dungeness as an example, the relative contribution of these four factors is shown in Figure 2.1. This figure highlights the relatively minor significance of land-level change (isostatic changes) and the high level of uncertainty in sea-level projections.

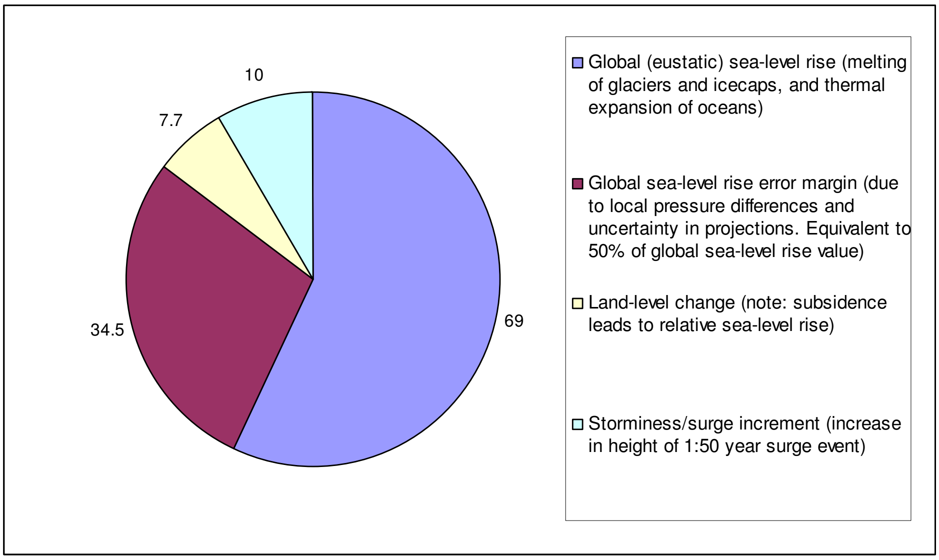
2.2.1 *Extreme water levels*

At each site, the impact of future extreme water levels were assessed in comparison with existing coastal defence levels, for the worst case scenario. The results are shown in Table 2.2.

2.2.2 *Waves*

Records of wave climate exist for some of the power station sites, but not all; where data did exist they were not always in the same form which made comparison between sites difficult. Table 2.3 summarises the data currently available. The changes in wave heights expected over the next 100 years were estimated using the Met Office predictions for increased wind speeds by 2080 (Met Office 2004), the latter report suggesting that prediction of change in wave height can be made using these data since wave height varies as the square of wind speed. Table 2.3 shows this calculation using, in each case, the maximum wind speed increase (values are extrapolated to 2105).

Figure 2.1. Factors contributing to projections of raised water-levels. Example from Dungeness (total rise in sea-level by 2080s = 122 cm. Values on chart in cm)



2.3 Tsunami hazard

Tsunamis are sea-surface waves generated by a vertical displacement of water above or below sea level. Initiating events for this process include:

- sudden vertical movement of the sea floor (e.g. earthquake)
- sudden submarine landslide
- sudden entry of large volumes of terrestrial material into the sea (e.g. volcano flank collapse, mass movement).

A re-assessment of knowledge regarding tsunami risk to the UK coastline was published by DEFRA in June 2006, jointly prepared by the BGS, HR Wallingford, the Met Office, and the Proudman Oceanographic Laboratory.

Table 2.2. Impact of future extreme water levels at the sites

Site	Ground level (m OD)	Defence crest elevation (m OD)	1:50 yr storm surge height (m OD)	Height of defence crest above surge (m)	2080s 1:50 yr storm surge height (m OD)	Height of defence crest above 2080s 1:50 yr surge (m)
Bradwell*	5.20	4.80	4.24	0.56	5.91	-1.11
Dungeness	5.50	11.0	5.05	5.95	6.27	4.73
Hartlepool	4.75	4.80	3.70	1.10	4.77	0.03
Heysham	8.25	8.80	6.56	2.24	7.46	1.34
Hinkley Point	10.25	14.0	7.19	6.81	8.07	5.93
Hunterston	7.47	No data	3.56	No data	4.55	No data
Sizewell	6.40	12**	3.00	2.70	4.70	7.30
Torness	11.35	10.0	3.43	6.57	4.37	5.63

*data for existing Magnox site ** primary flood embankment

Table 2.3 Wave heights at each power station site

	50 Year return interval wave height			
Site	Offshore Hsig (m)	Near shore Hsig (m)	Increase in Wind speed to 2105 (%)	Wave height by 2105
Bradwell	no data	0.8	9	0.95
Dungeness	no data	4.6	11	5.67
Hartlepool	10.70*	N/A	3	11.35
Heysham	7.20	N/A	5	7.94
Hinkley Point	4.56	N/A	7	5.22
Hunterston	1.60*	N/A	0	1.60
Sizewell	8.00*	N/A	9	9.50
Torness	8.90**	N/A	3	9.44

