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The implications of a major coastal flood on nature conservation interests in England

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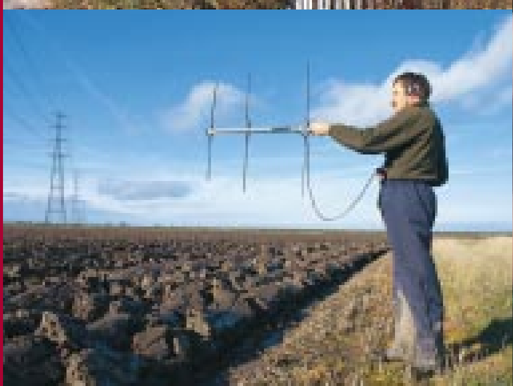

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The implications of a major coastal flood on nature conservation interests in England

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- Proudman Oceanographic Laboratory
- Joint Nature Conservation Committee
- Bath and North East Somerset Council
- Gravesend Council
- The Emergency Planning Society
- Environment Agency
- Met. Office
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Summary

The report examines the implications of major coastal storms or marine incursions such as storm surge, wind, wave and Tsunami on nature conservation interests along the coastal regions of England. Other influences such as rainfall and climate change were also been examined. For each of the major storm events outlined above predictions on their return periods and potential to change areas designated for their conservation interests have been evaluated. The evaluation process adopted generic terms for both landforms and habitat types in order to provide a meaningful interpretation of most likely changes following a major storm or marine incursion. A conceptual framework for the linkage between the source (storm event) and the pathways (landforms over which the events must travel) and the receptors (habitats) was used to examine sensitivity. The role of English Nature and the mechanisms driving both policy and planning have been assessed and recommendations proposed. In particular, the relevance to emergency response planning and the implications of the major events on the wider environment.

Abbreviations

ABP	Associated British Ports
ABPmer	ABP Marine Environmental Research Ltd.
CNC	Critical National Capital
CAN	Constant Natural Assets
Defra	Department for Environment, Food and Rural Affairs
DTA	David Tyldesley & Associates
EA	Environment Agency
HAT	Highest Astronomical Tide
IMO	International Maritime Organisation
IMT	Incident Management Team
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
MCA	Maritime and Coastguard Agency
Met. Office	The Meteorological Office
MHWN	Mean High Water, Neap Tides
MHWS	Mean High Water, Spring Tides
MLWN	Mean Low Water, Neap Tides
MLWS	Mean Low Water, Spring Tides
NCP	National Contingency Plan
ODPM	UK Office of the Deputy Prime Minister
OPRC	Oil Pollution Preparedness, Response and Co-operation
POL	Proudman Oceanographic Laboratory
QoLC	Quality of Life Capital
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
UNCLOS	United Nations Convention on the Law of the Sea
UKDMAP	United Kingdom Digital Marine Atlas
UKHO	United Kingdom Hydrographic Office

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1 Introduction

ABP Marine Environmental Research Ltd (ABPmer) has been commissioned by English Nature to investigate the implications of a major coastal storm or marine incursion on nature conservation interests in England.

The need for organisations involved in coastal management to be prepared for and be able to respond to major coastal storms arises because they are high magnitude events, which despite their very low frequency return periods, have the potential to result in:

- Loss of human life.
- Damage to sea defences and infrastructure.
- Incursion of saline water onto farmland and freshwater/terrestrial coastal habitat located behind seawalls or natural barriers.

Although storm events comparable in magnitude to the infamous one in 1953 have an estimated return period of 1 in 200 years, they are equally likely to occur tomorrow. Moreover, predicted increases in the levels of storminess over the next century mean that it is prudent for English Nature to consider its responsibilities and activities prior to and following a major storm event. Consequently, English Nature seeks to provide clarity and direction in the management of its coastal interests (namely, sites of nature conservation interest) before and after a major event or marine incursion. To achieve this state of readiness, English Nature has identified three key aims that are central to its role in managing the coastal environment. These aims are the focus of the present study.

Aims
• To provide guidance on the management of coastal sites of conservation interest in preparation for a major event. • To determine the likely scale of habitat changes (loss and gain) as a result of major event scenarios. • To provide advice on the response of English Nature to emergency flood defence works and media/public interest following a major event (via the provision of an emergency response plan).

It should be emphasised, however, that English Nature places the need to ensure public safety over and above that required for the protection of its nature conservation interests. It will also ensure that the risks to coastal communities from flooding or erosion are not increased because of its adherence to storm management. In addition, English Nature accepts that the maintenance of existing and the provision for new sea defences should be permitted where there is a direct threat to both coastal towns and villages, or where such a scheme is of national interest.

English Nature has a number of nature conservation responsibilities within the coastal zone, which relate to:

- The designation and management of SSSIs, Ramsar sites and Natura 2000 areas.
- Consideration of the dynamic nature of the coast and marine environment.

- Assisting the Government in achieving the coastal bio-diversity targets published in the UK Biodiversity Group Tranche 2 Action Plans (1999).
- Advocating the use of sustainable shoreline management approaches (eg soft engineering) or non-intervention wherever possible.

The following study provides guidance, advice and recommendations on the management of English Nature's nature conservation responsibilities in the event of a major storm or marine incursion.

2 Methodology

As part of the overall aims of the present study (see Section 1), English Nature has identified nine specific objectives. These are described in the following section along with details of our approach and methodology to addressing each objective.

Objective 1
Assess and describe the range of severe climatic or oceanographic events that could occur around the English coastline with a probability of 1 in 500 years or less.

To assess and describe the potential range, scale and scope of any acute natural events in the coastal zone, information and advice was provided by a number of UK scientific and governmental organisations (eg Environment Agency (EA), Proudman Oceanographic Laboratory (POL), Met. Office, Defra). Primarily, advice was sought to identify coastal forcing parameters and to identify the most relevant publications. Based on the information and data collated, the range of severe climatic or oceanographic events that could occur around the English coastline was characterised and the scale and frequency of these events assessed. The results for Objective 1 are presented in Section 3.

Objective 2
Account for the generic changes affecting designated conservation areas following such an event.

A desktop appraisal was undertaken to identify and characterise all coastal designated conservation areas (eg SPAs, SACs, SSSIs) into different generic habitat types. These types were based on the habitat and species descriptions for which they were designated. It is important to note that using a generic habitat type, rather than a designated conservation area, provided a more reliable method to assess the likely impacts from a storm event (as identified in Objective 1). This is because habitats are more closely associated to the landforms upon which they are supported and, in turn, more inherently 'sensitive' to change following a major storm event or marine incursion. Identification and characterisation of habitats was achieved using mapped data showing the UK distribution of SPAs, SACs, SSSIs and Ramsars from both the English Nature and JNCC websites. Only those sites designated within the coastal zone were used, although it should be noted that inland sites could also be affected by extreme events.

Objective 3
Determine the range and type of designated conservation areas likely to be threatened or adversely impacted by such events.

The implications for designated conservation areas potentially under threat or adversely affected from such events were assessed using a risk-based approach. This approach was applied to five different regions of the UK coastline (see Section 3.4.2. Figure 4), which were judged to closely reflect broadscale differences in topographical and coastal processes, and included the following criteria:

- The **magnitude** and **frequency** of key forcing events (the source of the risk).
- The identification of **receptors** (landforms and their associated designated conservation areas/habitats) and the degree of **exposure** to these key forcing events.
- An assessment of the **sensitivity (**to include range of tolerance to change**)** of the receptor to these key forcing events.
- The **vulnerability** of the receptor is based on a combination of the magnitude and frequency of an event relative to its sensitivity, which is based upon the nature of the receptor and the level of exposure.
- The **recoverability** of these landforms and their designated conservation areas/habitats following an event, which was based on expert knowledge and the scientific literature.

The assessment of risk was evaluated using:

- information collated for Objectives 1 and 2;
- English Nature and JNCC maps showing the location of designated areas;
- EA floodplain maps, which show areas susceptible to flooding under a 1 in 200 year event; and
- information on the sensitivity of receptors to the changes typically occurring during a major storm event.

Using the risk-based approach outlined above, professional judgement was used to assess the overall risk of a particular receptor to an event.

Objective 4
Assess the implications and options for English Nature in terms of policy and site management prior to such an event.

Objective 4 was divided into two components, i) English Nature's internal mechanisms in terms of policy prior to an event, and ii) their options for site management prior to an event.

As part of the first component, a number of internal options and recommendations have been formulated in the present study following consultation with English Nature. These include standardisation of protocols for storm event management, dissemination of recommendations and guidance provided by the present report and standardisation of terminology. In this case, a significant change in the conceptual attitude to nature conservation has been its approach to addressing the impacts of major storm events as ‘changes’ to habitats and ecosystems, as opposed to ‘loss or degradation’.

For the second component a review of the national and international policy and management obligations for coastal nature conservation sites was undertaken in collaboration with David Tyldesley and Associates (DTA). Their final report is presented in Appendix 1. The review examined the implications for preparatory management of coastal habitats affected by a major event. A number of specific aspects were examined and these included the following:

- An analysis of the provisions and expectations of policy frameworks.
- An examination of the obligations that may flow from certain nature conservation designations that English Nature would be involved in (eg SPAs, NNRs).
- A review of statutory requirements via the regulatory controls.

Overall, a key element of this objective has been the adoption of a flexible response due to the uncertainty surrounding the occurrence of a major storm event. By contrast, however, site-specific level management can be pre-defined and the most appropriate implementation strategy identified prior to an event.

Objective 5
Detail the policy and planning processes that English Nature should be seeking to influence (internally and externally) in terms of preparing for, and responding, to a major event.

A review of the national policy and planning processes that English Nature can influence to meet their objectives of preparing for, and responding to, a major event was undertaken. The present study provides advice on how English Nature can influence policy by looking at the consultation mechanisms. In particular, consideration has been given to most relevant local policy and non-statutory responses. This has been carried out in collaboration with DTA.

Objective 6
Outline the ways in which English Nature may potentially influence relevant policy mechanisms.

The most appropriate policy mechanisms available to English Nature in preparing and responding to a major event have been identified, together with recommendations for the ways in which staff (at a national and area team level) can influence such mechanisms. For example, the ‘pro-active relocation’ of existing premises or dwellings to a new location can be accommodated ‘naturally’ through the implementation of ‘time-dependent’ SMP policies. These ‘time-dependent’ policies provide an opportunity to relocate property in the interest of public safety when the maintenance or construction of a new sea defence is no longer sustainable or effective against a major storm event. The present study provides guidance and other recommendations that build on the policy and planning processes identified in Objective 5.

Objective 7
Provide information to inform an outline emergency response plan for English Nature following such an event for both national and area team offices.

A review of the potential emergency response mechanisms for English Nature to major coastal flood events has been undertaken to accommodate a nature conservation perspective. Further evaluation of other flood and emergency response plans (eg oil spill response approaches, OPRC and MCA plans) will be used to guide and recommend appropriate action. In particular, adoption of the ideals identified under the 'best-practice' protocol could be incorporated into English Nature's outline emergency response plan.

Objective 8
Provide evaluation criteria by which English Nature can establish which types of sites will be afforded emergency flood management works following a major event, and which areas, from a nature conservation perspective, could be left to respond 'naturally'.

In order to achieve this objective, a brief initial review of literature from the *Journal of Coastal Conservation* was undertaken. This revealed little information to support the work, so attention was focused on a relatively recent case study of where a gravel barrier at Porlock, Somerset was left to respond naturally following its breaching during a storm event. From a review of the key issues associated with this case study, a number of factors were identified that enabled the management decision to be made to leave the breach unrepaired. These factors were incorporated into the development of criteria by which English Nature can establish which areas should be afforded emergency flood management works, and which could be left to respond naturally. These criteria remained focused on protecting life and not increasing risk of flooding or erosion elsewhere. They also adopted English Nature's stance that the dynamic nature of the coast should be accommodated where possible, assisted by the incorporation of the Quality of Life Capital (QoLC) concept to assist in judgement of 'value' of a particular asset.

Objective 9
Outline the major issues English Nature needs to consider regarding the management of the wider environment following a major event.

The implications for storm management on the wider environment from a nature conservation perspective were evaluated. Based on preparatory response mechanisms already in use by other countries and available guidance on the ecological principles that should underpin post-flood responses outside of nature conservation sites, recommendations are provided.

3 Storm event conditions

Objective 1
Assess and describe the range of severe climatic or oceanographic events that could occur around the English coastline with a probability of 1 in 500 years or less.

3.1 Background

The gravitation pull of the moon, and to a lesser extent the sun, combined with the centrifugal force of the earth influence the movement of oceanic water to create tides. These ocean scale water movements are defined as massive ‘waves’ that peak and trough to create high and low water levels or tides. The frequency of these successive high and low tides is described as the tidal period, whereas the difference in water level between high and low tides is defined as the tidal range.

During the course of one-month, the orbital position of the earth, sun and moon change due to the relative and proportional forces of gravitation. This causes the forces acting on the earth to alter at different times during the month. When the sun and moon are both positioned along the same axis, for example, the forces acting on the earth are at their maximum, producing the highest and lowest waters levels or tides (spring tides). In contrast, when there is a 90^o offset in this axial alignment the forces acting on the earth are at their minimum and the resulting tides at their smallest (neap tides).

The aforementioned fluctuations in water levels are regular and predictable. However, superimposed upon them can be irregular factors, such as atmospheric pressure and winds. During low-pressure weather systems characteristically associated with storm events, water levels that are higher than the predicted astronomical tide are experienced, whilst during high-pressure weather systems, lower water levels than predicted tend to occur. Winds acting on the sea surface also contribute to surges, with strong onshore winds increasing water levels at the shoreline, and strong offshore winds decreasing them.

It is these irregular forces due to winds and atmospheric pressure acting on a regular tidal pattern, that have the potential to cause coastal storm events. Major storms have the potential to result in the loss of human life and damage to sea defences. Such events also lead to the incursion of saline water onto existing farmland and freshwater or terrestrial habitat located behind seawalls, flood embankments or natural barriers.

3.2 Tidal levels

The UK Hydrographic Office (UKHO) publishes predicted tidal levels annually as Tide Tables for standard ports around the British Isles. For the purposes of the present study, the lowest and highest astronomical tides (LAT and HAT) predicted for each of the standard ports in England (2002) are presented in Table 1. The table also shows statistics on the mean low and high water for both neap (MLWN, MHWN) and spring (MLWS, MHWS) tides and mean sea level (MSL).

Table 3.1 Predicted tidal levels at standard ports around England (UKHO, 2002)

Standard Port	Tidal Levels (in m, Relative to Chart Datum)						
	LAT	MLWS	MLWN	MSL	MHWN	MHWS	HAT
River Tyne	-0.1	0.7	1.8	2.9	3.9	5.0	5.7
River Tees	0.0	0.9	2.0	3.2	4.3	5.5	6.1
Immingham	0.1	0.9	2.6	4.2	5.8	7.3	8.0
Spurn Head	0.2	1.2	2.7	4.1	5.5	6.9	7.7
Lowestoft	0.0	0.5	1.0	1.6	2.1	2.4	2.9
Felixstowe Pier	-0.2	0.4	1.0	2.0	3.1	3.8	4.2
Harwich	-0.2	0.4	1.1	2.1	3.4	4.0	4.4
Walton-on-the-Naze	-0.1	0.4	1.1	2.2	3.4	4.2	4.6
London Bridge	-0.3	0.5	1.3	3.6	5.9	7.1	7.6
Tilbury	-0.3	0.5	1.4	3.3	5.4	6.4	7.0
Sheerness	-0.2	0.6	1.5	3.0	4.7	5.8	6.2
Margate	0.1	0.5	1.4	2.6	3.9	4.8	5.1
Dover	0.2	0.8	2.1	3.7	5.3	6.8	7.3
Shoreham	0.1	0.6	1.9	3.4	4.8	6.3	6.9
Chichester Harbour	0.2	0.9	1.9	2.9	4.0	4.9	5.3
Portsmouth	0.1	0.8	1.9	2.9	3.8	4.7	5.1
Southampton	-0.1	0.5	1.8	2.9	3.7	4.5	5.0
Cowes	0.1	0.8	1.8	2.7	3.5	4.2	4.6
Poole Harbour	0.0	0.6	1.2	1.6	1.7	2.2	2.6
Portland	-0.2	0.1	0.8	1.0	1.4	2.1	2.5
Torquay	0.0	0.7	2.0	2.8	3.7	4.9	5.3
Dartmouth	-0.2	0.6	2.0	2.9	3.8	4.9	5.3
Plymouth	0.0	0.8	2.2	3.3	4.4	5.5	5.9
Falmouth	0.0	0.8	2.1	3.2	43	5.4	5.8
Avonmouth	-0.1	1.0	3.8	7.0	9.8	13.2	14.8
Liverpool	-0.2	0.9	2.9	5.1	7.4	9.3	10.4
Barrow	0.1	1.1	3.0	5.0	7.1	9.3	10.3

The present line of coastal sea defence structures and natural barriers around England are expected to withstand the effects of the HAT and the typical water level ranges of a spring and neap tide.

A more detailed examination of the UKHO Tide Tables reveal that tidal ranges around England's coastline are generally greatest in the Bristol Channel and the southern part of Liverpool Bay. Medium tidal ranges, on the other hand, are more typical along the east coast and many parts of the south coast. The lowest tidal ranges are associated with the southern more central coastal regions of the English Channel (eg Poole Harbour).

3.3 Storm surges

The deviation of the observed tide from the tide that would otherwise occur with no meteorological influence is called a 'surge'. A surge is positive if the water level is higher than the tide caused only by astronomical forces, and negative if lower. In the UK, deviations between astronomical and actual tide levels are defined as 'storm surges' if they exceed 0.6m (UKHO, 2002). Positive storm surges primarily have implications for flooding (eg overtopping of defences), whilst negative storm surges primarily have implications for navigation (eg grounding of vessels). Wind effects and changes in atmospheric pressure can cause surges, and positive surge events can be disastrous, resulting in extensive flooding of low-lying areas, loss of lives and damage to property and other assets, such as habitats (Box A, Source: Met. Office).

Box A: Historic records of surge events
In the Netherlands on 18 November 1421, water from the North Sea breached sea defences and swept through 72 villages killing over 10,000 people. Similar disastrous breaches on the Dutch coast occurred in 1570, 1825, 1894, 1916 and 1953. During the infamous 1953 event, for example, it was estimated that 1,800 people were drowned in the Netherlands. These events prompted the Dutch Government to adoption a 'defend at all costs' policy to protect their country as over 40% of it lies below mean sea level. The 1953 storm surge also devastated the east coast of England, between the Humber and the Thames estuaries. In particular, the worst affected areas were Suffolk, Essex and Kent, including Canvey Island in the Thames where 58 people died. During the storm, wind speeds exceeding 80mph were recorded. The event resulted in the loss of over 300 lives, flooding of 100,000 hectares and caused damage to assets worth over £5 Billion (in present value). In response to this event, a massive programme of maintenance and capital works on flood defences was instigated. In addition, the Storm Tide Forecasting Service was introduction, which is operated by the Met. Office with Defra funding. The service provides the EA and Scottish Environment Protection Agency with regular coastal flooding, surge and wave activity forecasts. Prior to the 1953 event, the last major tidal flooding in the UK occurred in central London on 6 and 7th January 1928, when 14 people drowned. On 12 January 1978, however, another surge event caused flooding and damage between Humberside and Kent, with central London only escaping inundation by 0.5m. The susceptibility of the Thames estuary to major surge events led to the construction of the Thames tidal barrier, which became operational in 1984. Since its opening it has prevented further loss of life due to surge events.

Research has shown that fortuitously many of the large positive storm surges do not coincide with high tide. They also tend to be relatively short ranging from just a few hours to a few days. The process of storm surge generation is described in Box B (Pugh, 1987).

Box B: Generation of a storm surge
A storm surge is generated when a depression moves into a sea area and changes in atmospheric pressure causes the sea surface to fall resulting in a rise in sea level. Conversely, when the depression moves away from the area pressure rises, causing a lowering of sea level. The movement of a depression over a sea area is therefore associated with a rise in sea level followed by a fall. A rule of thumb is that a change of 1 millibar in atmospheric pressure results in a 1cm change in water level. Therefore, unless the depression is fast moving, small and very intense, as is the case with a tropical cyclone, the pressure effects only give a slowly varying contribution to the surge height at any given location. However, in many cases, the dramatic changes in surge levels around the coast of the British Isles may be attributed to the effect produced by wind fields associated with a depression, rather than changes in atmospheric pressure. The wind exerts a tractive force on the surface of the water. As a result, the water is dragged in the direction of the wind and under the influence of the Earth's rotation is deflected to the right in the Northern Hemisphere. When the coastline impedes the motion of an onshore wind the water level at the coast tends to rise. A storm surge, therefore, at any location may be generated by the combined forces of wind stress and atmospheric pressure.

3.3.1 Return periods

Storm surges can be described in terms of their return periods. For example, the United Kingdom Digital Marine Atlas (UKDMAP) presents a contour map of the 1 in 50 year return period for storm surges around the coastline of the UK and northern Europe (Figure 1).