*Maximum wave height; ** 1:100 Return interval. Hsig= Significant wave height (i.e. mean height of highest third of waves)

Potential sources and magnitudes for tsunami events that may impact the sites are listed in Table 2.4, which suggests a limited tsunami risk around the UK coastline. Furthermore the data suggest a low probability of future occurrence, typically less than 1:1,000 years, because of the limited number of locations of potential tsunami-triggering events (DEFRA, 2006). Importantly, the predicted tsunami wave heights do not exceed the typical storm surge levels shown in Table 2.2.

The required level of defence at operational nuclear sites for nuclear safety purposes is against the 1 in 10,000 year event.

Table 2.4. Sources and impacts of tsunami at the sites (DEFRA, 2006

Site	Source	Indicative Probability	Impact
Bradwell		No Credible Source	
Dungeness		No Credible Source	
Hartlepool	North Sea Earthquake (Dogger Bank)	1:1,000	2m Wave Within 2 Hours
Heysham		No Credible Source	
Hinkley Point	Azores-Gibraltar Plate Earthquake	1:100	1m High Wave Within 8 Hours
	Volcano Flank Collapse: Canary Islands	1:10,000	2m High Wave Within 8 Hours
	Celtic Sea Earthquake	1:1,000	1m High Wave Within 6 Hours
Hunterston		No Credible Source	
Sizewell		No Credible Source	
Torness	North Sea Earthquake (Dogger Bank)	1:1,000	No Significant Impact

3 Geohazard assessment

3.1 *Existing operational sites*

For each site a range of scenarios were compiled into a risk register that described how hazard events (loss of land and site inundation) might be generated by future coastal processes. The morphological adjustments and consequences arising from these scenarios were then predicted, assuming a 'hold the line' shoreline management policy. Estimates of the likelihood of the hazard scenarios and resulting consequences were determined by expert judgement. A summary of the coastal geohazard risk profile for each location is presented in Table 3.1.

Assuming that a shoreline management policy of hold the line is adopted, the specific conclusions for existing operational station sites include:

- At Heysham, Hunterston, Hartlepool and Torness, coastal geohazards are expected to present minor risk to 2105 provided the existing defences are maintained, repaired and improved
- At Dungeness, Sizewell and Hinkley Point, coastal geohazards are expected to present increased risks over the next 100 years and in order to maintain a uniform standard of protection throughout the period an improvement to existing defences would be required.

To support consideration of the NNB interest, this assessment assumed the need for a standard level of protection to be applied at each of the current operational sites over precisely the same geographical area (the full extent of the current operational site) through to 2105. In practice, given that their planned decommissioning dates lie predominantly within the period to 2020, such a need is unlikely. Actual plant protection needs will be subject to periodic review up until the point of decommissioning, at which point a further review would be completed relevant to the de-fuelled and partially dismantled site. For the remaining years of decommissioning, sites would cover a more limited area and have a more limited need of protection.

Table 3.1. Summary of coastal geohazard risk profile for existing power station sites, disregarding likely transition in flood defence and coastal protection needs upon decommissioning and presuming no corrective management measures

Site	Hazard	Adverse consequence	Estimated likelihood (2007 to 2105)
Dungeness	Loss of Land	Erosion of flood embankment Minor loss of site Partial loss of site Complete loss of site	Almost Certain Very Likely Possible Rare – Not Credible
	Site Inundation	Minor flooding of site Severe flooding of site	Possible Unlikely
Hartlepool	Loss of Land	Erosion of estuarine revetment (reparable damage) Minor loss of site (dredged channel bank failure) Partial loss of site Complete loss of site	Very Likely Possible Unlikely Rare – Not Credible
	Site Inundation	Minor flooding of site Severe flooding of site	Possible Rare – Not Credible
Heysham	Loss of Land	Reparable damage to revetment Minor loss of site Partial loss of site Complete loss of site	Almost Certain Unlikely Rare – Not Credible Not Credible
	Site Inundation	Minor flooding of site Severe flooding of site	Unlikely Rare – Not Credible
Hinkley point	Loss of Land	Erosion of western boundary Minor loss of existing site Partial loss of existing site Complete loss of site	Likely Possible Possible Rare – Not Credible
	Site Inundation	Minor flooding of existing site Severe flooding of existing site	Possible Rare – Not Credible
Hunterston	Loss of Land	Loss of land Loss of land Loss of land Loss of land	Likely Rare Not Credible Not Credible
	Site Inundation	Loss of land Loss of land	Unlikely Rare – Not Credible