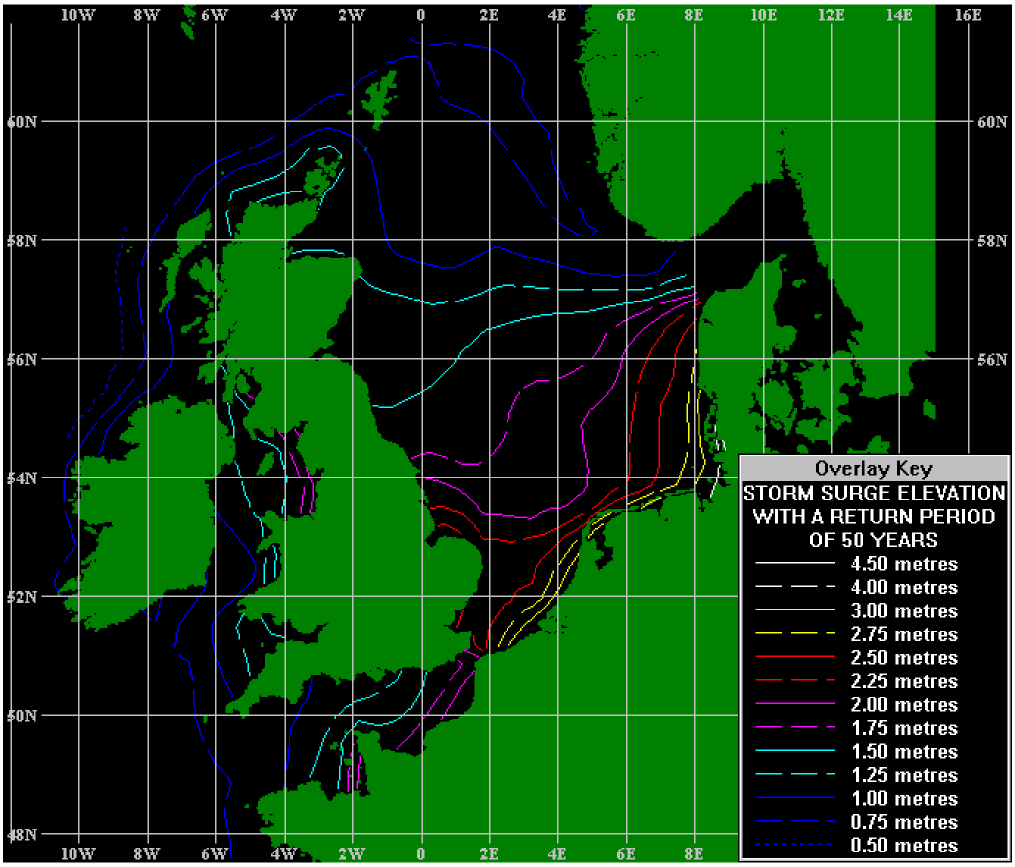


Figure 1. Contour map showing a 1 in 50 year return period for storm surges in the UK and northern Europe

(Source: UKDMAP)

This figure shows that the most susceptible areas of the UK to storm surges are in the east England between the Humber Estuary and the county of Kent. This stretch of coastline is predicted to have a major storm surge in the order of 2.5m above normal tide levels every 1 in 50 years. The implications of such an event will be particularly noticeable on this section of coast as it is generally relatively low-lying in many areas and densely populated. In addition, much of the land is considered highly valued coastal habitats. The northwest of England is also vulnerable to surge events, but the magnitude is slightly less than the east coast, with a 1 in 50 year event typically being estimated at 2m above normal tide levels. In the southwest and northeast of England, surge levels are noticeably lower with a 1 in 50 year event estimated at 1.5m. Large sections of the English coastline, however, are composed of hard rock cliffs and consequently they are not susceptible to flooding following a major surge event.

It is interesting to note that those coastal areas most susceptible to storm surges in England are also amongst the lowest lying, habitat-rich and densely populated areas in the UK.

The susceptibility of the Dutch, German and Danish coasts to storm surges is considerably greater than that in England. Predictions for a 1 in 50 year event, for example, show a possible surge level greater than 3m above normal tide levels.

In a comparison between different storm surge levels, the following levels were recorded during the 1953 storm, a 1 in 50 year return period data:

- Southend 2.74m
- King's Lynn 2.97m
- Netherlands 3.36m

At the POL, Dixon & Tawn (1997) carried out an investigation into the spatial distribution of extreme sea levels around the UK under different return periods. Their work was based on the application of a hydrodynamic model constructed with a regular grid resolution of 36km x 36km over the North-West European Continental Shelf. Using meteorological data the model was able to generate predictions of estimated surge heights and their spatial distribution over different return periods. POL noted, however, that there was relatively poor coverage of observational sites relative to model data sites, making validation of the model output difficult. Nonetheless, POL's work provided a consistent methodology to identifying the magnitude and spatial variation in storm surges around the UK.

Relevant data applicable to England has been extracted from POL's Internal Document No. 112 (Unpublished Manuscript) and presented in Table 2. These data describe the storm surge levels at various locations under different return period events; this is *relative* to the 1 in 1 year return period surge at each location. Unfortunately, the POL document does not contain details of the actual surge level value of the 1 in 1 year event to enable *absolute* values to be described for these less frequent events. The only information provide about the nature of the 1 in 1 year event is the combined probability of water levels and surge levels (Table 3).

Consequently, in order to 'crudely calibrate' the storm surge information in Table 2, the 1 in 50 year relative surge values can be compared with the absolute values presented as contours in Figure 1. Using this approach the order of magnitude of a 1 in 1 year surge event enabled values of less frequent return period to be approximated. For example, from Figure 1, it can be identified that a 1 in 50 year surge event at Beachy Head is of the order of 1.5m. Table 2 identifies that a 1 in 50 year event at the same location is 0.58m greater than a 1 in 1 year surge event. Consequently, the relative difference in magnitude between a 1 in 1 and a 1 in 50 year surge event is in the order of 0.92m. Based on this approach, a 1 in 500 year surge event at Beachy Head the surge would be 1.94m. Although this method of assessment is not completely accurate, it does satisfy the broadscale assessment that is required for the present national level study.

Table 3.2 Storm surges under different return periods around England

(Source: POL Internal Document No. 112, Unpublished Manuscript)

Indicative Location	Surge Level (m, relative to a 1 in 1 year surge)							
	10	25	50	100	250	500	1,000	10,000
Berwick	0.30	0.44	0.52	0.65	0.76	0.83	0.91	1.14
Lindisfarne	0.31	0.47	0.55	0.69	0.82	0.90	1.00	1.29
Seahouses	0.32	0.47	0.56	0.70	0.83	0.90	1.01	1.31
Tynemouth	0.33	0.48	0.57	0.71	0.85	0.92	1.03	1.35
Sunderland	0.36	0.52	0.61	0.76	0.91	0.99	1.10	1.45
Hartlepool	0.32	0.47	0.55	0.69	0.83	0.91	1.01	1.34
Whitby	0.36	0.52	0.61	0.76	0.91	1.00	1.11	1.46
Flamborough	0.38	0.54	0.63	0.79	0.93	1.02	1.14	1.50
Withernsea	0.39	0.56	0.65	0.81	0.97	1.06	1.18	1.56
Spurn	0.37	0.53	0.62	0.77	0.92	1.01	1.12	1.49
Skegness	0.46	0.65	0.75	0.92	1.10	1.20	1.33	1.75
Wash	0.51	0.71	0.83	1.02	1.21	1.32	1.47	1.94
Blakeney	0.52	0.73	0.85	1.05	1.25	1.37	1.52	2.02
Sheringham	0.55	0.78	0.91	1.14	1.35	1.48	1.66	2.21
Winterton	0.53	0.74	0.87	1.08	1.28	1.41	1.57	2.08
Yarmouth	0.53	0.74	0.87	1.09	1.3	1.43	1.59	2.14
Orfordness	0.50	0.71	0.84	1.04	1.24	1.36	1.53	2.04
Clacton	0.51	0.72	0.85	1.05	1.26	1.39	1.56	2.10
Canvey Island	0.47	0.66	0.77	0.95	1.14	1.26	1.41	1.91
Margate	0.57	0.81	0.95	1.19	1.43	1.58	1.77	2.42
Dover	0.47	0.67	0.78	0.97	1.17	1.29	1.45	1.98
Rye	0.36	0.52	0.61	0.76	0.92	1.02	1.15	1.62
Beachy Head	0.33	0.48	0.58	0.74	0.91	1.02	1.17	1.70
Brighton	0.32	0.50	0.62	0.82	1.04	1.18	1.37	2.08
Selsey Bill	0.31	0.50	0.62	0.84	1.06	1.21	1.41	2.17
Isle of Wight	0.28	0.46	0.57	0.76	0.98	1.11	1.31	2.05
Swanage	0.30	0.47	0.58	0.77	0.98	1.12	1.31	2.05
Portland Bill	0.36	0.55	0.67	0.88	1.11	1.26	1.48	2.30
Chesil	0.39	0.58	0.70	0.91	1.15	1.30	1.51	2.33
Slapton	0.40	0.58	0.70	0.90	1.12	1.26	1.46	2.21
Torcross	0.31	0.45	0.53	0.68	0.84	0.94	1.09	1.63
Rame	0.30	0.43	0.50	0.63	0.77	0.86	0.99	1.45
Falmouth	0.31	0.45	0.53	0.66	0.81	0.9	1.02	1.47
Lizard	0.22	0.34	0.4	0.52	0.63	0.71	0.81	1.16
Porthleven	0.20	0.30	0.36	0.47	0.57	0.63	0.71	0.96
Land's End	0.19	0.28	0.34	0.44	0.55	0.61	0.69	0.96
Newquay	0.21	0.32	0.38	0.49	0.6	0.66	0.74	1.00
Bude	0.22	0.34	0.41	0.54	0.66	0.73	0.83	1.13
Ilfracombe	0.32	0.52	0.63	0.81	0.99	1.10	1.24	1.67
Wirral	0.52	0.74	0.87	1.09	1.31	1.45	1.63	2.24
Blackpool	0.55	0.77	0.91	1.13	1.36	1.50	1.69	2.33
Barrow	0.54	0.76	0.90	1.12	1.35	1.49	1.68	2.33
Whitehaven	0.45	0.63	0.73	0.91	1.09	1.20	1.36	1.88

Table 3.3. Joint probability of tide and surge levels combining

(Source: POL Internal Document No. 112, Unpublished Manuscript)

Indicative Location	1 in 1 Year Joint Probability Return Period (m ODN)	Indicative Location	1 in 1 Year Joint Probability Return Period (m ODN)
Berwick	2.92	Beachy Head	3.74
Lindisfarne	2.67	Brighton	3.07
Seahouses	2.81	Selsey Bill	2.57
Tynemouth	2.92	Isle of Wight	2.09
Sunderland	3.08	Swanage	1.59
Hartlepool	3.01	Portland Bill	1.71
Whitby	3.10	Chesil	2.07
Flamborough	3.39	Slapton	2.35
Withernsea	3.73	Torcross	2.67
Spurn	4.24	Rame	2.76
Skegness	4.89	Falmouth	2.74
Wash	4.40	Lizard	2.90
Blakeney	3.81	Porthleven	3.33
Sheringham	2.93	Land's End	3.12
Winterton	3.12	Newquay	3.96
Yarmouth	2.18	Bude	4.46
Orfordness	2.33	Ilfracombe	5.14
Clacton	2.86	Wirral	5.16
Canvey Island	3.68	Blackpool	5.40
Margate	2.99	Barrow	5.48
Dover	3.92	Whitehaven	5.02
Rye	4.60		

Extreme sea levels were also investigated by POL (Internal Document No. 112) using a combination of astronomical tide and surge data at a number of different geographical locations around the UK coast (Table 4). Based on the actual measured data, as opposed to the modelled results (eg Table 2), sea level information indicated that the Bristol Channel area (eg Illfracombe, Avonmouth, Newport) is exposed to the greatest potential extreme water level. The primary reason for this, however, is the large tidal range already in existence rather than massive surge effects.

The EA utilised information on water levels and surges to provide a general overview of areas of land that are located in floodplains and therefore potentially at risk of flooding in England. The resulting Indicative Floodplain Maps do not distinguish between differing levels of risk, but do present the area of the natural floodplain that would become inundated. A national version of the Indicative Floodplain Map, depicting both coastal/tidal flooding and river flooding is presented in Figure 2. For coastal and tidal flooding, the area of floodplain has been determined using either a 1 in 200 year return period event or the highest ever recorded flooding event (whichever is greater).

Table 3.4. Extreme sea levels under various return periods, based on site data

(Source: POL Internal Document No. 112, Unpublished Manuscript)

Location	Extreme Sea Levels (in m, relative to Chart Datum)			
	1 in 10 year	1 in 100 year	1 in 1,000 year	1 in 10,000 year
North Shields	5.81	6.15	6.44	6.69
Whitby	6.39	6.76	7.12	7.44
Immingham	8.22	8.68	9.37	10.33
Cromer	6.24	6.71	7.10	7.42
Lowestoft	3.92	4.38	4.85	5.28
Felixstowe	5.05	5.66	6.46	7.47
Harwich	5.20	5.80	6.60	7.58
Walton-on-the-Naze	5.39	5.99	6.78	7.75
Southend	6.80	7.25	7.73	8.22
Sheerness	6.90	7.35	7.83	8.31
Dover	7.74	8.21	8.80	9.47
Newhaven	7.59	7.94	8.33	8.76
Portsmouth	5.40	5.89	6.63	7.67
Newlyn	5.91	6.17	6.37	6.51
Ilfracombe	10.32	10.79	11.51	12.55
Avonmouth	14.51	14.87	15.21	15.55
Heysham	11.14	11.73	12.53	13.54

Due to the large-scale of the map presented in Figure 2, information contained in Defra's Futurecoast study CD was used to locate designated areas at risk from coastal/tidal flooding.

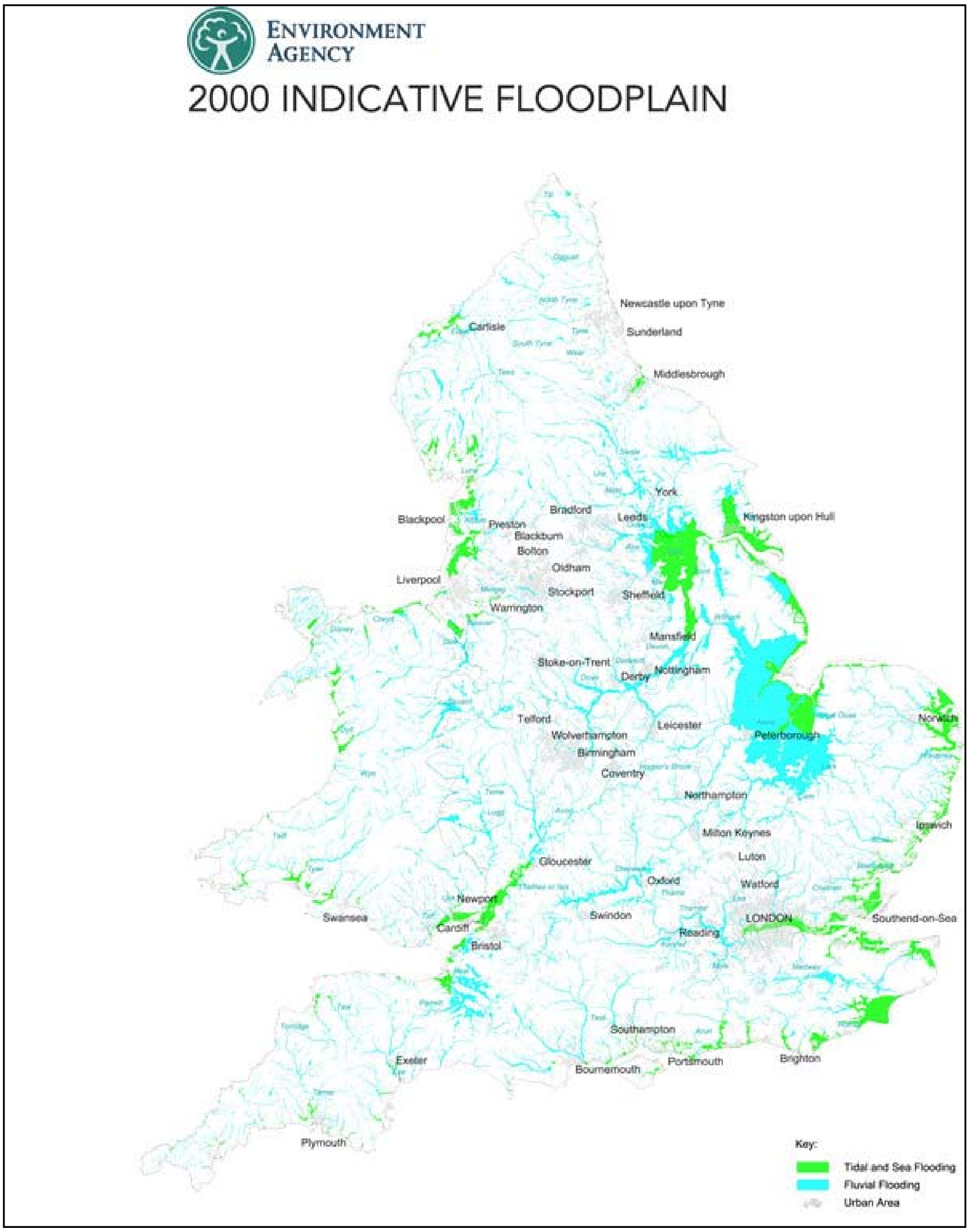


Figure 2. Environment Agency indicative floodplain map

3.4 Wind and waves

3.4.1 Wind climate variation around the English coastline

In addition to the role that winds play in influencing surge levels (see Section 3.3), they also create energy that is transferred into wave action. The potential for wave generation is a function of the fetch distance across which the wind blows. This includes wind speed and duration, and the original state of the sea, which acts as a surface roughness. The longer the fetch distance, the greater the potential for wind to interact with the water surface and generate waves.

Severe wave action can cause considerable erosion to inter-tidal and backshore landforms, and can damage structural sea defences. In an extreme scenario, such events could also cause breaching of protective structural and natural defences (eg shingle barriers, dune ridges), allowing tidal waters to flood onto low-lying hinterland in the lee of these defences.

The UKDMAP data shows the spatial variation in wind speeds with a return period of 1 in 50 year around the UK and northern mainland Europe (Figure 3). This figure indicates that the west coast is the most exposed area of England, with wind speeds of 36m/s experienced under severe wave events. In the southwest, these high wind speeds also combine with an extremely large fetch that extends across the Atlantic. The east coast of England is also exposed to relatively high wind speeds travelling across a moderately long fetch, whereas by contrast the south coast is subject to slightly lower wind speeds and, east of Portland Bill, relatively short fetch.

3.4.2 Wave climate variation around the English coastline

Variations in wave height occur around the English coastline largely because of the following factors:

- Variations in exposure to wind.
- Changes in wave exposure and sheltering.
- The available fetch distances for waves to develop.
- Water depth.

As a result of these factors, the west coast of England generally experiences larger wave heights than the east coast. The south coast experiences a wide range of different wave heights, owing to the decreasing exposure from west to east, although the south western section of the south coast experiences larger wave heights than the southeastern section.