Site	Hazard	Adverse consequence	Estimated likelihood (2007 to 2105)
Sizewell	Loss of Land	Erosion of primary dune ridge Minor loss of site Partial loss of site Complete loss of site	Very Likely Likely Possible Rare – Not Credible
	Site Inundation	Flooding between dune ridges Minor flooding of site Severe flooding of site	Almost Certain Unlikely Rare – Not Credible
Torness	Loss of Land	Reparable damage to defences Minor loss of site	Very Likely Likely
		Partial loss of site Complete loss of site	Not Credible Not Credible
	Site Inundation & Loss of Land	Minor flooding of site Severe flooding of site	Unlikely Rare – Not Credible

3.2 *NNB sites*

Coastal geohazard risk profiles were generated for each of the potential NNB locations. This assessment was based on the assumption of a 'do nothing' shoreline management strategy over the next 100 years, i.e. existing defences will *not* be maintained and new defences will *not* be constructed. In other words, a common worst case baseline was established against which actual engineering and management needs might then be scoped. A summary of the estimated likelihood of the consequences of a 'do nothing' approach on these frontages is presented within Table 3.2.

Following this assessment, specific conclusions were reached on the management needs of each site:

- Coastal geohazards are expected to present minimal risks at Heysham, Hunterston and Torness provided that the existing defences are maintained, repaired and improved
- Coastal geohazards at Hartlepool are expected to present minor risks provided existing defences are maintained, repaired and improved
- At Dungeness and Sizewell, coastal geohazards are expected to present significant risks. However, these sites can be safely developed if defences are maintained, repaired and improved

- Bradwell and Hinkley Point would require significant investment in new coast protection measures before development.
- At each site, the measures required for future flood defence and coastal protection are likely to be entirely feasible within existing engineering knowledge.

Table 3.2. Summary of coastal geohazard risk profile for NNB sites assuming, if any present, no improvements in existing flood defences or coastal protection measures on these frontages.

Site	Hazard	Adverse consequence	Estimated likelihood (2007 to 2105)
Bradwell	Loss of Land	Erosion of embankment (reparable damage)	Almost Certain
		Minor loss of site (<10%) – mudflat creation following breach	Likely
		Partial loss of site (c50%) following breach	Likely
		Complete loss of site following breach	Likely
	Site Inundation	Minor flooding of site (overwash)	Very Likely
Dungeness	Loss of Land	Erosion of flood embankment	Almost Certain
		Minor loss of site	Very Likely
		Partial loss of site	Possible
		Complete loss of site	Rare – Not Credible
	Site Inundation	Minor flooding of site	Almost Certain
		Severe flooding of site	Possible
Hartlepool	Loss of Land	Erosion of estuarine revetment (reparable damage)	Almost Certain
		Minor loss of site (dredged channel bank failure)	Likely
		Partial loss of site	Possible
		Complete loss of site	Rare – Not Credible
	Site Inundation	Minor flooding of site	Almost Certain
		Severe flooding of site	Rare – Not Credible
Heysham	Loss of Land	Reparable damage to revetment	Almost Certain
		Minor loss of site	Possible
		Partial loss of site	Unlikely - Rare
		Complete loss of site	Not Credible
	Site Inundation	Minor flooding of site	Likely
		Severe flooding of site	Unlikely - Rare

Site	**Hazard**	**Adverse consequence**	**Estimated likelihood (2007 to 2105)**
Hinkley Point	Loss of Land	Erosion of western boundary Minor loss of new build site Partial loss of new build site Complete loss of new build site	Likely Likely Likely - Possible Rare – Not Credible
	Site Inundation	Minor flooding of new build site Severe flooding of new build site	Unlikely Rare – Not Credible
Hunterston	Loss of Land	Reparable damage to defences Minor loss of site Partial loss of site Complete loss of site	Likely Possible Not Credible Not Credible
	Site Inundation	Minor flooding of site Severe flooding of site	Unlikely Rare – Not Credible
Sizewell	Loss of Land	Erosion of primary dune ridge Minor loss of site Partial loss of site Complete loss of site	Very Likely Very Likely Likely Rare – Not Credible
	Site Inundation	Flooding between dune ridges Minor flooding of site Severe flooding of site	Almost Certain Possible Rare – Not Credible
Torness	Loss of Land	Reparable damage to defences Minor loss of site Partial loss of site Complete loss of site	Very Likely Unlikely Possible Not Credible
	Site Inundation & Loss of Land	Minor flooding of site Severe flooding of site	Possible Unlikely - Rare