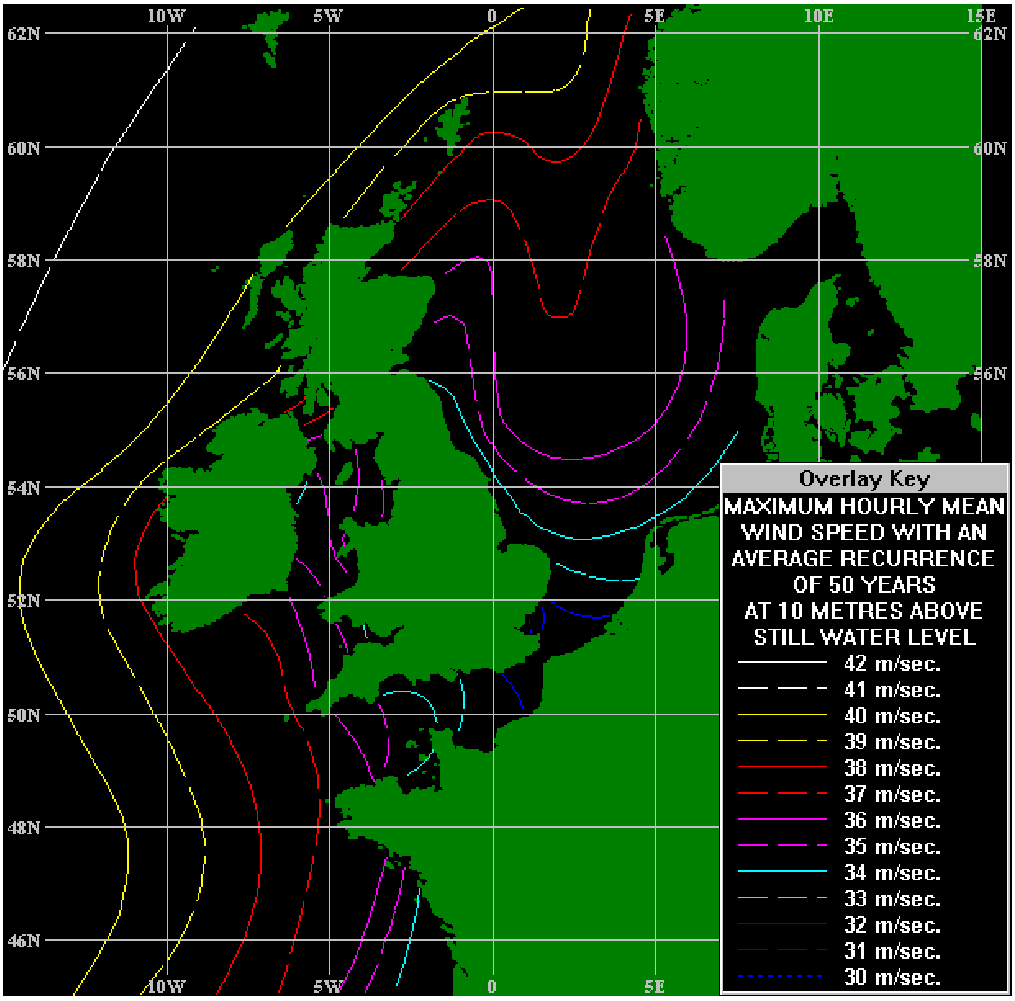


Figure 3. Contour map showing a 1 in 50 year return period for wind speeds

(Source: UKDMAP)

A review of relevant literature has shown that different methods have been used to estimate wave heights for different return periods around the English coastline (Table 5). Differences in the methods used are described in Box C. The variation in predicted wave heights for different return periods shows the degree of uncertainty in wave assessment methods at a large scale. Based on the evidence extracted from these data sources (UKDMAP, 1998; JERICHO, 1999; Department of Energy, 1990; MAFF, 1981 and HR Wallingford, 1997), sections of the English coastline have been assigned a wave ranking to reflect the relative magnitude of wave heights experienced and expected within each section. The three wave rankings of Low, Medium and High are colour-coded yellow, orange and red respectively. This is a generalised approach, which simply intends to distinguish the more severe wave climate sections from the less severe. It is therefore for general guidance only.

Table 3.5. Significant wave height (Hs) variation for different return periods for English coastal regions

Symbols in superscript A, B, C, D and E are explained in Box C.

Region	(1) North East	(2) East	(3) South	(4) South West	(5) North West
H_s range annual 10% exceedence (m)[A]	1.5-2.0	0-1.5	0-3	0-3	01-Feb
1 in 1 year H_s (m)[B]	4.46-5.03	4.10-6.14	4.58-11.88	6.77-11.88	5.03-6.70
1 in 10 year H_s (m)[B]	5.50-6.25	5.05-7.66	5.66-14.73	8.43-14.73	6.25-8.33
1 in 50 year H_s (m)[B]	6.23-7.10	5.72-8.71	6.41-16.72	9.58-16.72	7.10-9.48
1 in 100 year H_s (m)[B]	6.55-7.47	6.00-9.17	6.74-17.57	10.08-17.57	7.47-9.97
1 in 50 year H_s (m)[C]	08-Oct	08-Oct	Aug-14	<8-14	<8
1 in 50 year H_s (m)[D]	20-25	Oct-25	Oct-25	<18-25	14-18
Swell: H_s exceeded 24h per year[E]	02-Mar	1-2.5	01-Apr	<3-4	01-Feb
Swell: H_s exceeded 1 in 1 year[E]	2.5-3.5	1.5-3.0	1.5-5	<3.5-5	2-2.5
Swell: H_s exceeded 1 in 100 year[E]	3.5-5	02-Apr	02-Jul	<5-7	3-4.5
H_s denotes significant wave height. This is a standard wave parameter, equivalent to the average height of the highest one third of the waves.					

Sources: [A]UKDMAP, 1998; [B]JERICHO, 1999; [c]Dept. of Energy, 1990; [D]MAFF, 1981; [E]HR Wallingford, 1997

The sections of the English coast are ranked as below:

HIGH: South West England (Porlock Bay to Portland Bill, except Start Point to Lyme Regis)

MODERATE: South Coast (Portland Bill to North Foreland)
East Coast (Lowestoft to North of Berwick-upon-Tweed)
West Coast (River Dee to Solway Firth)
West Coast (Porlock Bay to Weston-Super-Mare)

LOW: West Coast (Weston-Super-Mare to Gloucester)
South Coast (Start Point to Lyme Regis)
East Coast (North Foreland to Lowestoft)

For the purpose of this study, it was necessary to categorise the UK coastline into 5 different regions to evaluate the degree of exposure from a major storm event. The categorisation was based on a broadscale understanding of coastal processes and geomorphology of each region. This provided an effective approach to quantify the magnitude and exposure of a major storm event eg wave, surge, wind and tsunami (Figure 4).

Box C: Different methods used to quantify wave height
[A]UKDMAP (1998) Results were based on three decades of instrumental wave recording to produce contour maps. In areas of complex topography, such as the southern North Sea, large variations in the wave climate occur over small distances due to the shape of the seabed and local currents. Therefore, the values presented should only be regarded as average values. [B]JERICHO (1999) Analysis was undertaken using satellite altimeter data between the period 1992 and 1998 to create a grid size of 1° latitude by 2° longitude around the British Isles. Monthly values have been combined into annual and multi-annual values. These estimates have been derived for the offshore wave climate, which is defined as being more than 30km from the coast. Only the values for the closest available grid square to the coast are presented in Table 5. It should be noted that in some grid squares wave climate is highly variable (cf. UKDMAP, 1998). [C]Dept. of Energy (1990) Values based on long time series of measurements at sites around the British Isles and is used to inform the planning of offshore installations. However, the wave height contour maps produced are based on relatively few site measurements resulting in the information between sites dependent on large areas of interpolation. [D]Defra, formally MAFF (1981) The contour maps are produced from both modelled and measured wave data, and was designed to inform offshore installations, in the same way as Department of Energy (1990). The modelled data is determined by a wave forecasting method, which uses the Meteorological Office estimates of 50 year extreme wind events. This method assumes that the storm responsible for the waves will last in its 'fully-developed' state for 12 hours. Therefore, the values should be regarded as best available estimates from the worst storm in any 50 year interval which might be encountered by ships or offshore structures. In shallow water near the coast, the extreme wave heights will be reduced. [E] HR Wallingford (1997) In this publication, the wave height estimates are presented to illustrate the relative influence of the swell component to wave heights at the coast. This component is dependent on both swell and locally generated wind-sea conditions. Swell is defined as 'long period wave conditions produced by decaying storm waves'. The results are sourced from a large area ocean wave model (Met Office European Wave Forecasting Model).

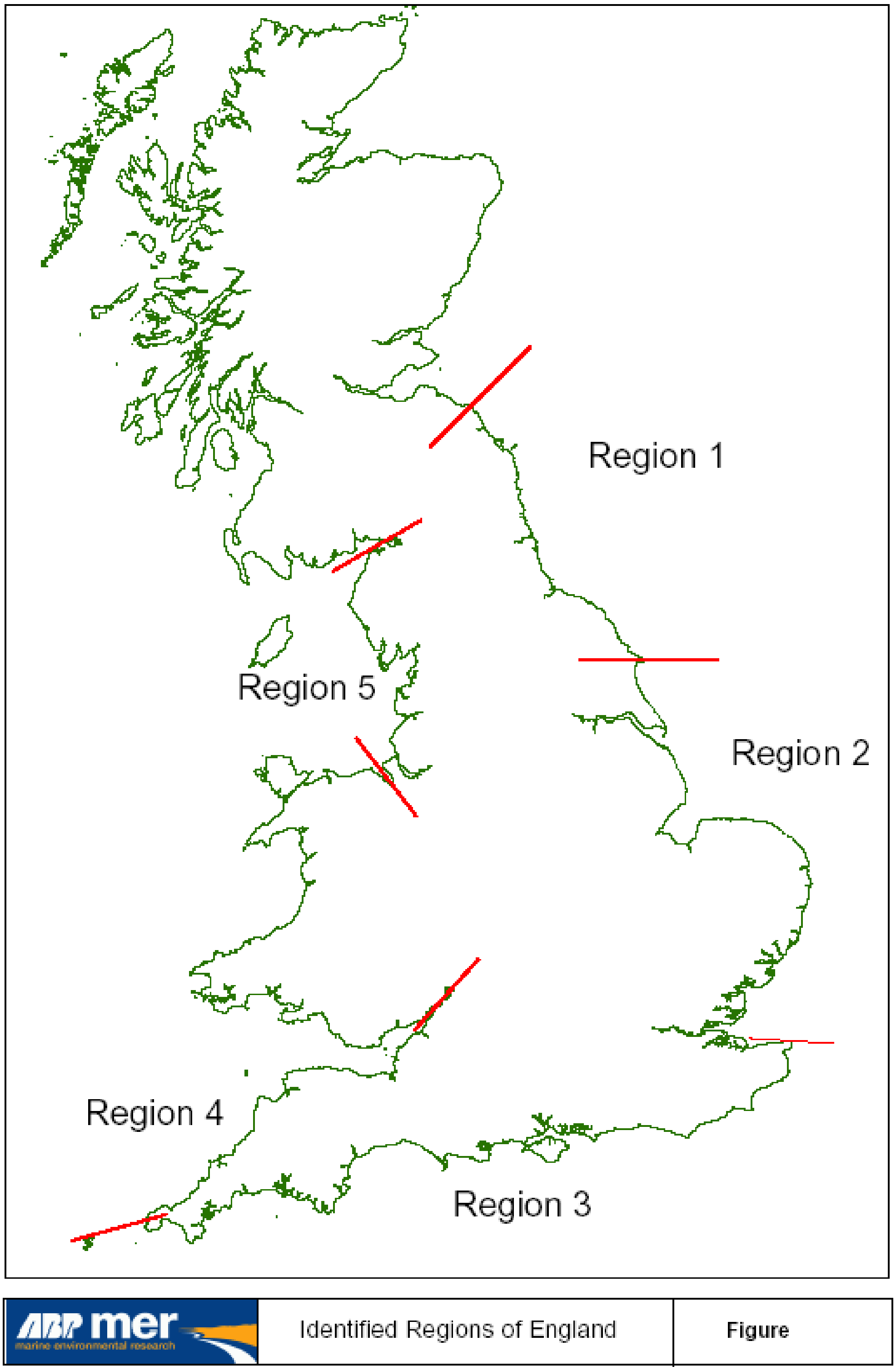


Figure 4. Regions of England for risk assessment of physical events

A contour map showing significant wave heights that are exceeded for 10% of the year are presented in Figure 5. This figure illustrates how the wind energy influences wave height around the UK. Due to the lower wind speeds and limited exposure (relatively short fetch from most sectors), the southeast coast experiences lower wave action than the rest of the English coast.

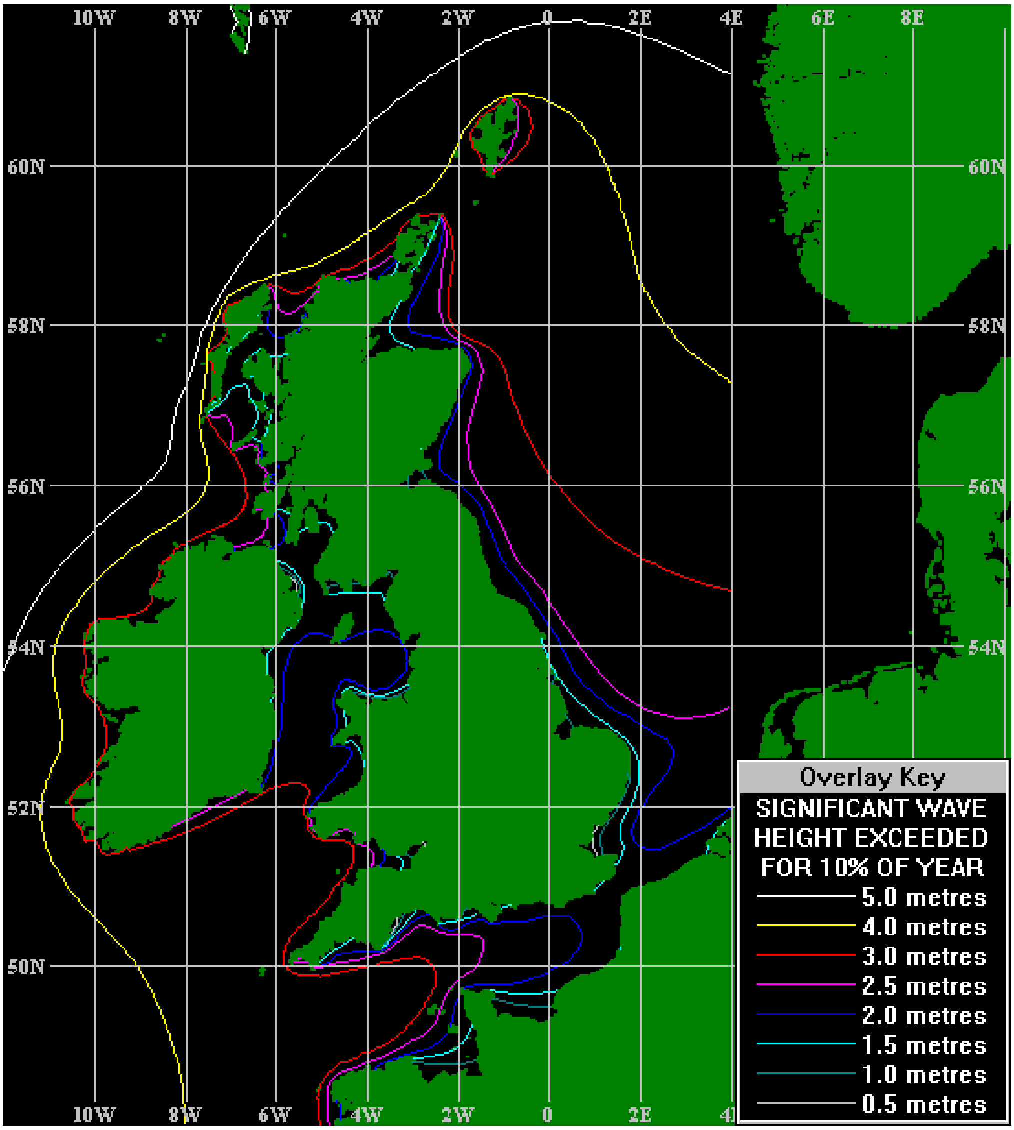


Figure 5, Significant wave height exceeded for 10% of the year

(Source: UKDMAP)

It is possible to quote further wave statistics with different return periods derived from probabilistic techniques (eg Weibull extremes analysis). However, a general 'rule of thumb' is that wave return periods can only reliably be predicted for return events that are three times the length of data record available. If 1 year's worth of data are available, for example, then a 1 in 3 year return period event could be predicted. The lack of a long term and consistent wave monitoring record for the English coastline makes it dubious to rely on predictions much beyond a 1 in 10 year event. Areas most at risk from wave action, however, can be identified based on the spatial patterns of wave height distributions around the coast, as shown in Figure 5.

3.5 Other influences

In addition to the influence of tides, surges, winds and waves, designated conservation areas may be vulnerable to other influences during storm conditions.

3.5.1 Tsunami

Tsunami (from the Japanese 'tsu', meaning harbour, and 'nami', meaning wave) is often referred to as 'tidal waves', but they have nothing whatsoever to do with tidal action. Instead, tsunami originates from massive energy inputs to the ocean caused by either sub-marine earthquakes, volcanic eruptions of seamounts or giant mudslides (shoreline or sub-marine). Of all these potential triggering events, only shoreline mudslides are likely to be storm related.

The enormous power of tsunami is harnessed in the wave, which is propelled at great speed towards the shore. When it enters shallow water, the waves created rapidly build in height and the resulting impact can be devastating (Table 6).

Table 3.6. Examples of tsunami events and their impact on human life from around the world

Date	Location	Cause	No. of Deaths	Comments
1883	Indonesia	Eruption of Krakatoa	36,000	Travelled half way around the world
1960	Chile	Earthquake	Unknown	Travelled across Pacific Ocean, reaching Japan in under 21 hours
1998	Papua New Guinea	Earthquake	3,000	Waves 10m high

Most tsunami events originate in the Pacific Ocean due to the volcanic activity around its rim. By contrast, the likelihood of occurrence of tsunami event in UK coastal waters is exceptionally low. However, since 1980, small earthquakes have been more frequency recorded in coastal waters, particularly in the southern North Sea (Figure 6). The threat of a tsunami may be one that is created further a field than UK waters. A sufficiently large earthquake could trigger slumping and sliding off the Norwegian coast, for example, which could lead to the creation of tsunami. Such an event is believed to have occurred 7,000 years ago where tsunami-generated water levels in Norway were believed to be higher than 20m, whereas in Scotland the flood levels associated with the event reached between 4 and 6m (Holt and others 2001).

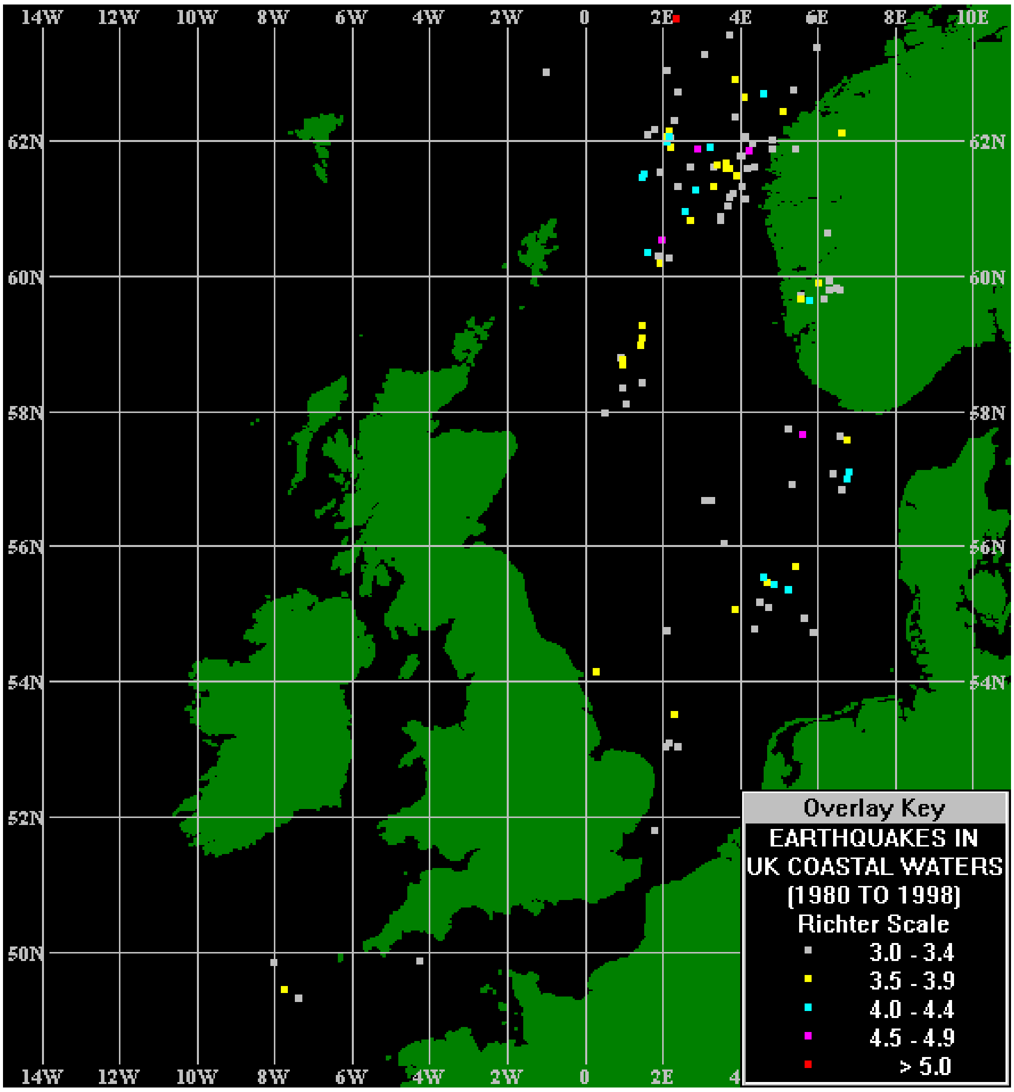


Figure 6. Earthquakes recorded in UK coastal waters between 1980 and 1998 in relation to other earthquakes in the North Sea

(Source: UKDMAP)

3.5.2 Rainfall

Rainfall can have a profound effect on the structural stability of many coastal landforms, in particular cliffs. Soft cliffs, for example, are not only susceptible to erosion at their toe during storm events, but are equally susceptible to erosion by rainfall. In clay cliffs, rainfall intensity also has the potential to trigger landslide, as water moves along slip-planes within the cliff structure, weakening its integrity. As pressure builds in these faults rotational failure and mass movement of large sections of the cliff face occur. This also has the potential to cause the complete loss of a cliff-face and its cliff-top vegetation.

3.5.3 Climate change

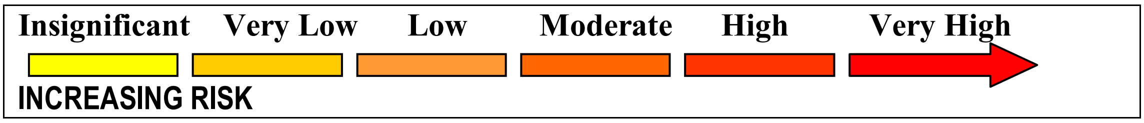
Climate change has the potential to cause direct increases in sea level, changes in tidal wavelength and propagation, and changes in the magnitude and frequency of storms. For England as a whole, sea level rise is the main physical impact of climate change that will have a gradual impact at the shoreline.

Scientists forecast that over the next few decades a significant increase in the frequency of precipitation in the UK will lead to more flooding events on the scale of recent years.

Climate change-induced events can have different affects on coastal landforms and these will be addressed in Section 4.

3.5.4 Assessing regional risk

The present study has graded the magnitude of risk from storm events and tsunamis based on a review of their nature and frequency in UK coastal waters. This qualitative scale was derived, in part, through expert knowledge and judgement. The scale is intended to standardise the element of risk across the key aspects of a storm event (ie surge, wave and wind) and a tsunami.



There is considerable variability in the likelihood of storm and tsunami events occurring along different regions of England (Table 7). The risk of surge, for example, is low on the south coast (Region 3) and in the southwest region (4), but very high on the east coast (2). Conversely, wave risk is high for the south coast (particularly the western section) and southwest region owing to longer fetch lengths and wind strengths, whilst the risk to the east coast is only low to moderate. The northwest region (5) is moderately susceptible to surge, wave and wind.

Table 3.7. An assessment of the risk from different types of storm event and a tsunami to five coastal regions of England

(see Figure 4 for regional map)

Region	Boundaries	Risk			
		Surge	Wave	Wind	Tsunami
(1) North East	North of Berwick-upon-Tweed to Flamborough Head	Moderate	Moderate	Moderate	Very low
(2) East	Flamborough Head to North Foreland	Very High	Low to Moderate	Low to Moderate	Very low
(3) South	North Foreland to Lands End	Low	Low to High	Low to High	Insignificant
(4) South West	Lands End to Gloucester	Low	Moderate to High	Moderate to High	Insignificant
(5) North West	River Dee to Solway Firth	High	Moderate	Moderate to High	Insignificant

3.6 Summary

The cumulative risk from the suite of physical events places the northwest coast and the east coast as being most at risk in England. Both these regions are susceptible to surges (northwest coast, 1969; east coast, 1953), with the east coast being at greater risk due to the tracks of Atlantic depressions (storms) and the lower-lying land. However, the northwest coast has a higher risk of wave and wind activity due to the predominant wind direction over the British Isles being from the west/southwest. Therefore, since the principal focus of this study relates to extreme conditions, it is the east coast that is most likely to experience a major coastal storm or marine incursion.

It is very unlikely that a tsunami will occur in the foreseeable future that will cause physical damage to the English coast. Historically, these events have occurred in times of major geological change such as the last Ice Age or in areas of volcanic activity, eg Pacific Ocean.

It should be stressed that this is a regional assessment of sources of risk, ie meteorological and oceanographic conditions. The risk to habitats, species and geological features is dependent on their extent and sensitivity to the driving forces, and these are considered in the next two sections of the report.

4 Generic changes to designated conservation areas

Objective 2
Account for the generic changes affecting designated conservation areas following such an event.

To examine the generic changes likely to affect designated conservation areas following a major storm event, the task was divided into the following components:

- The identification of those habitat types for which conservation areas had been designated eg reefs, *Spartina* swards, humid dune slacks, blanket bogs and calcareous fens, and their characterisation into more generic forms or 'habitat types' in order to quantify change in the event of a major storm.

- The identification and generic description of the coastal landforms, which sustain these 'habitat types', and their 'sensitivity' to major storm events.

Using these generic descriptions, it was possible to identify which type of landforms and designated conservation areas and their habitats would be most vulnerable to the range and type of storm events described in Section 3.

4.1 Internationally and nationally designated nature conservation areas

There are a number of sites designated in England because of national and international legislation. Those that are covered in the context of the present study include Special Protection Areas (SPA), Ramsar sites, candidate Special Areas of Conservation (cSAC) and Sites of Special Scientific Interest (SSSI).

4.1.1 Special Protection Areas (SPA)

The EC Birds Directive (79/409/EEC) requires all member states to identify and protect areas recognised for their rare or vulnerable species as listed in Annex 1 (Article 4.1). This recognition also extends to regularly occurring migratory species (Article 4.2) and the protection of wetlands, especially those considered of international importance.

4.1.2 Ramsar Sites

Under the 1972 Ramsar Convention on Wetlands of International Importance, it is a requirement of signatory states to protect wetland sites of international importance, including those that are important waterfowl habitats.

4.1.3 Special Area of Conservation (SAC)

The EC Habitats Directive (92/43/EEC) requires the establishment of a network of important high quality conservation sites that will make a significant contribution to conserving the 169 habitat types and 623 species identified in Annexes I and II of the Directive. The listed habitat types and species are those considered most in need of conservation at a European level. The ultimate aim of the Directive is the conservation of biodiversity.

4.1.4 Sites of Special Scientific Interest (SSSI)

SSSIs represent the country's best sites for wildlife and geology. In the UK over half of its sites, by area, are internationally important and play an important part in local culture, wildlife, landscape and economic interests. Notification of a site as an SSSI is primarily a legal mechanism, designed to protect areas of importance because of either their biological or geological features, or both.

4.2 Generic habitat types

The distribution and nature of designated conservation areas for England's coastal region was assessed using the most recent data from the Joint Nature Conservation Committee (JNCC) and English Nature. Different types of designations cover a range of natural assets including habitats, species and geological features. For more information on the habitats and species that make up these designations, see Appendix 2, and for geological features, see Section 4.3.

For the purposes of this report, however, the 'assets' of these designated conservation areas were grouped into categories that were more generic. This categorisation was primarily based on expert understanding of the landforms, geology and the habitats/species they sustain. In some cases generic habitat types were either dependent on the landform or were landforms themselves. The following 17 generic habitat types were identified:

- Estuaries
- Coastal lagoons
- Inlets and bays
- Cliffs (cliff face and/or top)
- Caves (submerged and/or partially)
- Freshwater
- Heath and scrub
- Grassland
- Raised bogs, mires and fens
- Forests
- Beach (Barrier and spits/shingle/sandy)
- Saltmarsh
- Mud and sand flats
- Sand dunes
- Reefs
- Limestone pavements
- Sandbanks

The identification and use of species information associated with the designated conservation areas were too numerous to be considered realistic or practical for assessment within the present study. Their importance is noted, however, because they are closely associated with the habitats and/or landforms they occupy. Further consideration of the implications of a major storm event on these species could be inferred from this association (see Appendix 2). A complete list of designated species can be found on the JNCC website (www.jncc.gov.uk).

4.3 Geology

There are approximately 1400 SSSIs that include geological features as part of their designation. English Nature distinguishes geological SSSIs as being exposure or integrity sites. The key difference is that an *exposure* site exhibits geological features that are relatively extensive underground, whereas *integrity* sites display features that are finite and irreplaceable if destroyed (English Nature, 2003).

Candidate geological SSSIs have been identified through the Geological Conservation Review (GCR), which was a systematic process of site selection undertaken throughout Great Britain between 1977 and 1990 (Ellis and others 1996). A specific description of each type of geological feature would be a considerable task. Instead, brief details of the site selection process are presented to outline the different themes of geology that may categorise a site.

The overall structure of site selection for the GCR is based on subject 'blocks' that cover the different themes of earth science. Each of the blocks has characteristic features that are sought when choosing a representative site. Within individual blocks, groups of sites fall into natural groupings related to the geological features or scenarios. These groups are referred to as networks and there can be one or more network in any block (JNCC, 2003).

Many of the GCR blocks correspond to standard divisions of geological time or to major events within those periods. The blocks can be grouped and categorised as follows:

Table 4.1. The total number of GCR blocks classified in Great Britain

Subject of GCR Block	No. of Blocks
Stratigraphy	35
Palaeontology	16
Quaternary geology	16
Geomorphology	10
Igneous petrology	6
Structural and metamorphic geology	10
Mineralogy	7

It is difficult to generically describe the geological features present in each of the regions in a similar fashion to habitats because of their diverse nature. Therefore, to assess their sensitivity and risk of physical damage from meteorological and oceanographic events, a simple approach of whether the geology is 'hard' or 'soft' has been utilised. These simple descriptions feature in the regional tables presented in Section 5.2.

The geological features present in each region have been described as being 'hard' or 'soft', as described by the JNCC in their Coastal Directory Series of the United Kingdom (JNCC, 2001 CD). The definitions of 'hard' and 'soft' rock are as follows:

- **Hard** - consolidated geology developed from resistant bedrock.
- **Soft** - unconsolidated geology developed in easily-eroded materials, such as Tertiary and Quaternary - Pleistocene and Holocene - deposits.

To qualify this crude categorising of rock hardness, details are presented of the main rock types in each region (www.coastalguide.org, 2003) that correspond to the geology of different periods in time with an indication of their hardness (Table 9). It is reiterated that this approach is generalised and within different geological periods, some rock types are harder than others.

Table 4.2. Regional Geology of England and relative rock hardness

Region	Geological Period	Rock Type	Hard/Soft
1	Lower Palaeozoic and Proterozoic (meta)	Schists, gneisses	Hard
	Permian (sed)	Magnesian limestones, marls and sandstones	Hard
	Triassiac (sed)	Marls, sandstones, conglomerates	Hard
	Jurassic (sed)	Limestones, clays	Hard and soft
	Cretaceous (sed)	Chalk, clays, sands	Soft
2	Cretaceous (sed)	Chalk, clays, sands	Soft
	Tertiary and marine Pleistocene (sed)	Clays, sands	Soft
3	Cretaceous (sed)	Chalk, clays, sands	Soft
	Tertiary and marine Pleistocene (sed)	Clays, sands	Soft
	Jurassic (sed)	Limestones, clays	Hard and soft
	Triassiac (sed)	Marls, sandstones, conglomerates	Hard
	Permian (sed)	Magnesian limestones, marls and sandstones	Hard
	Devonian (sed)	Sandstones, shales, conglomerates (Old Red Sandstone), slates, limestones	Hard
	Intrusive (ign)	Granite, granodiorite, gabbro, dolerite	Hard
4	Devonian (sed)	Sandstones, shales, conglomerates (Old Red Sandstone), slates, limestones	Hard
	Intrusive (ign)	Granite, granodiorite, gabbro, dolerite	Hard
	Lower Palaeozoic and Proterozoic (meta)	Schists, gneisses	Hard
	Jurassic (sed)	Limestones, clays	Hard and soft
	Triassiac (sed)	Marls, sandstones, conglomerates	Hard
5	Triassiac (sed)	Marls, sandstones, conglomerates	Hard
	Lower Palaeozoic and Proterozoic (meta)	Schists, gneisses	Hard
Note: (sed) = sedimentary rocks, (meta) = metamorphic rocks, (ign) = igneous rocks			

4.4 Generic sensitivity of landforms

Using the key coastal landform categories outlined in Section 4.3, expert judgement and information from the scientific literature was applied to identify the generic sensitivity of each category to storm surge, wind stress, wave action and other events such as rainfall, tsunamis, and sea level rise. Landform sensitivity was considered a more appropriate method to quantify the potential changes to designated conservation areas following a storm event than addressing impact on a site-by-site basis. If landforms support habitats that are themselves closely associated with designated conservation areas (eg SPA, SAC, SSSI), then assessing the vulnerability of these areas could be based largely on its association with a particular landform. For example, a vegetated cliff (habitat type), which is associated with the landform sea cliff, will be sensitive to the same impacts caused from surges, winds and waves.

Impacts to landform features provide a better method for assessing change at a broad national level because their spatial extent is at the region scale used to quantify storm events around the UK coast (see Section 3). Table 10 presents a summary of the key coastal landforms and their generic sensitivity to surges, winds, waves and other factors.

Table 4.3. Generic sensitivity of different landforms and habitat types

Landform Components		Sensitivity			
		Storm Surge	Wind Stress	Wave Action	Other Factors
Landform complexes (eg estuaries, coastal lagoons, inlets and bays)		Prolonged period of higher water levels, enabling wave action on complex over a longer duration or greater spatial extent. Overtopping or breaching of estuary/inlet banks possible	Negligible	Increased erosion of outer estuary/inlet mouth Breaching of estuary/inlet banks possible.	Extreme rainfall will affect river discharge characteristics and may alter freshwater/saline mixing zones, suspended sediment concentrations, and create plumes of sediment extending from the estuary/inlet mouth to the open coast.
Sea cliff	Hard geology	Increased exposure of cliff toe to marine forcing. This could lead to the creation of undercutting of the cliff face, or the removal of talus debris prompting instability.	Mechanical weathering and increased sea spray leading to chemical weathering.	Increased exposure of cliff toe to marine forcing. This could lead to the creation of undercutting of the cliff face, or the removal of talus debris prompting instability.	
	Soft geology			Development of caves, arches and stacks.	Clay cliffs are susceptible to increased porewater pressure associated with high rainfall intensity. This can trigger landsliding events.
Lowland		Permanent or temporary inundation if fronting barriers or defences are overtopped or breached.	Negligible	Permanent or temporary inundation if fronting barriers or defences are overtopped or breached.	Flooding due to high rainfall raising the water table and/or insufficient surface drainage.
Beach	Sandy beach	Sediment loss, cross-shore.	Sand beach only: Sediment loss to backshore dunes.	Sediment loss, alongshore.	Landward migration to long-term sea level rise.
	Shingle beach	Temporarily flattened profile.		Temporarily flattened profile.	
	Shingle or sand barriers and spits	Overtopping and/or overwashing and crest flattening.		Overwashing and crest flattening. Breaching and/or breakdown.	

Landform Components	Sensitivity			
	Storm Surge	Wind Stress	Wave Action	Other Factors
Tidal flats and marshes	Inundation for longer period/larger spatial extent, allowing greater duration for wave action on feature.	Negligible	Front-edge marsh erosion. Re-suspension of deposited sediments.	Landward migration to long-term sea level rise.
Sand dunes	Front-edge erosion.	Increased saltation and dune building, dune blow-outs, dune deflation.	Front-edge erosion.	During periods of heavy rainfall, sand becomes wet and although typically winds are stronger during storms, the increased cohesion of the wet sand may preclude or reduce aeolian transport.
Shore platforms	Inundation for longer period/larger spatial extent, allowing greater duration for wave action on feature.	Mechanical weathering makes surfaces more susceptible to wave erosion.	Mechanical erosion.	Negligible
Offshore seabed	Negligible	Negligible	Local changes to seabed form (eg changes in crest height or alignment of sandbanks).	Negligible

It should be noted that not all storm damage to coastal landforms is disadvantageous in the longer-term, or in the wider perspective. For example, the propensity for increased landsliding of soft cliffs during severe storm events yields a volume of sediment to the foreshore that can be transported to other areas, potentially feeding and helping to sustain beaches, dunes and barriers. Additionally, since inter-tidal beaches and supra-tidal sand dunes are an integral cross-shore geomorphological system, a complex relationship exists whereby the presence of one is sustained by the presence of the other. For example, dunes are formed and maintained by wind-blown sand moving off the beach and on to the upper shore where the sand becomes arrested by vegetation growth and hence accumulates. However, during storm events sand is eroded from the dunes in order to feed the lower beach profile and enable it to flatten and extend landwards, presenting the more dissipative inter-tidal profile needed to attenuate the greater storm energy. Following the storm, beach sediment is then transported by the wind back to storage in the dunes.

4.4.1 Relationship between habitat type and landforms

Linking landforms with habitat type and geology will provide an appropriate assessment method for assessing the risk of storm events on nature conservation. Table 11 shows this linkage.

Table 4.4. Showing the relationship between generic landforms and the generic habitat types they support

Generic Landforms	Generic Habitat Type
Landform complexes	Estuaries
	Coastal lagoons
	Inlets and bays
Sea cliff	Cliffs (cliff face and/or top)
	Caves (submerged and/or partially)
Lowland	Freshwater
	Heath and scrub
	Grassland
	Raised bogs, mires and fens
	Forests
Beach	Barrier and spits/Shingle/Sandy
Tidal flats and marshes	Saltmarsh
	Mud and sand flats
Sand dunes	Sand dunes
Shore platforms	Reefs
	Limestone pavements
	Wave cut platform
Offshore seabed	Sandbanks

5 Range and type of designated conservation areas likely to be threatened or adversely impacted

Objective 3
Determine the range and type of designated conservation areas likely to be threatened or adversely impacted by such events.

In order to assess the range and type of designated conservation areas likely to be threatened or adversely impacted by a major storm event, a risk-based approach was adopted. Risk is the combination of probability and severity of occurrence and arises from connection between a source (eg a storm event) and a receptor (eg designated conservation areas). The pathway is the set of mechanisms that could lead to the harm being realised (Figure 7).

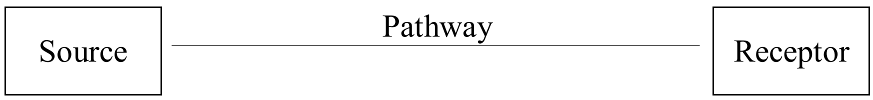


Figure 7. Schematic diagram of a Risk Model

In the context of this study, the risk assessment was based on four main sources as these were quantified in terms of their magnitude and frequency, and hence assessed on the significance of their exposure to regional level receptors (landforms, generic habitat types):

- Surges
- Waves
- Winds
- Tsunami

Reference to heavy rainfall, which is a characteristic of storm event, has been made where appropriate in the supporting text.

Potential pathways for this model included both direct impacts to a landform and indirect impact or over which the major storm event travels. For example, these could include:

- Breaching through a natural barrier or coastal defence structure enabling the ingress of tidal water.
- Water overtopping of a natural barrier or coastal defence structure.
- Wave-induced shoreline (tidal flat and marsh, beach, cliff) erosion.
- Cliff landsliding.
- Wind deflation.

Both the landform and the generic habitat it supports are the potential receptors. For examples of habitats at a board scale these could include:

- Sub-tidal designated conservation areas (eg reefs).
- Inter-tidal designated conservation areas (eg saltmarshes, mudflats, beaches, shore platforms).
- Supra-tidal designated conservation areas (eg dunes, cliffs).
- Terrestrial designated conservation areas (eg freshwater marsh, ancient woodland).

5.1 Sources of risk

For the present study, surge, wind, wave and tsunamis were identified as the main sources of risk to the coastal zone of the UK. Although other sources were considered such as heavy rainfall and climate change, in particularly sea level rise, these were not included in the assessment of risk (see Section 3.5.4). The regional assessment used the categories ‘very high’, ‘high’, ‘moderate’, ‘low’, ‘very low’ and ‘insignificant’ to define the magnitude and exposure (see Table 7).

5.2 Receptors at risk

For the risk assessment, landforms were identified as the landform receptor, as they supported generic habitat types (see Table 11), which were are at risk from a major storm event. A summary of the number and distribution of designated conservation areas and generic habitat types, between coastal regions of the UK, are presented in Table 12. This information provides a subjective means to ‘value’ the nature and type of conservation interest most vulnerable to the risks of a major storm event. Region 2 and 3 has the largest number of designated sites. However, this analysis does not take into account the spatial extent (area) of the conservation sites, which may influence the ‘susceptibility’ of a site to an event. For example, a single very large conservation area is more likely to recover or withstand a major event than several much smaller areas. Spatial extent should be featured in future studies.

Table 5.1. Showing the number of nature conservation designations, generic habitat types and the dominant geology between regions

Designations		**Region**				
		1	**2**	**3**	**4**	**5**
Number of coastal SACs		14	17	37	9	10
Number of Coastal SPAs		8	26	16	3	7
Number of Coastal Ramsar Sites		3	26	11	5	8
Number of Coastal SSSIs		43	103	143	58	48
Generic Landforms/Habitat Types		Region				
		1	2	3	4	5
Landform complexes	Estuaries	2	2	3	0	3
	Coastal lagoons	0	5	4	0	1
	Inlets and bays	1	1	2	0	1
Sea cliff	Cliffs (cliff face and/or top)	5	2	15	4	1
	Caves (submerged and/or partially)	0	0	1	1	0

Designations		Region 1	2	3	4	5
Lowland	Freshwater	0	2	7	0	3
	Heath and scrub	0	3	20	17	2
	Grassland	1	3	10	4	1
	Raised bogs, mires and fens	1	5	11	3	12
	Forests	1	8	15	6	7
Beach	Barrier and spits/Shingle/Sandy	0	6	11	0	3
Tidal flats and marshes	Saltmarsh	1	12	13	0	9
	Mud and sand flats	2	4	10	2	3
Sand dunes	Sand dunes	7	19	15	8	21
Shore platforms	Reefs/Limestone pavements	2	2	4	1	2
Offshore seabed	Sandbanks	2	4	6	1	2
Predominant geology		Hard	Soft	Hard /soft	Hard	Hard

5.3 Risk assessment

This section assesses whether the sources of risk from storm events identified in Section 3.5.4 have the potential to modify or change the receptors (landforms) and hence the habitats (receptors) they support. For the risk assessment, the nature of the source, the likely pathways to the receptors were evaluated.