4 Future needs

4.1 Approach to risk mitigation and feasibility assessment

4.1.1 *Risk mitigation options*

Approaches to mitigation or control of risk from coastal erosion and flooding, in relation to site operation, NNB and decommissioning may involve the following:

- **For existing site operation**: Reducing the frequency of hazardous events by maintaining or upgrading existing defences
- **For NNB sites:** Reducing the frequency of hazardous events by upgrading existing defences, constructing new defences, or reducing the exposure to hazardous event by locating NNB sites away from hazardous zones, e.g. moving structures slightly inland (by establishing a buffer zone) to accommodate potential coastal erosion.
- **For decommissioned sites, both current operational and NNB:** The change in land use from a nuclear-fuelled generation operation to a de-fuelled and partially dismantled one covering a much smaller area will inevitably be associated with a review of flood defence and coastal protection needs. Should the remaining liabilities be located further back from the coastline, or on higher ground, this would limit their exposure to erosion or flooding risk over the remaining years of site life. An alternative or potentially supplementary approach would be to engineer the residual structures in such a way as to provide their own flood defence, without the need to do so on a wider perimeter. In each instance both the height and geographical extent of defences might be reduced to match the needs of the residual hazard on site.

4.1.2 *Assessment of feasibility*

The feasibility of risk mitigation options for sites was assessed on technical and environmental grounds for each stage of the stations' life-spans: operation, NNB and subsequent decommissioning. Technical feasibility was assessed on the basis of currently available data. Detailed design drawings and structural asset condition surveys will be required in order to make more detailed comments on future engineering needs.

The environmental feasibility of coastal defence options was assessed with reference to the location of environmentally designated sites local to the current operational site. Key designations included: Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation (SACs), Special Protection Areas (SPAs), and Ramsar Sites. The outlines of such designated areas do not necessarily represent the limit of protection involved and the indirect impact of developments on adjacent environmental sites would also require detailed consideration.

4.2 Results

The projected levels of future risk at the existing operational and NNB sites have been summarised in Tables 3.1 and 3.2 respectively. Risk mitigation options for the new build sites are shown in Table 4.1 and the feasibility of these options is shown in Table 4.2. It is expected that future risk management approaches would take account of:

- Adaptive management and consideration of soft defences, e.g. careful shoreline management for flood and erosion control at Hartlepool
- Potential for habitat creation, e.g. at Sizewell, where dune habitat creation may be possible.

New defences would be required for the NNB sites at Bradwell and Hinkley Point and potentially substantial upgrades would be needed at Dungeness and Sizewell. Other sites may only require maintenance and upgrading of existing defence structures.

There is the potential for adopting an adaptive management strategy from the outset at many of the NNB locations. At Bradwell, Dungeness, Hinkley Point and Sizewell, there is the potential to set back NNB sites to accommodate increased erosion potential. At many sites, raising site levels provides a strategy to minimise flood risk. Sources of fill may be associated with decommissioning of existing sites, but actual availability will be determined by the relative timing of new build and decommissioning. At Dungeness there is currently an opportunity to review the specification of the required defences in light of the current understanding of a very low tsunami probability at the site.

The data required to reduce uncertainty associated with the mitigation options discussed above is shown in Table 4.2.

The measures required for future flood defence and coast protection for NNB at the sites studied here are likely to be entirely feasible within existing engineering knowledge.

Table 4.1. Risk mitigation options for proposed nuclear sites.