Figure 8 is a schematic diagram showing the complexity between source, pathway and receptors, and was used to define more precisely the likely risks of a storm event on a receptor. The diagram is intended to aid the manager by providing a conceptual framework of all the likely event and their consequences on the nature conservation. In this case, generic habitat types were used as a 'proxy' for evaluating the value and vulnerability of nature conservation interests (designations). In the diagram, if pathways from source to the landform receptors are followed then their sensitivity to a particular storm event can be found. By following the lines through the boxes that describe landform sensitivity, links to the generic habitat types they support can be found. Note the risk from tsunamis were either very low or insignificant and so were not drawn in Figure 8. Instead, reference is given to their potential impacts as similar to those described for surge and wave. Note that the 'sensitivity box' in Figure 8 represents the potential effects a particular storm has on the landform receptor.

Tables 13-17 describe the landform, habitat, their regional importance and their relative vulnerability to a major storm event. The assessment is based largely on expert knowledge, which is appropriate for a regional scale.

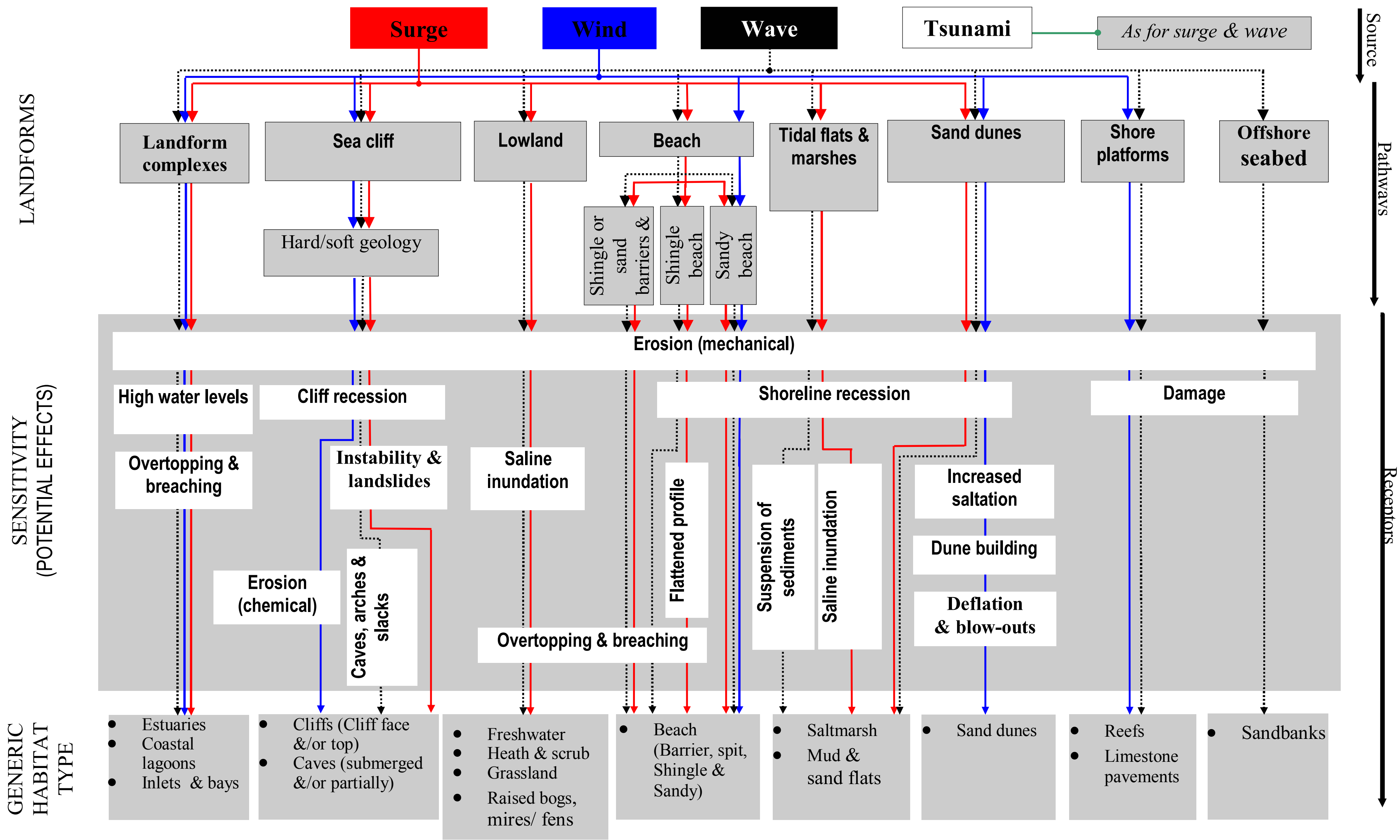


Figure 8 A schematic diagram showing the complexity between source, pathway and receptors, and the likely risks of a storm event on a receptor

Table 5.2. Showing the risk, vulnerability and impact of generic habitat types to storm event for Region 1 (North East)

Storm Event		**Regional Risk Level (North East)**	
Surge		Moderate	
Wave		Moderate	
Wind		Moderate	
Tsunami		Very low	
Generic Landforms	**Generic Habitat Type**	**Regional Assessment of Impact**	**Vulnerability of Habitat Types**
Landform complexes	Estuaries	There are very few landform complexes in this region; in particular, no coastal lagoon habitats have been designated. However, on a national basis there appears to be very few estuary designations, suggesting that these landforms complexes (especially Inlets and bays) are relatively valuable. Impact low to moderate.	As a whole, these complexes are more resilient to change than their component habitats, which make up these generic habitat types. Although ideally their spatial extent would need to be considered, they have a low to moderate vulnerability. Some permanent/temporary change expected, particularly in relation to saltmarsh and muddy components.
	Coastal lagoons		
	Inlets and bays		
Sea cliff	Cliffs (cliff face and/or top)	Cliff habitats are one of the dominant features in this region. Their hard geology, however, will make impact very low.	Low vulnerability, due to their hard geology.
	Caves (submerged and/or partially)		
Lowland	Freshwater	There are very few of these habitat types designated in this region. Although inundation of saline water is a significant impact on these habitats, the risk in this region is low.	Highly vulnerable habitats to inundation of saltine water would result in permanent/temporary change in these habitats.
	Heath and scrub		
	Grassland		
	Raised bogs, mires and fens		
	Forests		
Beach	Barrier and spits/Shingle/Sandy	There are no beach habitats designated in this region. Impact negligible.	Moderate vulnerable, as these habitats are generally mobile in nature.
Tidal flats and marshes	Saltmarsh	Very few designated habitats in this region. Risk of impact low to moderate.	Saltmarsh habitats are low to moderate vulnerability and permanent/temporary change expected. Mud and sand flat habitats less sensitive to change and has a low to moderate vulnerability.
	Mud and sand flats		
Sand dunes	Sand dunes	A relative moderate number of sand dunes in the region. This habitat is the most commonly designated in the UK. Risk of impact low to moderate.	Moderate vulnerability as these habitats as generally adapted to change through succession, sediment erosion, for example, but their spatial extent needs to be considered.
Shore platforms	Reefs	Although relatively low in the number of designated sites, these habitats are rare around the UK. Risk of impact moderate for reefs and insignificant for limestone pavement.	Reefs are vulnerable to wave impact and permanent/temporary change expect. They have a long recover time once damaged (moderate to high vulnerability). Limestone pavement able to withstand storm events (vulnerability negligible).
	Limestone pavements		
Offshore seabed	Sandbanks	Relatively few numbers of designated sites in this region. Risk of impact low to moderate.	Relatively low vulnerability, as they are unstable in nature and mobile.

Table 5.3. Showing the risk, vulnerability and impact of generic habitat types to storm event for Region 2 (East)

Storm Event		Regional Risk Level (East)	
Surge		Very high	
Wave		Low to moderate	
Wind		Low to moderate	
Tsunami		Very low	
Generic Landforms	**Generic Habitat Type**	**Regional Assessment of Impact**	**Vulnerability of Habitat Types**
Landform complexes	Estuaries Coastal lagoons Inlets and bays	There is relatively high number of landform complexes designated in this region; in particular, coastal lagoons. However, on a national basis there appears to be very few estuary designations, suggesting that these landforms complexes (especially Inlets and bays) are relatively valuable. Impact moderate to very high.	As a whole, these complexes are more resilient to change than their component habitats, which make up these generic habitat types. Ideally, their spatial extent would need to be considered (low to moderate vulnerability). Some permanent/ temporary change expected, particularly in relation to saltmarsh and muddy components.
Sea cliff	Cliffs (cliff face and/or top) Caves (submerged and/or partially)	Very few cliff habitats designated in this region. More importantly, their geology is characterised as soft. Impact very high.	Moderate vulnerability, being cliff but storm events that coincide with heavy rainfalls could lead to landslides, which could increase vulnerability.
Lowland	Freshwater Heath and scrub Grassland Raised bogs, mires and fens Forests	There are a moderate number of these habitat types designated in this region. Inundation of saline water is a significant impact and the risk in this region is very high.	Highly vulnerable habitats to inundation of saltine water would result in permanent/temporary change in these habitats.
Beach	Barrier and spits/Shingle/Sandy	A moderate number of beach habitats designated in this region. Impact negligible to very low.	Moderate vulnerable, as these habitats are generally mobile in nature.
Tidal flats and marshes	Saltmarsh Mud and sand flats	A high number of these designated habitats in this region. Risk of impact very high.	Saltmarsh habitats are low to moderate vulnerability and permanent/temporary change expected. Mud and sand flat habitats less sensitive to change and has a low to moderate vulnerability.
Sand dunes	Sand dunes	A very high number of sand dunes in the region. This habitat is the most commonly designated in the UK. Risk of impact moderate to very high.	Moderate vulnerability as these habitats as generally adapted to change through succession, sediment erosion, for example, but their spatial extent needs to be considered.
Shore platforms	Reefs Limestone pavements	Although relatively low in the number of designated sites, these habitats are rare around the UK. Risk of impact moderate for reefs and insignificant for limestone pavement.	Reefs are vulnerable to wave impact and permanent/temporary change expect. They have a long recover time once damaged (moderate to high vulnerability). Limestone pavement able to withstand storm events (vulnerability negligible).
Offshore seabed	Sandbanks	Relatively few numbers of designated sites in this region. Risk of impact low to moderate.	Relatively low vulnerability, as they are unstable in nature and mobile.

Table 5.4. Showing the risk, vulnerability and impact of generic habitat types to storm event for Region 3 (South)

Storm Event		**Regional Risk Level (South)**	
Surge		Low	
Wave		Low to high	
Wind		Low to high	
Tsunami		Insignificant	
Generic Landforms	**Generic Habitat Type**	**Regional Assessment of Impact**	**Vulnerability of Habitat Types**
Landform complexes	Estuaries Coastal lagoons Inlets and bays	There is relatively high number of landform complexes designated in this region; in particular, coastal lagoons. However, on a national basis there appears to be very few estuary designations, suggesting that these landforms complexes (especially Inlets and bays) are relatively valuable. Impact low to high.	As a whole, these complexes are more resilient to change than their component habitats, which make up these generic habitat types. Ideally, their spatial extent would need to be considered (low to moderate vulnerability). Some permanent/ temporary change expected, particularly in relation to saltmarsh and muddy components.
Sea cliff	Cliffs (cliff face and/or top) Caves (submerged and/or partially)	This region has the highest number of cliff habitat designations. Their geology is characterised as both hard and soft. Impact low to high.	Moderate vulnerability, being cliff but storm events that coincide with heavy rainfalls could lead to landslides, which could increase vulnerability.
Lowland	Freshwater Heath and scrub Grassland Raised bogs, mires and fens Forests	This region has the highest number of these habitat designations. Inundation of saline water is a significant impact and the risk in this region is more likely to be moderate or high.	Highly vulnerable habitats to inundation of saltine water would result in permanent/temporary change in these habitats.
Beach	Barrier and spits/Shingle/Sandy	This region has the highest number of beach habitat designations. Impact negligible to very low to high	Moderate vulnerable, as these habitats are generally mobile in nature.
Tidal flats and marshes	Saltmarsh Mud and sand flats	This region has the highest number of these designated habitats. Risk of impact low to high.	Saltmarsh habitats are moderate to low vulnerability. Mud and sand flat habitats less sensitive to change and has a low to moderate vulnerability.
Sand dunes	Sand dunes	A very high number of sand dunes in the region. This habitat is the most commonly designated in the UK. Risk of impact moderate to low to high.	Moderate vulnerability as these habitats as generally adapted to change through succession, sediment erosion, for example, but their spatial extent needs to be considered.
Shore platforms	Reefs Limestone pavements	This highest number of designated sites found in this region. These habitats are rare around the UK. Risk of impact low to high for reefs and insignificant for limestone pavement.	Reefs are vulnerable to wave impact and permanent/temporary change expect. They have a long recover time once damaged (moderate to high vulnerability). Limestone pavement able to withstand storm events (vulnerability negligible).
Offshore seabed	Sandbanks	The highest numbers of designated sites in this region. Risk of impact low to high.	Relatively low vulnerability, as they are unstable in nature and mobile.

Table 5.5. Showing the risk, vulnerability and impact of generic habitat types to storm event for Region 4 (South West)

Storm Event		**Regional Risk Level (South West)**	
Surge		High	
Wave		Moderate	
Wind		Moderate to high	
Tsunami		Insignificant	
Generic Landforms	**Generic Habitat Type**	**Regional Assessment of Impact**	**Vulnerability of Habitat Types**
Landform complexes	Estuaries	There are no landform complexes designated in this region. Impact negligible.	Complexes are more resilient to change than their component habitats, which make up these generic habitat types. Ideally, their spatial extent would need to be considered (low to moderate vulnerability). Some permanent/ temporary change expected, particularly in relation to saltmarsh and muddy components.
	Coastal lagoons		
	Inlets and bays		
Sea cliff	Cliffs (cliff face and/or top)	The geology is characterised as hard. Impact moderate to high.	Moderate vulnerability, being cliff but storm events that coincide with heavy rainfalls could lead to landslides, which could increase vulnerability.
	Caves (submerged and/or partially)		
Lowland	Freshwater	There are a relatively high number of these habitat types designated in this region. Inundation of saline water is a significant impact and the risk in this region is high.	Highly vulnerable habitats to inundation of saltine water would result in permanent/temporary change in these habitats.
	Heath and scrub		
	Grassland		
	Raised bogs, mires and fens		
	Forests		
Beach	Barrier and spits/Shingle/Sandy	There are no beach habitats designated in this region. Impact negligible.	Moderate vulnerable, as these habitats are generally mobile in nature.
Tidal flats and marshes	Saltmarsh	There are few saltmarsh designations in this region, although there are a few mud/sand flat habitats high number of these designated habitats in this region. Risk of impact moderate to high.	Saltmarsh habitats are moderate to high vulnerability and permanent/temporary change expected. Mud and sand flat habitats less sensitive to change and has a low to moderate vulnerability.
	Mud and sand flats		
Sand dunes	Sand dunes	Relatively few sand dunes in the region. This habitat is the most commonly designated in the UK. Risk of impact moderate to high.	Moderate vulnerability as these habitats as generally adapted to change through succession, sediment erosion, for example, but their spatial extent needs to be considered.
Shore platforms	Reefs	Very low in the number of designated sites, these habitats are rare around the UK. Risk of impact moderate to high for reefs and insignificant for limestone pavement.	Reefs are vulnerable to wave impact and permanent/temporary change expect. They have a long recover time once damaged (moderate to high vulnerability). Limestone pavement able to withstand storm events (vulnerability negligible).
	Limestone pavements		
Offshore seabed	Sandbanks	Very low number of designated sites in this region. Risk of impact moderate to high.	Relatively low vulnerability, as they are unstable in nature and mobile.

Table 5.6. Showing the risk, vulnerability and impact of generic habitat types to storm event for Region 5 (North West)

Storm Event		Regional Risk Level (North West)	
Surge		Moderate	
Wave		Moderate	
Wind		Moderate	
Tsunami		Very low	
Generic Landforms	**Generic Habitat Type**	**Regional Assessment of Impact**	**Vulnerability of Habitat Types**
Landform complexes	Estuaries Coastal lagoons Inlets and bays	There are very few landform complexes in this region; in particular, no coastal lagoon habitats have been designated. However, on a national basis there appears to be very few estuary designations, suggesting that these landforms complexes (especially Inlets and bays) are relatively valuable. Impact moderate.	As a whole these complexes are more resilient to change tan their component habitats, which make up these generic habitat types. Although ideally their spatial extent would need to be considered, they have a low to moderate vulnerability. Some permanent/ temporary change expected, particularly in relation to saltmarsh and muddy components.
Sea cliff	Cliffs (cliff face and/or top) Caves (submerged and/or partially)	There are no cliff habitat designations in this region. Their geology is hard. Impact moderate.	Moderate vulnerability, being cliff but storm events that coincide with heavy rainfalls could lead to landslides, which could increase vulnerability.
Lowland	Freshwater Heath and scrub Grassland Raised bogs, mires and fens Forests	There is relatively high numbers of these habitat types designated in this region. In particular, bogs, mires and fens. Inundation of saline water is a significant impact and the risk in this region is moderate.	Highly vulnerable habitats to inundation of saltine water would result in permanent/temporary change in these habitats.
Beach	Barrier and spits/Shingle/Sandy	A low number of beach habitats designated in this region. Impact negligible to very low.	Moderate vulnerable, as these habitats are generally mobile in nature.
Tidal flats and marshes	Saltmarsh Mud and sand flats	A relatively high number of these designated habitats in this region. Risk of impact moderate.	Saltmarsh habitats are low vulnerability. Mud and sand flat habitats less sensitive to change and has a low to moderate vulnerability.
Sand dunes	Sand dunes	The highest number of sand dunes in the region. This habitat is the most commonly designated in the UK. Risk of impact moderate to moderate.	Moderate vulnerability as these habitats as generally adapted to change through succession, sediment erosion, for example, but their spatial extent needs to be considered.
Shore platforms	Reefs Limestone pavements	Relatively low number of designated sites; these habitats are rare around the UK. Risk of impact moderate for reefs and insignificant for limestone pavement.	Reefs are vulnerable to wave impact and permanent/temporary change expect. They have a long recover time once damaged (moderate to high vulnerability). Limestone pavement able to withstand storm events (vulnerability negligible).
Offshore seabed	Sandbanks	Relatively few numbers of designated sites in this region. Risk of impact low to moderate.	Relatively low vulnerability, as they are unstable in nature and mobile.

6 Implications and options for English Nature prior to an event

Objective 4
Assess the implications and options for English Nature in terms of policy and site management prior to such an event.

This section examines the implications and options for English Nature in terms of policy and site management prior to a major storm event.

6.1 Policy

The requirement to develop policies to respond to risks to nature conservation assets associated with major coastal storms cannot be considered in isolation from English Nature's overall remit or wider Government policy.

English Nature already has specific policy objectives in relation to the management of nationally and internationally designated sites. In particular, a key focus relates to achieving/maintaining favourable condition for habitats and species within protected areas whilst recognising natural change.

The review by DTA (see Appendix 1) did not identify any legal requirement that created an obligation on English Nature to prevent change occurring to designated areas or to land which English Nature manages or controls as a result of an extreme event, although it is suggested that English Nature seeks legal confirmation of this. Nor did they identify any obligation on English Nature to remedy the effects of change that occurred as a result of an extreme event, other than normal civil law obligations to neighbouring landowners and the public.

English Nature's existing policy is to accept natural change to habitats and ecosystems, with exceptions only being made in very specific circumstances, such as where a large proportion of the UK resource was at risk. We do not see any compelling reasons to modify existing policies to specifically address risks from major coastal storms.

6.2 Site management

It should be recognised that existing actions to maintain/achieve favourable condition at protected sites will also contribute to protecting sites from the impacts of major storm events. Where habitats are of high quality and extent, they are likely to be more resilient to major storm impacts than habitats that are not in favourable condition. At a wider level, where a habitat or species is at favourable conservation status throughout its biogeographic range, it is also more likely to be resilient to an impact from a major storm.