Risks and mitigation	Bradwell	Dungeness	Hartlepool	Heysham	Hinkley Point	Hunterston	Sizewell	Torness
Mitigation options for PROPOSED sites								
Erosion	• Upgrade coastal defences to control erosion and flooding. • Create soft defences, such as salt marsh, to adapt to sea level change and avoid 'coastal squeeze'. • Setback site to accommodate future erosion	• Maintain existing defences and beach management. • Reduce beach management intervention • Set back site to accommodate future erosion and create additional shingle habitat. • Reduce specification of coastal defences in view of tsunami probability	• Install new coast protection to control estuary erosion. • Create soft defences, to adapt to sea level change and avoid 'coastal squeeze'. • Change management and behaviour of Seaton Spit to provide adaptive coast protection.	• Upgrade existing coast protection to limit future storm damage especially with lower beach levels. • Extend existing coast protection to south to prevent outflanking.	• Construct new coast protection to prevent cliff retreat • Set back site to accommodate future cliff retreat.	• Existing sea defences sufficient if current beach level persists	• Construct new coast protection, similar to those at existing site, to control increasing erosion. • Set back site to accommodate future coastal erosion. • Create new outfall to form a 'hydraulic groyne' to affect pattern of coastal erosion	• Upgrade existing coast protection to limit future storm damage • Extend defences to the east to prevent outflanking
Flooding	• Upgrade coastal defences to control flooding • Raise site level, or design structures to accommodate flooding	• Maintain existing coastal defences and beach management • Reduce beach management intervention • Reduce specification of coastal defences in view of tsunami probability • Raise site level, or design structures to accommodate flooding.	• Install new defences, similar to those at existing site, against river and coastal flooding. • Change management of Seaton Spit to provide adaptive coast protection. • Raise site level, or design structures to accommodate flooding.	• Upgrade existing coast protection to limit future storm damage especially with lower beach levels. • Extend existing coast protection to south to prevent outflanking. • Raise site level, or design structures to accommodate flooding.	• Construct new defences to control flooding • Design structures to accommodate flooding.	• No action required	• Construct new defences, similar to those at existing site, to control increasing flood risk. • Raise site level, or design structures to accommodate flooding.	• Existing sea defences require upgrading and extension to stop outflanking

Table 4.2 Feasibility of risk mitigation options and requirements for additional data

	Bradwell	Dungeness	Hartlepool	Heysham	Hinkley Point	Hunterston	Sizewell	Torness
PROPOSED (NNB) sites								
Technical feasibility	• Upgrade of clay bank feasible. • New defences require careful design to avoid coastal squeeze and loss of inter-tidal habitat. • Source of fill required to raise site level. Material may be derived from decommissioned site.	• Setting back site feasible but potential recession distance requires review. • Opportunity to review specification of gravel barrier crest height.	• Upgrade of river protection likely to be feasible. • Careful design required to minimise coastal squeeze and loss of habitat.	• Upgrade and extension of coast protection likely to be feasible.	• Construction of new cliff protection measures likely to be feasible. • Setting back site feasible with knowledge of future recession potential	• Maintenance of sea defences feasible	• Construction of new defences feasible. • Impact of new outfall (and hydraulic groyne) on the rate and pattern of coastal change is unknown • Opportunity to revise specification of design of sea defences. • Setting-back site likely to be feasible.	• Upgrade and extension of existing sea defences likely to be feasible.
Environmental feasibility	• Raising site level may increase visual impact of site • Creation of natural defences, e.g. salt marshes, that adapt to sea level will require detailed assessment to determine feasibility	• Opportunity to review frequency of beach recycling scheme • Impact of setting back requires review. There would be additional foreshore habitat, but potential loss of established gravel habitats inland.	• Use of Seaton Spit as 'soft', adaptive sea defence measure may increase dune habitat. • Raising site level may increase visual impact of site	• Upgrade and extension of sea defences may lead to coastal squeeze and loss of intertidal habitat.	• Construction of new cliff protection measures likely to lead to loss of rocky shore and shingle habitats.	• Maintenance of sea defences may lead to coastal squeeze and loss of intertidal habitat.	• Raising site level may increase visual impact of site, e.g. at Minsmere. • Revisions to adaptive defences will require detailed assessment • Setting-back may afford opportunity for habitat creation.	• Upgrade and extension of sea defences may lead to coastal squeeze and loss of rocky shore habitat.
Requirements for further data								
	• Geomorphological baseline and sediment budget. • On-going beach and bathymetry surveys and data analysis. • Consider installing local tide gauge. • Environmental screening study. • Defence asset condition survey.	• Bathymetry survey programme • On-going beach surveys • Reconcile sediment budgets • Install tide gauge • Environmental screening study.	• Geomorphological baseline and sediment budget • Set up bathymetry and beach survey programme • Wave data in estuary • Install tide gauge • Environmental screening study. • Defence asset condition survey.	• Geomorphological baseline • Set up bathymetry and beach survey programme • Additional wave data • Develop sediment budget • Environmental screening study. • Defence asset condition survey.	• Geomorphological baseline and sediment budget • Set up bathymetry survey programme • Monitoring of coastline • Evaluate wave data • Environmental screening study. • Defence asset condition survey.	• Geomorphological baseline and sediment budget • Set up bathymetry and beach survey programme • Wave data in Forth of Clyde needed • Aerial photos or LiDAR data • Environmental screening study.	• On-going beach and bathymetry surveys and data analysis. • Sediment budget. • Tide gauge needed • Environmental screening study. • Defence asset condition survey.	• Geomorphological baseline sediment budget • Set up bathymetry and beach survey programme • Tide gauge needed • Aerial photos or LiDAR data • Environmental screening study. • Defence asset condition survey.

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