It is important to emphasise that English Nature's policy to prepare for a major event has to be judged against the likelihood of the event and the 'value' of the habitat/conservation areas under threat. In the context of this present report, English Nature could do nothing and accept 'change' to habitat/conservation interest. In particular, this is a balance between the cost of preparation for an event and its likelihood. It is unlikely to be cost-effective to undertake general preparations for extreme events at all protected sites because of the high costs of such preparations and the large number of sites at risk. There may be a case for undertaking specific actions at individual sites where the cost is low and/or the value of the protected interest is exceptionally high.

The main actions that might be considered in advance of a major storm might be to:

- Undertake a risk assessment at individual sites to identify the vulnerability of specific habitats and species;
- Consider the possibility of relocation of any particularly rare/threatened species to other suitable sites (where feasible, this is already happening under English Nature's general conservation powers and duties); and
- Discuss with organisations such as the EA, the production of detailed emergency response plans for key sites to minimise damage during emergency works, for example, marking preferred access routes, defining how particular impacts can be managed.

7 Description of policy and planning processes that English Nature can influence

Objective 5
Detail the policy and planning processes that English Nature should be seeking to influence (internally and externally) in terms of preparing for, and responding, to a major event.

There is a wide range of policy and planning mechanisms that have a bearing on major storm events.

The latest and most comprehensive overview of government policy in respect of extreme events of coastal flooding is found in PPG25 *Development and Flood Risk*. Based on the definition given above, the Government advises planning authorities (Paragraph A.1) that floods of greater magnitude than one in two hundred year return period on the coast 'will occur'. The PPG advises that in coastal areas susceptible to flood risk on a 1 in 200 to 1 in 500 year return period (0.5% to 0.1% annual probability) new development proposals should be subject to flood risk assessment appropriate to the scale and nature of the development; and flood-resistant construction and suitable warning/evacuation procedures may be necessary.

However, in Paragraph 31 and the sequential test in Table 1, such areas are considered to be low-medium risk and suitable for 'most development' except essential civil infrastructure such as hospitals, fire stations and emergency depots. Local authorities should apply the precautionary principle where effects of flooding would be uncertain (PPG25 Paragraphs 13-14). They should evaluate the potential impact of extreme events even where it may not be economic to contemplate high levels of protection (Paragraph A.8). Appendix A of the PPG addresses causes of flooding and the impacts of climate change. Paragraph A.5 indicates that whilst climate change and sea level rise could significantly affect risk, the areas at risk are not expected to be significantly larger than the existing areas within the 1 in 200 year return period category.

There is very limited provision for, or even reference to, extreme events in other policy, outside the MAFF/Defra policy frameworks. The thrust of policy in earlier PPGs, including PPG20 *Coastal Planning* and PPG14 *Planning on Unstable Land*, are consistent with the MAFF *Strategy for Flood and Coastal Defence* (1993) which encourages adequate and cost effective flood warning systems and the provision of adequate and technically, environmentally and economically sound and sustainable flood defence measures; whilst discouraging inappropriate development in flood risk areas. There is notably a lack of any expectation that any public body should take action to relocate development or proactively change land uses that may be at risk, although there is a passing reference to long term relocation to 'help tackle the legacy of past development in unsuitable locations' (PPG25 Paragraph 9).

In terms of wider policies, there is a range of potentially relevant policy frameworks including: planning policy guidance; MAFF/Defra flood defence guidance and the increasing volume of guidance and policy in respect of integrated coastal zone management arising from the EC and national government. There has been considerable effort expended in the production of a suite of strategies and (mainly non-statutory) plans that are intended to implement the policies including: shoreline management plans, estuary management plans, coastal habitat management plans, local EA plans, water level management plans, river basin management plans and, of course, the statutory development plans. This policy and strategic framework deals comprehensively with flood risk management but largely in respect of the 1 in 100 year (fluvial) and 1 in 200 year (coastal) return periods, but makes little reference to extreme events.

8 Mechanisms and ideas for influencing policy

Objective 6
Outline the ways in which English Nature may potentially influence relevant policy mechanisms.

There is already a suite of policies, in a wide variety of frameworks, at all levels, which could contribute to minimising effects and risks from extreme events. However, they are heavily (and sometimes exclusively) focused on policy relating to new projects and plans and to regulating and managing change, or threats of change, that are perceived as more obviously imminent, predictable and manageable.

There are adequate consultation mechanisms in place but the lack of references to extreme events in almost all policy frameworks is likely to be caused by low levels of awareness, lack of perceived priority, uncertainty and unfamiliarity of the issues, perceptions of low risk and lack of resources to prioritise action on dealing with extreme events. English Nature may well find that an effective role would be to facilitate debate, raise the profile and understanding and lead by a responsible, measured and people-sensitive debate whilst taking opportunities through routine consultations to influence policy and projects as necessary.

English Nature could influence national and regional policy most effectively by continuing to respond to national consultations (draft policies, green papers etc) in the normal way, but perhaps raising the profile of the need to plan for and consider extreme events. The most important policy documents to influence are likely to be: planning policy guidance/new planning policy statements; Defra flood defence guidance and guidance and policy in respect of integrated coastal zone management arising from the EC and national government.

Reviews of shoreline management plans, estuary management plans, coastal habitat management plans, local EA plans, water level management plans, river basin management plans and, of course, the statutory development plans are also important documents to influence. English Nature is already engaged in consultation processes on the production and review of all, or at least the majority of, these plans and strategies.

It is a time of considerable opportunity to influence the revision of PPGs because the UK Office of the Deputy Prime Minister (ODPM) intends to review and reissue most of the key PPGs, including PPG9 Nature Conservation and PPG20 Coastal Planning. Two other key PPGs to monitor are PPG23 Planning and Pollution Control - (English Nature responded to a recent consultation) which is relevant in respect of the potential for major pollution or contamination arising from flooding or incursion or damage to defences; and PPG 25 Development and Flood Risk.

Regional Planning Guidance and new Regional Spatial Strategies and Sub-regional Spatial Strategies are likely to increase in influence and whilst detailed proposals are inappropriate they could be useful vehicles for raising the profile and awareness of the risk of extreme events and their land use planning implications etc. They will set out strategic policy for coastal planning and development and identify key locational strategies of major development proposals including infrastructure.

English Nature is a statutory consultee in respect of all Local Plans and Unitary Development Plans and is likely to continue to be a statutory consultee in respect of new Local Development Documents under the *Planning and Compulsory Purchase Bill*. There is a need to build in an increased awareness of these issues when responding to consultations. Also each local authority has emergency planning policies and programmes and these could be audited for potential effects on nature conservation.

English Nature could consider disseminating key messages to interest groups such as local coastal fora, flood defence groups, Environmental Management Systems (EMS) relevant authorities etc

English Nature could consider issuing advice to key stakeholders and partners and could consider preparing internal guidance on the application of English Nature's controls through S.28 Wildlife and Country Act (WCA) and Regulations 19 and 23 of the Habitats Regulations in event of an emergency.

English Nature will need to be vigilant in casework to identify proposed changes (developments, land use change or management change) that could increase risks in storm events or close options in future. In particular English Nature will need to monitor compliance with national policies ensuring that the only development permitted on the coast is that which requires a coastal location and that potentially harmful/hazardous uses/developments are not placed at risk or development will not in the future lead to demands for hard engineering defences etc. However, English Nature teams are already generally aware of these issues and existing consultation arrangements should be adequate to accommodate any increased profile of the consideration of extreme events in consultation responses.

9 Outline emergency response plan

Objective 7
Provide information to inform an outline emergency response plan for English Nature following such an event for both national and area team offices.

In order to provide information to English Nature to inform an outline emergency response plan following a major coastal storm event, other emergency response plans have been reviewed and the general principles that they contained were identified and incorporated, where appropriate, in the provision of guidance within the following section.

9.1 English Nature's marine pollution response plan (Draft)

Key points to note about this document are listed below:

- The objective is immediately set out, and mechanisms for achieving this objective are provided;
- The roles and responsibilities of various individuals or groups are identified;
- The geographical and organisation scope of the plan are defined;
- The role of English Nature in line with the National Contingency Plan (NCP) is described;
- The integration of the plan with other plans is described.

The plan essentially contains six key stages, described below.

- **Initiating the emergency response**. This is undertaken in reaction to receipt of a report of an emergency event from the relevant responding agency and involves a nominated English Nature individual receiving the report.
- **Incident assessment**. In this stage a preliminary environmental assessment is undertaken and the findings are used to evaluate the appropriate level of response. This guides a decision about whether the Area Team can handle the incident locally or whether it needs wider Maritime Team involvement, and identifies what type and volume of resources are required. Following this preliminary assessment, key staff with a level of authority commensurate with the risk posed by the incident are notified internally.
- **Incident management**. An Incident Management Team (IMT) will be established, with the size, organisation and composition dependent on the nature of the incident, with a single incident co-ordinator appointed. This team is deployed as close to the incident as possible and in most cases would include a press officer to coordinate the media response.
- **Planning process**. The IMT develops an incident action plan using a number of pro-forma to direct English Nature's response. This plan should be updated as new information becomes available and focuses on four key areas, namely: (i) the incident situation and how this is changing; (ii) environmental assessment describing the location, sensitivity and importance of threatened natural and wildlife resources; (iii) operational strategies; and (iv) resource deployment details. Financial control of the

response is coordinated through an Administrative Officer at English Nature's Head Office.

- **Operational process**. During this stage, English Nature's role is to assess and advise on the response operations to be, or being, implemented.
- **Response termination**. The satisfactory end-points of the emergency response will be defined and when they have been reached, the stand-down, debriefing and reporting procedures will be undertaken.

In addition to the above, the plan will be maintained through review and updating procedures, particularly based on practical lessons learnt. In order to be implemented efficiently, staff training and practical simulation exercise will be undertaken.

9.2 ABP Port of Ipswich OPRC plan

The United Kingdom is a party to the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC). This agreement requires parties to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Originally aimed at preventing pollution from ships, the convention also covers offshore units and these arrangements are co-ordinated with national systems for responding promptly and effectively to oil pollution. The convention came into force in May 1995 (IMO, 2003).

ABP has a target to ensure that all of its ports have approved OPRC Plans operational to ensure minimum risk from any marine incidents involving oil spill. The OPRC plans must be prepared by the ports and submitted to the Maritime and Coastguard Agency (MCA) for formal approval. These plans outline the response to a marine pollution incident that occurs within the area of jurisdiction of harbour authorities or as a result of operations occurring at oil handling facilities and offshore installations. The Plans are designed to respond to spills of local significance and provide guidance on managing large incidents. As an example, the ABP Port of Ipswich Oil Spill Contingency Plan has been reviewed.

The ABP Port of Ipswich Oil Spill Contingency Plan was developed to conform to the Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998, which entered into effect on 15 May 1998. Its primary purpose is to set in motion the necessary actions to stop or minimise a discharge of oil and to mitigate its effects.

The plan guides the Harbour Master, Orwell Navigation Service (ONS) Officers and Duty Superintendents through the decisions which will be required in an incident response. The procedures and stages of the plan are fairly comparable with those stages identified in English Nature's Marine Pollution Response Plan, which highlights a consistent, generic approach to emergency response. These stages and other important details are indicated below.

Firstly, there are some overarching principles in the plan, which are intended to ensure the plan's effectiveness. These principles state that the plan must be:

- **Familiar** to those with key response functions in the Port;
- **Regularly exercised**; and,
- **Reviewed and updated** on a regular basis.

The structure of the plan document has three elements:

- **Strategy** - statutory requirements, purpose, scope of plan; relationship to other plans (national and local); responsibilities of individuals (***purpose, initiation, assessment***).
- Action - procedures to mobilise resources (planning and operations).
- Data Directory - supplementary information, eg contact directory, risk assessment, sensitivity maps, roles of Government and other agencies, resources directory (information).

The plan uses a tiered response to oil pollution incidents depending on the scale of the incident ***(assessment)***. In a Tier 3 incident (worst case) the MCA may decide to implement NCP (see Section 9.3), ie handing over of responsibility. The three tiers are:

- Tier 1 - small incident, resources immediately available.
- Tier 2 - medium incident, substantial use of resources, could involve regional assistance.
- Tier 3 - large incident, which may exceed resources of plan and may require national assistance and national plan.

The Harbour Master has overall responsibility (***delegation of responsibility***) supported by a team for Tier 2 and Tier 3 incidents (Tier 1 might not need a team). In a wider emergency, the safety of personnel will take precedence over pollution response ***(priorities)***; for example, reference is made to the Ipswich Emergency Procedures (***position of plan in overall structure of plans***). It is important to stress that the response activities must always take account of the following items (***incident management***):

- Site hazard information (***know the area***).
- Site pre-entry briefing (***know the facts***).
- Personal danger, eg drowning, wave impact (***know the limitations***).

9.3 Maritime and Coastguard Agency's national contingency plan

As a party to the United Nations Convention on the Law of the Sea (UNCLOS), the UK has an obligation to protect and preserve the marine environment. The MCA NCP is one of the measures that the UK has taken to meet this obligation. After saving human life, the key purpose of responding to a maritime incident is to protect human health, and the marine and terrestrial environment; this policy is in agreement with English Nature's role in protecting the environment.

The key points to note from a review of the NCP are:

- The ***legal basis*** (Merchant Shipping and Maritime Security Act 1997) of the NCP and how it meets the international obligations of the OPRC (see Section 9.2).
- The ***area covered*** by the NCP.

- The ***purpose*** of the NCP is to ensure a timely, measured and effective response to incidents.
- The MCA ***implements*** this plan and has powers of intervention.
- A ***designated person*** must have overall power of responsibility, particularly if more than one authority is involved.
- Initially, the MCA ***expects to receive information*** concerning the incident.
- A duty officer (the designated person) establishes a ***level of response***, ie local, regional or national.
- A ***national or regional response*** is suggested when local and neighbouring authorities do not have the resources to deal with the situation.
- After initiating a national or regional response, the MCA ***inform/liase with relevant authorities*** (EA, Defra, DTLR) who should receive situation reports.
- Various ***communication*** methods should be utilised, eg telephone/email/ fax/radio/pager etc.
- The hierarchy of aims of the response unit is to ***prevent*** damage, ***minimise the extent*** of damage and ***mitigate the effects*** of the damage.
- A ***shoreline unit*** is set up to direct operations equipped with all communications, TV and video, stationery and wall charts.
- ***Situation boards*** should be updated regularly.
- A ***contacts listing*** must be on site an up-to-date.
- The shoreline unit may require an ***administration team*** to assist with operations.
- As part of an Environmental Group, English Nature must advise and ***monitor*** the situation as well as ***provide data immediately***.
- Failure to ***consider media response*** at an early stage may have serious implications for the management of the whole incident.
- A ***designated Press Officer*** must be in place to oversee the media response.
- A ***Media Control Centre***, where the lead agency will provide the manager, may need to be large enough to house 200 to 300 journalists during a press conference.
- The 'polluter pays' principle means the response operation can claim back any ***expenses*** incurred; therefore, records need to be kept.
- The regulatory body has a duty to secure evidence for possible use in court if it has reason to believe that an ***offence*** has been committed.

These procedures should help English Nature identify their current responsibility, capability and limitations for dealing with an emergency response for nature conservation, in a manner similar to the MCA and pollution. It is clear from the NCP that an adequate allocation of people and resources must be immediately available and potentially for a substantial period to execute the emergency response plan.

9.4 Bath and North East Somerset Council emergency management

Bath and North East Somerset Council has an Emergency Management Unit which provides a range of services to the council and the community, including the preparation of manuals and contingency plans covering a variety of civil emergencies, major incidents or crises. Examples include:

- flooding and severe weather;
- transport incidents;
- terrorist activities;
- fire, buildings or mines collapse;
- pollution and chemical incidents.

The key element of all of these plans is to protect people's lives and restore essential services as quickly as possible. In order to achieve this, the plans recognise the need for various local authority services to respond together in an integrated manner to ensure the most appropriate response is adopted and that it is implemented in the most effective and efficient manner.

An interesting point to note about this Emergency Management Unit is that they develop and manage exercises to test readiness against specific scenarios. Furthermore, if an emergency covers more than one authority's jurisdiction, provision is made within the plan for the immediate appointment of one 'lead' authority to coordinate a response, drawing on the resources available form all authorities.

In addition to the response during an emergency, the council's plans make provision for the ongoing work following the end of the emergency. Such factors include:

- Clear-up of any detritus or damage;
- Rebuilding of a community;
- Managing resources and financial implications;
- Social care and assistance.

9.5 Environment Agency flood response plan

The EA does not possess a stand-alone emergency plan document that is generic enough to address all scales of emergency, since each incident is treated specifically. However, the EA has a role in the police force's command and control centre emergency response system. This ranks emergencies into three categories:

Gold	National scale emergency; senior members of all government agencies, integrated management to save lives, medical care for casualties and facilities for victims.
Silver	Regional scale emergency, principal or senior members of government agencies.
Bronze	Local scale emergencies.

The EA has its flood forecasting and warning system to prepare for a flood emergency in any area of England and Wales, which is communicated to the public and industry as soon as reasonably possible. Flood rooms are set up to co-ordinate the response in the affected locality. The flood warning statuses have the following meanings:

	***Flooding possible***. *Be aware! Be prepared! Watch out! (Red sign)*
	***Flooding expected*** *affecting homes, businesses and main roads. Act now! (Red sign)*
	***Severe flooding expected***. *Imminent danger to life and property. Act now! (Red sign)*
	*An **all clear** will be issued when flood watches or warnings are no longer in force. (Blue sign)*

9.6 Gravesham Borough Council flood warning response plan

Gravesham Borough Council's flood warning response plan enables a response to be made to storm tide flood forecasts so that action can be taken to minimise the risk of sea or river flooding. The Plan primarily requires a nominated officer (or deputy) to disseminate warnings to industries and other high-risk properties situated along the tidal river frontage of this authority's jurisdiction. Some individual properties will receive an automated warning via a voice message telephone call system. These warnings are graded as follows:

- **FLOOD WATCH** — Possible minor flooding to roads and low lying land caused by wind blown spray overtopping seawalls.
- **FLOOD WARNING** — Possible flooding to a number of roads and/or large areas of land and some high risk properties by wave and spray overtopping of exposed seawalls. Some seepage may occur through defences and surface water drains may back up.
- **SEVERE FLOOD WARNING** — Possible serious flooding affecting properties and roads and/or large areas of land by significant overtopping and possible breaching of sea defences.
- **ALL CLEAR** — The warning shall be deemed to be cancelled by the passing of the high water for that tide.

As can be seen, these warnings are similar to the EA's flood warning status described in Section 9.5. Gravesham Borough Council's Plan provides information on what actions residents should take if flooding is likely, and what to do after the flood waters have receded.

- What to do if flooding is likely:
    - Move people, pets and valuables to a safe place.

- Alert neighbours and assist the elderly or infirm.
- Check your car and move it to high ground if possible.
- Have warm spare clothing, a torch, battery radio and keep food, drink and a first aid kit at hand.
- Block doorways and airbricks with sandbags or plastic bags filled with earth.
- Keep up to date with flood warnings information by telephone.
- Listen to local radio.
- Switch off gas and electric supplies when the flooding is imminent.

- What to do after a flood:
  - Have your gas and electricity checked before use.
  - Boil tap water until it has been declared safe and do not eat food that has been in contact with floodwater.
  - Avoid contact with floodwater as it may be contaminated.
  - Ventilate your property to reduce damage from dampness.
  - Contact your insurers.

9.7 Collation of ideas

Since responding agencies, such as the EA or local maritime authorities, will have the principal role in responding to a major coastal storm, instigating emergency repair works where deemed to be necessary, to safeguard life and property, English Nature's role may be to provide effective advice and support to these agencies within a fully integrated response.

Following the elements of 'best practice' within the reviewed plans, the suggested approach to developing an emergency response plan for a major coastal storm event should involve the following tasks:

(1) Identify a clear objective for the plan.

(2) Identify how these objectives will be met by the mechanisms within the plan.

(3) Identify the roles and responsibilities of various individuals under the plan.

(4) Identify the geographical and organisation scope of the plan.

(5) Identify a nominated officer to receive news and disseminate information - commence collection and collation of information to support decision-making.

(6) Identify an appropriate person or team to liase and communicate with the media.

(7) Undertake an initial assessment to define level of response (Area Team/Maritime Team).

(8) Propose a mechanism for identifying an IMT.

(9) Develop pro-forma for:

- Situation - define the source of the risk, and how it is changing.

- Environmental assessment - identify the receptors at risk and ascertain their sensitivity and importance.
- Operational response - identify and provide technical expertise and advice on the appropriateness of the emergency response options.
- Resource deployment.

(10) Identify and recognise the position of an English Nature emergency response plan within a hierarchy of plans from responsible authorities.

(11) Identify all contacts and their up-to-date details that are likely to be involved during the emergency response.

(12) Identify a suitable building to house the emergency response team with all the necessary infrastructure.

(13) Identify a suite of communication methods to be utilised during the emergency.

(14) Identify the extent and limitations of habitat and species knowledge for the English coastline.

(15) Identify suitable resources (people and equipment) to monitor during execution of the plan.

(16) Identify methods of training staff with specific roles - for example, in dealing with EA staff or members of the public.

(17) Identify an appropriate method of terminating the emergency response plan.

(18) Review/revise plan at regular intervals.

10 Evaluation criteria

Objective 8
Provide evaluation criteria by which English Nature can establish which types of sites will be afforded emergency flood management works following a major event, and which areas, from a nature conservation perspective, could be left to respond 'naturally'.

In order to achieve this objective, it is first necessary to consider two of English Nature's principal requirements:

- It is paramount that public safety interests must not be compromised in any way and that risk to coastal communities from flooding or erosion is not increased by consideration of nature conservation; and
- The dynamic nature of the coast and marine environment should be accommodated where possible, even where this may result in a change in conservation 'value' of an area, for example due to transition between different habitat types.

Furthermore, the wording of the objective implies that the focus is on storm events that may cause overtopping or breaching of natural barriers or flood defence structures, resulting in subsequent flooding of low-lying areas, rather than the focus being on erosion of inter-tidal areas or higher ground.

Although a review of the contents pages of *Journal of Coastal Conservation* was undertaken, surprisingly little literature world-wide has been published on the effects of hazardous events on coastal habitats. Indeed, most focus is on the effects of oil spills on the natural environment (see for example Glassom and others 1997) or other natural hazards, such as fire (eg Vestergaard & Alstrup, 1996). *English Nature Research Reports*, No 629 (Risk and Policy Analaysists Ltd 2006) provides information on standards for coastal flood defence and has identified a series of useful papers.

Given the surprising lack of world-wide literature on the subject, focus turned to learning more from a relatively recent case study where a decision was taken to leave a breach through a gravel barrier to respond naturally. This was at Porlock in south-west England (Figure 9) and further details can be found in Box D.

The changes to the Porlock gravel barrier following its natural breaching are ongoing and overall generally appear favourable for earth science conservation and habitats, as important new landforms and accreting salt marsh have been created (Bray and Duane, 2001). It is important that these changes continue to be monitored to understand the longer-term impact of ‘extreme storm events’ on geomorphological features and habitats.

Photographs courtesy of Malcolm Bray

Figure 9. Aerial views of the Porlock gravel barrier

Prior to breaching, looking west (top left), post-breaching looking east at high tide (top right), and post-breaching, vertical view at low tide (bottom)

Box D Natural breaching of the Porlock gravel barrier, south-west England

The breaching of the gravel barrier beach at Porlock Bay, Somerset, in 1996 represents a classic recent example of the effects of an extreme event on flood defence management and nature conservation. A storm event caused the barrier to breach, resulting in tidal inundation of backing land. The barrier's natural behaviour prior to the storm, its management and its subsequent natural response to the storm are the key issues illustrated by this example. These issues highlight the importance of decisions and actions made both prior to an event and following an event.

Porlock Bay is situated along the generally high cliffed coast of Somerset fronting on to the macro-tidal Bristol Channel. The coarse, gravel barrier beach extends 5km between the headlands of Gore Point and Hurlstone Point. The barrier is backed by Porlock Marsh, an area of low-lying land susceptible to periodic saline and freshwater flooding, and Porlock Weir village and harbour. Porlock Marsh lies within Exmoor National Park and was notified as a biological SSSI in 1990 for the range of habitats present. These are noted as strandline, shingle, maritime grassland, salt marsh, swamp and brackish water ditch habitats.

A severe storm on 28th and 29th of October 1996 caused major overwashing and significant landward migration of the barrier. In one section, continual overwashing led to the creation of a permanent breach channel and the consequent creation of an inter-tidal lagoon. The reasons behind these changes were considered to be co-incident factors of gravel depletion, an artificially steepened profile due to management activities, storm surge, high spring tide and wave action. As the barrier transgressed landwards an existing ditch became exploited by tidal exchange. The accelerated movement of water led rapidly to erosion of a channel in the clay substratum, which could not be sealed naturally by drifting sediments owing to its formative dimensions.

The barrier has been evolving naturally and dynamically throughout the past 4,000 years. In this period, the barrier behaviour has included overwashing, landward migration, breaching and tidal lagoon development. From an anthropogenic view, a sluice at New Works has controlled the water levels within a small predominantly freshwater lagoon backing the barrier since at least the mid 1800s. Until the early 1990s, the Environment Agency (EA) and its predecessors have utilised active management techniques to maintain the stability of the barrier. This has involved replenishment and scraping to maintain a continuous, high berm crest with a steepened profile.

From the early 1990s the EA relaxed its management approach towards the gravel barrier. The primary reason for this change was the economic viability and sustainability of defending the coastline in this location; a secondary reason was due to nature conservation. Two reports into the coastal management and coastal defence of Porlock Bay by Halcrow (1985) and Posford Duvivier (1992) contributed evidence to this decision. Various coastal defence options were appraised for the area, most of which involved an investment in man-made defences or activity, ie replenishment. It is likely that due to the limited tangible asset value present in the area, the cost-benefit analysis favoured a 'do-nothing' approach. Although there was awareness that a major storm event could cause a breach in the barrier, this type of 'worst case scenario' was not specifically appraised in detail under the 'do-nothing' option. Nevertheless, Posford Duvivier (1992) noted 'the uncertainties of the ecological and landscape consequences of the do-nothing option'. As a result of the study reports, the EA consciously decided to 'allow nature to take its course' at the site.

The consequences of the EA's decision were initially met with objection by local people. However, following the event and continuing today, the EA has pursued a policy of non-intervention so that the barrier and marsh could develop naturally. Although the landowner expressed a desire to seal the breach in 1997, their attempts were unsuccessful. The revised landscape of Porlock Bay is now generally accepted and well received; indeed, reversion to its former state would now meet some opposition.

The scale of the 1996 breach suggests the barrier adjusted its form considerably to accommodate the storm-forcing event, by allowing an inlet for tidal water movement, and thereby reducing the build-up of water acting on the barrier. Nevertheless, four vulnerable locations were identified during monitoring in 1998-2000 that could potentially breach in the future. Therefore, the EA have continued to monitor the area and will continue to do so into the near future, not least of all to address any persisting local concern.

Today at Porlock, the back barrier lowlands that were previously a predominantly freshwater lagoon have been succeeded by an inter-tidal lagoon and a strongly accreting and expanding salt marsh. These new dynamic landforms and other features formed as a result of breaching, including mobile barriers and spits, an ebb tidal delta and an evolving inlet contribute significant value to earth science and nature conservation because of their recent, and ongoing, development.

In terms of changes to habitats, the newly formed dynamic barriers are likely to be too active at present to permit development of significant shingle vegetation communities. In addition, the recent change in lagoon regime from freshwater to saline could modify bird usage owing to the open water being replaced by inter-tidal mudflats. Due to the rapid rate of sedimentation at the site, strong potential for salt marsh development exists.

In its current breached condition, the barrier provides little protection to the backing lowlands against flooding due to efficient tidal exchange at the breach inlet. Therefore, the back-barrier inter-tidal margins will remain sensitive to storm surges and sea-level rise, although the barrier will prevent wave penetration. Since the topography of the landward side of the marsh slopes steeply to the 10m contour, this would ultimately inhibit transgression of the barrier.

With respect to littoral sediment transport, the breach has introduced a new drift boundary and a local drift reversal. Gravels drift into the channel from the west and the east, forming spits and are flushed seaward where they can accumulate in a small ebb tidal delta. The western spit is accreting and extending into the breach channel whereas the eastern spit is retreating away from the breach so that the inlet at the breach is gradually migrating eastward.

The dynamic nature of the landforms involved in this case study, and the variations likely in sea level and storm activity as a result of probable future climate change, mean that full adjustment and static stability are unlikely to ever be achieved by the barrier. Future management needs to recognise the long-term effect of major storm forcing events and accommodate subsequent adjustments that may take place in the future. If possible, back-barrier land uses should be planned according to surface elevation and allowances made to absorb the combined effects of future sea-level rise and storm surges in a dynamic manner.

From a review of the case study of the Porlock gravel barrier, a number of factors can be identified that enabled, or assisted, the decision to allow the natural breach to respond dynamically, as opposed to artificially being sealed through management intervention. These factors are:

- there was no risk to life or property due to the breaching;
- the breaching did not enhance the risk of flooding or erosion elsewhere within the wider environment;
- a deep channel developed through the breach relatively rapidly, making it technically challenging (although not impossible) to artificially repair the breach;
- a relaxed management approach was already being adopted by the EA;
- there was wider public awareness of this management approach prior to occurrence of the storm event;
- the inundated site was backed by naturally steeply-rising land;
- there were considered to be significant nature conservation and earth science benefits in observing the resulting ecological and geomorphological changes at the site;
- there was limited tangible asset value at risk from the flooding;
- the nature conservation assets at the site prior to breaching were not internationally or nationally rare or unique.

For English Nature, an appreciation of the generic aspects of the event at Porlock could be transferable to other exposed British shorelines with natural shingle ridges that are at severe risk of breaching. Potential examples include:

- Chesil Beach (Dorset);
- Medmerry (West Sussex);
- Slapton (Devon); and
- Cley/Salthouse (Norfolk).

In addition to these natural barrier features, there exist a number of sites that previously were defended by flood defence structures (eg clay embankments), but following breaching during a major storm were left to respond naturally. The most recent example is at Capeshead on the Leven Estuary, Morecambe Bay where a flood defence embankment was breached in February 2003. Since the site is backed by steeply rising land at the landward side of the inundation area, it is presently proposed to leave this breach unsealed, allowing tidal inundation of a small area of land. On a more widespread scale, there were a large number of sites within the Essex estuaries where during the infamous 1953 storm surge (see Section 3) breaching of flood embankments occurred and sites were left unrepaired[1]. This may have been primarily due to the fact that focus of attention during this notorious event was on saving of lives and repairing of larger breaches near towns and villages, and not on repairing breaches where only agricultural land was at risk.

The above findings may guide the management decisions prior to, during, or after an event, to accept a non-interventionist approach in consultation with the EA and other stakeholders. In cases where people and property are at risk, however, the need for emergency reparation works will take priority, as agreed by both English Nature and the EA.

The factors and lessons previously described in this section have been considered in the development of evaluation criteria by which English Nature can establish which types of sites will be afforded emergency flood management works following a major event, and which areas, from a nature conservation perspective, could be left to respond 'naturally'. These criteria are set out in Table 18 and they can be applied using the flow chart in Figure 10.

Table 10.1. Criteria for determining which sites will be afforded emergency flood management works and which could be left to respond naturally

Stage	Key Question	Indicators
1	Is human life at risk?	Emergency response plan
2	Are other assets[2] at risk?	Emergency response plan
3	Are any of these 'at risk' assets mobile?	Emergency response plan
4	Can mobile assets be re-located without further risk to life?	Emergency response plan
5	Are fixed assets of very high importance?	Apply 'Quality of Life Capital' indicators
6	Is the extent of flooding controlled by secondary/ tertiary defences, counterwalls, or rising ground?	Seek advice from Environment Agency
7	Does allowing a natural response increase the risk of flooding or erosion elsewhere?	Seek advice from Environment Agency and Local Authorities during co-ordinated Emergency Response
8	Would there be adverse effects on the wider environment?	See Section 11

As can be seen from the Table 18, Stage 5 of the assessment process requires a level of importance to be placed on the assets that are at risk (see important note below). It is extremely difficult to be prescriptive about how such 'value' can be determined, especially when value judgement is often a highly subjective process. English Nature previously attempted to address this issue for natural environment assets by developing and applying concepts of 'Critical National Capital' (CNC) and 'Constant Natural Assets' (CNA). However, the more recent development of 'Quality of Life Capital'[3] (QoLC) is seen as a better method for maximising environmental, social and economic benefits as an integral part of any sustainable management decision. Furthermore, QoLC is presently being promoted by English Nature alongside three other agencies[4] and is also being used as a decision-support tool in the Procedural Guidance presently being developed by Defra for second generation Shoreline Management Plans. Indeed, in this Procedural Guidance (in progress), values are described as outlined in Table 19.

1 eg Brandy Hole, River Crouch
2 Such assets can relate to the developed, natural and historic environments.
3 www.qualityoflifecapital.org.uk
4 The Countryside Agency, English Heritage, Environment Agency.

Table 10.2. Descriptions of quality of life capital bands

Value	Description
Very high	Very high importance and rarity, international scale, limited potential for substitution, high impact.
High	High importance and rarity, international scale, limited potential for substitution, low impact.
High	High importance and rarity, national or regional scale, limited potential for substitution, high impact.
Medium	High importance and rarity, national or regional scale, limited potential for substitution, low impact.
Medium	High or medium importance and rarity, regional or local scale, limited potential for substitution, high impact.
Low	High or medium importance and rarity, regional or local scale, limited potential for substitution, low impact.
Low	Medium or low importance and rarity, local scale, high impact.
Negligible	Medium or low importance and rarity, local scale, low impact.
Negligible	Very low importance and rarity, local scale, high or low impact.

Important note: It should be noted that in keeping with English Nature's philosophy of accommodating the dynamic nature of the coast and marine environment where possible, even where this may result in a change in conservation 'value' of an area, it is expected that assets may be identified as being of 'very high importance' in Stage 5 of the procedure only in exceptional circumstances. For example, in the developed environment, such a site may include a nuclear power station (which would also have adverse effects on the wider environment if flooding or erosion occurred: see Stage 8). Similarly, in the natural environment such an asset would include an irreplaceable or unique habitat or species like, for example, an ancient woodland (ie most 'designated conservation areas' - even if SPA, SAC or Ramsar - would not necessarily be considered as being of 'very high importance').

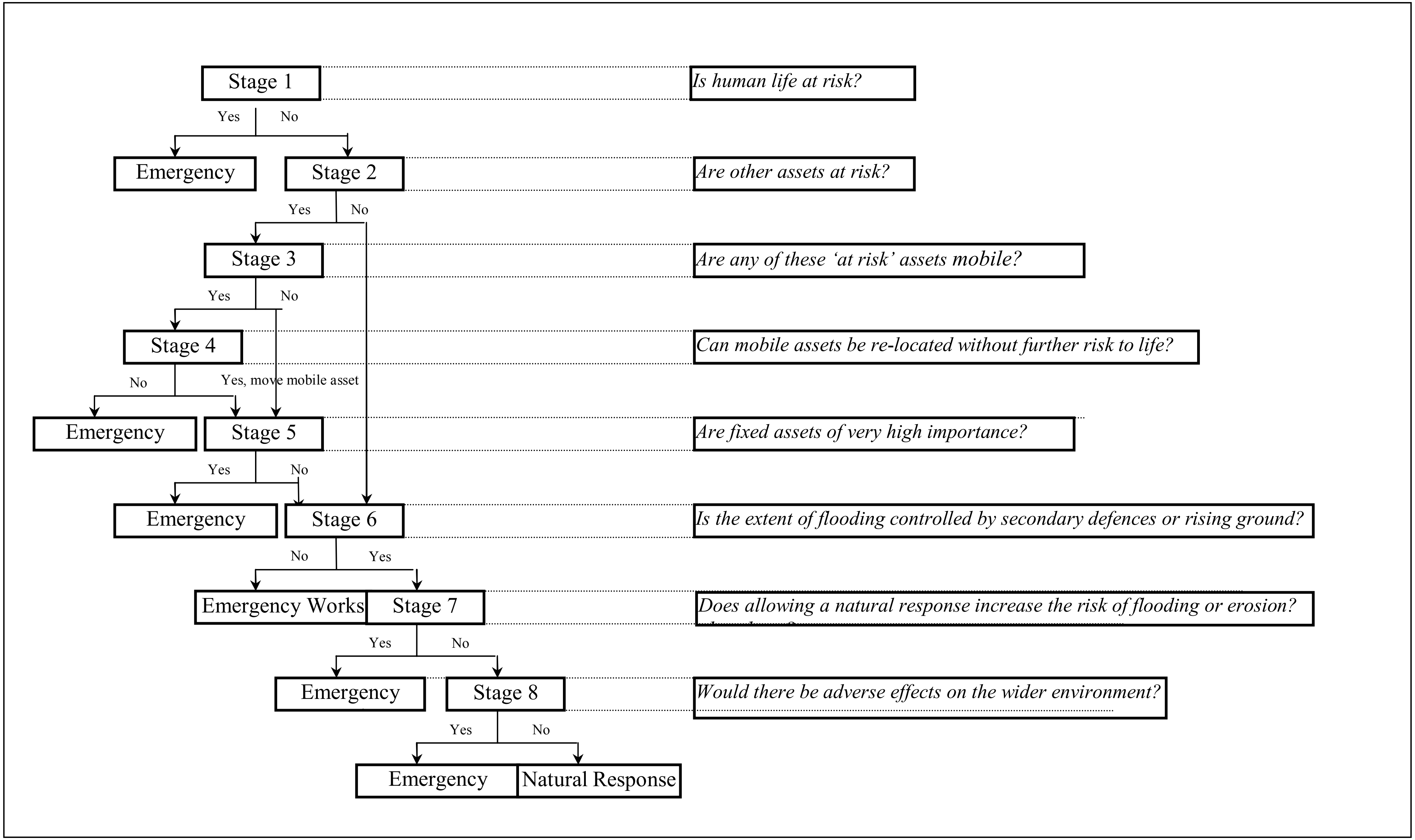


Figure 10 Flow chart for applying the evaluation criteria

11 Wider environment management

Objective 9
Outline the major issues English Nature needs to consider regarding the management of the wider environment following a major event.

A flooding or storm event has the potential to affect the wider environment beyond the immediate confines of the designated conservation sites that are directly affected by the event. This can be both during and after the time of the storm event and has implications over a number of spatial and temporal scales. Some physical and ecological examples of wider environmental effects are presented below, along with the implications on the environment of human behaviour during a storm event.

11.1 Physical change

The hydraulic behaviour of water during and after a flooding or storm event is capable of altering the physical characteristics of the open coast and estuarine environments. In these examples, the changes in water movement can induce change outside of the designated area in one of the following ways.

11.1.1 Changes to tidal prism

The tidal prism is the volume of sea water that a flood tide carries into, or an ebb tide carries out, an estuary or bay (Whittow, 2000). A storm surge in an estuary for example, may cause inundation of a designated area, subject to the types, standard and inundation of coastal defences in place. If the defences are compromised by the storm, a greater volume of water will enter the mouth of the estuary because of the increase in estuary volume in the region of the designated area. This increase in tidal prism, moving into and out of the estuary in the same time period means tidal current velocities will increase. The locations of increased current velocity, such as the mouth may cause erosion of the bed and increase sediment transport. Depending on the physical extent and duration of the velocity changes, there may also be changes caused to the tidal asymmetry, potentially affecting the wider import or export of suspended sediment on an estuary-wide scale.

11.1.2 Creation of a breach channel

The breaching of a gravel barrier or flood defence structure can result in the formation of a channel through which tidal water enters and leaves a particular site. Such a channel can prevent mobile sediment moving along the coast from one section to another. This is because of the width and depth of the channel and the flow of water through the channel acts like a 'hydraulic groyne' intercepting longshore transport and starving downdrift areas of sediment. It is possible that tidal deltas may form in the vicinity of the breach channel that will also interrupt sediment movement by acting as temporary or permanent stores of sediment.

11.1.3 Creek formation

A designated area, such as a saltmarsh may become inundated when natural defences are overtopped or overwashed. As water levels recede in the flooded area, the discharging water may erode the existing foreshore and any intertidal habitats through formation of a creek.

Therefore, the physical environment that exists in front of the designated area to landward may also change as a consequence of inundation due to a storm event.

11.2 Ecology

Freshwater and terrestrial species that are located or inhabit areas outside of the designated areas at the time of a storm event, may suffer adverse effects. The severity of these affects will be determined by the tolerance of these species to such changes in environmental conditions and the duration of the exposure period.

Species that are not directly inundated or impacted at the time of a storm event can also be affected. Migratory birds, for example, which use areas of coastline for feeding and roosting will be affected by changes in habitat type. This could ultimately disrupt the migrationary routes of these species which has further implications in terms of food availability and energetic costs. The loss of freshwater habitat may also affect species from neighbouring areas that use these sites for part of their lifecycle or for drinking water.

If the marine incursion or flooding extended to areas containing industrial, agricultural or domestic land uses there is potential for pollutants to enter the water course and pollute the wider environment. These pollutants can then be transferred outside of the designated areas via a number of routes. This can result in direct toxic effects as well as more long term effects via processes such as bioaccumulation.

11.3 Human behaviour

A storm or marine incursion will affect people's behaviour if the situation becomes life threatening. Although advice and warnings are widely available and publicised through various media, in reality the public will not always follow instructions. This 'lifesaving behaviour' may be to the detriment of designated habitats and species outside the zone of immediate flooding. People will use the most convenient, shortest, least demanding and least threatening route to seek shelter or higher ground with little priority given to the environmental consequences they create due to disturbance to species and trampling of habitats. Therefore, no matter what plans and expectations English Nature may have in an emergency, these will be diminished to an extent by the 'priorities' of other emergency respondents.

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Appendix 1. Implications of a major coastal flood on nature conservation interests in England. Draft report of research findings

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1. Introduction

1.1 In light of the Brief and our remit in the project, we structured our approach to the investigation of policy and legislative requirements as follows:

A] an analysis of the provisions and expectations of policy frameworks;

B] an examination of the obligations that may flow from certain nature conservation designations that English Nature would be involved in (eg SPAs, NNRs etc); and

C] a review of statutory requirements via the regulatory controls.

1.2 In policy relating to land use and coastal zone management and planning (including the town and country planning system and coastal zone planning) "extreme events" are generally defined (eg PPG25 *Development and Flood Risk*) as those which would occur in excess of a 1 in 200 year return period (0.5% annual probability) and up to a 1 in 1,000 year return period (0.1% annual probability), beyond which there is "little or no risk".

1.3 In this report we summarise the findings of the literature review and desk study of policy, designation and legislation and then summarise our conclusions and recommendations.

2. Review of policy

2.1 The latest and most comprehensive overview of government policy in respect of extreme events of coastal flooding is found in PPG25 *Development and Flood Risk.* Based on the definition given above, the Government advises planning authorities (para A.1) that floods of greater magnitude than one in two hundred years return period on the coast "will occur". The PPG advises that in coastal areas susceptible to flood risk on a 1/200 to 1/500 year return period new development proposals should be subject to flood risk assessment appropriate to the scale and nature of the development; flood-resistant construction and suitable warning / evacuation procedures may be necessary. In the PPG the 1/200 to 1/500 year return periods are quoted as 0.5% to 0.1% annual probability, but we would have thought the 1/500 year return period should be a 0.2% probability.

2.2 However, in para 31 and the sequential test in Table 1 of PPG25, such areas are considered to be low – medium risk and suitable for "most development" except essential civil infrastructure such as hospitals, fire stations and emergency depots. Local authorities should apply the precautionary principle where effects of flooding would be uncertain (PPG25 paras 13-14). They should evaluate the potential impact of extreme events even where it may not be economic to contemplate high levels of protection (para A.8). Appendix A of the PPG addresses causes of flooding and the impacts of climate change. Paragraph A.5 indicates that whilst climate change and sea level rise could significantly affect risk, the areas at risk are not expected to be significantly larger than the existing areas within the 1/200 year return period category.

2.3 There is very limited provision for, or even reference to, extreme events in other policy, outside the MAFF/Defra policy frameworks. The thrust of policy in earlier PPGs, including PPG20 *Coastal Planning* and PPG14 *Planning on Unstable Land*, are consistent with the MAFF *Strategy for Flood and Coastal Defence* (1993) which encourages adequate and cost effective flood warning systems and the provision of adequate and technically, environmentally and economically sound and sustainable flood defence measures; whilst discouraging inappropriate development in flood risk areas. **There is notably a lack of any expectation that any public body should take action to relocate development or proactively change land uses that may be at risk**, although there is a passing reference to long term relocation to "help tackle the legacy of past development in unsuitable locations" (PPG25 para 9).

2.4 A list of all policy documents checked in the research is provided at Annex 1 below. We summarise the policy situation as follows.

2.5 There is a wide range of potentially relevant policy frameworks including: planning policy guidance; MAFF/Defra flood defence guidance and the increasing volume of guidance and policy in respect of integrated coastal zone management arising from the EC and national government. There has been considerable effort expended in the production of a suite of strategies and (mainly non-statutory) plans that are intended to implement the policies including: shoreline management plans, estuary management plans, coastal habitat management plans, local Environment Agency plans, water level management plans, river basin management plans and, of course, the statutory development plans. This policy and strategic framework deals comprehensively with flood risk management but largely in respect of the 1 in 100 year (fluvial) and 1 in 200 year (coastal) return periods, but makes little reference to extreme events.

2.6 Furthermore, the policy framework described above is heavily (and often exclusively) focused on new proposals – be they discouraging development that may be subject to, or that may exacerbate, flood risk or regulating development intended to reduce or otherwise manage flood risk. **There is virtually no reference and certainly no expectation to proactively change land use or management or to anticipate and provide for extreme events**.

3. Implications flowing from nature conservation designations and international obligations

3.1 We have considered the following designations as comprehensive of English Nature's likely suite of designation interests: Special Protection Areas (SPAs), Special Areas of Conservation (currently candidate ie cSACs), Ramsar sites, European Marine Sites (EMS), Biogenetic Reserves (Berne Convention), Areas of Special Protection (ASPs), Bird Sanctuaries, National Nature Reserves (NNRs), Marine Nature Reserves (MNRs), Local Nature Reserves (LNRs), Sites of Special Scientific Interest (SSSI), Regionally Important Geological / Geomorphological Sites (RIGs) and County Wildlife Sites / Sites of Importance for Nature Conservation (SINCs).

3.2 It is possible that implications could arise that may be relevant to managing extreme flood events from the following designations: SSSI, SPAs, cSACs (thus including European Marine Sites) and Ramsar sites as follows.

3.3 **Special Protection Areas**: arising from classification under Directive 79/409/EEC on The Conservation of Wild Birds, commonly known as The Birds Directive, amended in 1981, 85, 86, 91, 94 and 97. The Directive (Articles 1 to 3) places a duty on Member States to sustain populations of naturally occurring wild birds by restricting their killing and capture and by sustaining or re-establishing sufficient diversity and area of habitats. It applies to birds, their eggs, nests and habitats. It requires Member States to take measures to preserve a sufficient diversity of habitats for all species of wild birds naturally occurring within their territories in order to maintain populations at ecologically and scientifically sound levels. Under Articles 1 to 3 of the Directive, however, there are no requirements to protect birds or their habitats from exceptional naturally occurring events.

3.4 One of the key provisions of the Directive was the introduction of Special Protection Areas (SPAs) in respect of the rare or vulnerable species of birds listed in Annex 1 and for other birds, especially those requiring wetlands for breeding, moulting or wintering areas or for staging posts on migration. Over 50 of the 175 species of birds listed in Annex 1 of the Directive naturally occur regularly in the UK. Many SPAs and proposed SPAs in England occur in the coastal zone. Article 4(4) created obligations on Member States to avoid pollution and deterioration of habitats and significant disturbance to birds in the SPAs. This severe obligation, which had no derogation mechanism (such as a reason of overriding national interest allowing loss of habitat) was replaced with the requirements of Article 6 of the Habitats Directive by virtue of Article 7 of that Directive (see below). Article 6 of the Habitats Directive does have derogation mechanisms that can allow deterioration and disturbance in prescribed circumstances (see para 4.4 below). Even outside SPAs there remains a general duty on a Member State to strive to avoid pollution and deterioration of bird habitats generally, but these duties could not conceivably mean that a Member State had to take specific action to avoid any bird habitats being affected by an exceptional coastal storm.

3.5 However, as a result of the judgment, in 2000, of the European Court of Justice in C-374/98 *Basses Corbières* the original requirements of Article 4(4) of the Birds Directive still do apply to areas that should be classified as SPAs but have not been. These may be areas adjacent to but excluded from a classified SPA necessary for the ecological functioning of the SPA; or they may be separate areas which merit classification as SPA but have been omitted from the series as a result of, for example, oversight or insufficient information at the time of classification or review. In that sense, the obligations in respect of a proposed or other "should be" SPA may, therefore, be more serious than those in respect of classified SPAs. Regulatory controls under the provisions of the Birds and Habitats Directives are discussed in more detail in section 4 below.

3.6 **Special Areas of Conservation**: Directive 92/43/EEC, of May 1992, on the Conservation of Natural Habitats and of Wild Fauna and Flora, commonly known as "The Habitats Directive" requires each Member State to take measures to maintain or restore natural habitats and wild species at a favourable conservation status in the Community, giving effect to both site and species protection objectives. The Directive created the concept of the Natura 2000 network of protected "European" sites comprising the classified SPAs under the Birds Directive and Special Areas of Conservation (SACs) designated under the Habitats Directive. The Directive also required Member States to ensure the protection of species of Community Interest listed in the Annexes to the Directive. The Directive is primarily applied in England via the *Wildlife and Countryside, Conservation (Natural Habitats &c) Regulations* 1994, commonly referred to as the Habitats Regulations; they were amended in 1997 and twice in 2000 in England.

3.7 One of the key ecological functions of SACs is to help maintain or restore habitats and species of European interest at favourable conservation status (as defined by the Directive). Pursuant to this requirement, Member States must establish priorities for SAC designation relating to "the threats of degradation or destruction to which those sites are exposed" (Article 4.4) including natural threats. Article 6 (1) and (2) impose general duties to establish the necessary conservation measures for SACs, including management plans and to take "appropriate steps" to avoid deterioration and significant disturbance, but there is no indication as to what may be regarded as appropriate or inappropriate steps. That is to say if an identified threat to a SAC is a deterioration in habitats for which it is designated, as a result of a possible incursion during a major storm event, the Directive gives no indication as to whether works to prevent such an incursion would be appropriate, and therefore an implied obligation, or inappropriate, for example because of low risk of the storm event and high cost of the works.

3.8 The implications of Article 6(3) and (4) are discussed in section 4 below but it is worth drawing attention here to two points. Firstly, there are derogation procedures to allow damage to a cSAC or classified SPA in prescribed circumstances. Secondly, Article 9 of the Directive explicitly provides for the declassification of a SAC where monitoring reveals that this is warranted "by natural developments" that is, by naturally occurring events rather than by plans or projects or deficient management. Overall the general tenor of the Directive and its provisions for SACs is that changes that may be brought about by plans and projects or otherwise induced by human activity should be anticipated and controlled. Changes brought about by natural processes detected by monitoring (implying long term processes such as coastal squeeze or coastal erosion) are anticipated and accepted as inevitable. Major "extreme events" are not anticipated, or at least not provided for in the Directive.

3.9 It may reasonably be assumed that if long term natural change is anticipated and accepted as inevitable, and may lead to a declassification of a cSAC (implying there is no obligation to stop it even if it were preventable), it would be unreasonable to suggest that Member States are expected to proactively intervene to prevent damage or deterioration by extreme, but still naturally occurring, events. As a result, not surprisingly, management of cSACs is focused on the more obviously imminent, predictable and manageable threats to the favourable conservation status of the habitats and species that practical management activity can influence.

3.10 For those cSACs and SPAs or parts of them that are, or form part of, an EMS, English Nature must advise relevant authorities (as defined in the Habitats Regulations) of operations (ongoing works or activities), which may cause damage or significant disturbance to the interest features. This is with a view to exploring how such operations could be controlled to reduce the threat to the site. Para 4.12 of DETR 1998 (see Annex 1 below for references) indicates that in establishing the extent to which a management scheme for a EMS needs to provide for change, the presumptions in most cases are expected to be: continuing day to day use of the area in general; retention of existing activities and controls where these do not cause damage or significant disturbance; to change the activities or controls only where necessary to avoid damage or significant disturbance and "for responses to marine emergencies to continue to be pursued in accordance with priorities of those situations". There is no indication as to the level of priority that may be awarded to the likelihood of damage resulting from an extreme event but, equally, there is no implication that designation of an EMS changes any pre-existing arrangements to plan for extreme events.

3.11 **Ramsar sites**: the Ramsar Convention concerning wetlands of international importance especially as waterfowl habitat was adopted at Ramsar, Iran in 1971. It came into force in 1975 was ratified by the UK in 1976 and amended in 1985. It requires contracting parties to designate (list) internationally important wetland sites as Ramsar Sites. Ramsar sites are often also proposed / candidate or designated / classified European sites and thus protected by statute under the Habitats Regulations. Government policy in England is expressed in *Ramsar Sites in England* 2000 and makes clear that Ramsar sites, and the Ramsar interests that may be additional to the European site interests, should be treated as if they are fully designated European sites / interests for the purposes of considering development proposals that may affect them.

3.12 Ramsar sites should be protected in planning processes and their conservation must be promoted (Article 3.1). The area of Ramsar sites may be reduced "in the urgent national interest" (Article 2.5) but in such cases Member States shall as far as possible compensate for any loss of wetland resource by creating additional nature reserves and protecting a further area representing an adequate portion of the original habitat (Article 5.2). Article 3.2 requires contracting parties to inform the Ramsar bureau of any changes or likely changes in Ramsar sites resulting from technological developments, pollution or other human intervention but notably not of naturally occurring habitat changes such as those arising from coastal processes or the effects of coastal storms. The duty would include notification of any deterioration in Ramsar sites resulting from any flood prevention works.

3.13 **Sites of Special Scientific Interest** notification of SSSI also has potential implications for operations relating to extreme events but these are related to the statutory provisions of Section 28 *Wildlife and Countryside Act* 1981 and are, therefore, considered in section 4 below.

3.14 We conclude that the following designations carry no implications for English Nature in respect of extreme flood events: Biogenetic Reserves, Areas of Special Protection, Bird Sanctuaries, NNRs, MNRs, LNRs, RIGs and County Wildlife Sites / SINCs.

3.15 Biogenetic Reserves flow from the provisions of the Berne Convention established under the auspices of the Council for Europe, September 1979, for the conservation of European wildlife and natural habitats. Biogenetic Reserves are designated (by the Council of Europe) for heathlands and dry grasslands. Whilst the Convention is still monitored for compliance it is now implemented primarily through the provisions of the Habitats Directive and Habitats Regulations.

3.16 Areas of Special Protection, Bird Sanctuaries, NNRs, MNRs and LNRs all arise within domestic (English / GB) legislation and are aimed either at empowering statutory bodies to create nature reserves or to otherwise protect and manage land for the benefit of wildlife conservation. Designation brings no special duties that compel a landowner or manager or any nature conservation body to undertake any specific types of works and they are variously focused on management of the land for nature conservation, interpretation, education and research.

3.17 RIGS, County Wildlife Sites / SINCs are non-statutory designations aimed primarily at protecting locally important habitats, species and natural features through the planning system and prioritising nature conservation interests outside statutorily designated sites for management and enhancement. There are no obligations arising from designation but as a matter of policy central and local government should seek to protect such sites in decision making and regulatory controls where they have substantive nature conservation value (para 18 PPG 9).

3.18 We have also considered the obligations arising from other international conventions listed below for potential implications. We conclude that there are no special provisions for planning or managing a response to a major coastal storm of marine incursion arising from these international agreements and it is highly unlikely that any responses would lead to action inconsistent with these conventions.

A] The Aarhus Convention, about access to information, public participation and access to justice in environmental matters, UNECE, June 1998 which draws heavily on EC Directive 90/313.

B] The Convention on Biological Diversity, Rio de Janeiro, part of the Earth Summit signed 1992 Article 6A of the Convention requires each Contracting Party to "*develop national strategies, plans or programmes for the* *conservation and sustainable use of biological diversity, or adapt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned".* The UK and local Biodiversity Action Plans flow from this obligation.

C] The Bonn Convention on the conservation of migratory species of wild animals, June 1979, requires concerted action to ensure appropriate conservation and management of threatened populations of migratory species. Implemented in the UK via national legislation (WCA) and policy.

D] The Washington Convention on International Trade in Endangered Species (CITES), applied in the UK through EC Regulation 3626/82 and parts of the *UK Endangered Species (Import Export) Act* 1976 and the *Control of Endangered Species (Enforcement) Regulations* 1997.

4. Statutory powers and regulatory controls

4.1 We have considered the following statutory regimes and regulatory controls that appear relevant to English Nature's interest in the topic: *Wildlife and Countryside Act* 1981 (abbreviated to WCA) as amended especially by *Countryside and Rights of Way Act* 2000 (abbreviated to CRoW) and the *Conservation (Natural Habitats &c) Regulations* 1994 (the Habitats Regulations) as amended 1997 and 2000 (implementing the EC *Birds Directive* and the EC *Habitats Directive)*. These are the principal regulatory controls, which English Nature is responsible for administering that are relevant to the research. It follows that English Nature may have to apply these controls to itself or to others before, during or after an extreme event and should, therefore, anticipate what the implications may be, especially in respect of emergency measures that may be required.

4.2 Section 28 WCA and Regulations 19 and 23 of the Habitats Regulations (operations likely to damage a SSSI or European Site) contain explicit provisions for the exemption, subject to conditions, of emergency operations such as may be required during or immediately after an extreme flood event. Notably, Regulation 48 of the Habitats Regulations (consideration of plans and projects) does not contain such emergency provisions, but does provide:

A] exemption for projects directly connected with and necessary to the management of the European Site (which could include projects designed to avoid or remedy adverse effects of an extreme event); and

B] a derogation provision where it cannot be ascertained that a project would not have a significant adverse effect on the integrity of a European (or Ramsar) site, and there are no alternative solutions, the project must be carried out for imperative reasons of overriding public interest (which could include measures related to the management of extreme events associated with the protection of human health and public safety).

4.3 Thus, under the provisions of the WCA and Habitats Regulations, there may be important distinctions between operations that are emergency operations and those which are not, and between planned projects and unplanned projects. The application of S.28 WCA, Regs 19/23 and 48/49 of the Habitats Regulations and the EIA Regulations to unplanned emergency works is summarised in Table 1 below.

4.4 Before deciding to undertake a plan of operations, for example, emergency operations designed to help to avoid or remedy the effects of an extreme event, that would not be directly connected with and necessary to the management of the European Site for nature conservation, for example those operations that might be necessary for the protection of people or property, every competent authority as defined by the Habitats Regulations, and including English Nature, must follow the decision making procedures in Regulations 48, 49 and 53 of the Regulations. However, in doing so, the appropriate assessment must assess the effects of the proposed works / operations on the integrity of the site, not the effects of the extreme event that they may be designed to deal with. Thus, even if the extreme event may cause an adverse effect on the integrity of the site, the planned works may not, and therefore the plan of operations would pass the tests of Regulation 48 and could be put in place. Even if it could not be ascertained that the plans would not adversely affect the integrity of the European or Ramsar site, if there were no alternative solutions less damaging to the site, the plan could still be implemented for imperative reasons of overriding public interest. If no priority species or habitat would be affected, the imperative reasons could be of an economic or social nature, but even where a priority habitat or species may be affected, the reasons could relate to the protection of human health and public safety, so the plan could still be implemented, although compensatory measures under Regulation 53 may be required if necessary to maintain the overall coherence of the Natura 2000 network.

4.5 The above procedures apply to any schemes that may be generated by any competent authority including local authorities, statutory undertakers and other public bodies in respect of flood defence and management of extreme or other potential flood events under a variety of legislation (*Coast Protection Act* 1949, *Harbours Act* 1964, *Water Resources Act* 1991, *Land Drainage Act* 1991 and *Environment Act* 1995).

S.28 Wildlife and Countryside Act 1981

4.6 Various public bodies including local authorities and statutory undertakers have varying duties in respect of considering the effects of carrying out their statutory functions on the environment, but, whatever other duties they have, S.28 of the WCA now prevails because the most demanding duty and the one most relevant to consider here as the land which English Nature will be concerned about in respect of extreme events is likely to be a SSSI.

4.7 S.28G WCA requires all ministers, government departments, local authorities, statutory undertakers, public bodies and everyone holding public office (S.28G Authorities) including English Nature, to take reasonable steps, consistent with the proper exercise of their functions, to further the conservation and enhancement of the special interests of SSSIs. There are no exceptions, so even when undertaking emergency works in preparation for, during or after an extreme event, all S.28G authorities must comply with this general duty. However, the duty is to take reasonable steps and reasonableness must prevail in the administrative / legal sense. What may be regarded as reasonable in any particular circumstance is a case by case judgment, and it is unlikely to be reasonable to expect a S.28G authority to expend large sums of money in order to protect a SSSI from the possible, potential or theoretical adverse effects of an extreme event.

4.8 S.28H WCA requires all section 28G authorities to follow certain procedures before carrying out any works likely to affect the special interests of a SSSI, whether or not the works would be on the SSSI. The procedures include giving notice to English Nature. The S28G authority may only proceed with the proposed operations in accordance with any assent given by English Nature (including conditions) or, if English Nature do not assent to the proposed operations, in accordance with the requirements of S.28H which *inter alia* includes giving notice to English Nature of their intention to commence, causing as little damage to the SSSI interests and restoring the site to its former condition, as is reasonably practicable.

4.9 S.28I WCA requires all section 28G authorities to follow certain procedures before giving consent for any operations likely to affect the special interests of a SSSI, whether or not the works would be on the SSSI. The procedures include consulting English Nature and taking account of any advice from English Nature. If the S28G authority decide to give consent to the operations other than in accordance with English Nature's advice they must follow the requirements of S.28I which *inter alia* includes giving notice to English Nature of how their advice was taken into account and not allowing the operations to commence for at least 21 days after English Nature has been given notice of the terms of the proposed consent.

4.10 S.28E WCA requires all owners and occupiers, other than S28G authorities, not to cause or permit any specified operations to be carried out within a SSSI unless one of them has given prior notice to English Nature and English Nature has given consent, or the operation is in accordance with a management agreement (under previous legislation) or a management scheme (under S.28J) or management notice (under S.28K). As a result of the strengthening of SSSI legislation in CRoW 2000, these provisions are more rigorous than those of Regulations 19 and 23 of the Habitats Regulations that refer to operations likely to damage a European site.

4.11 It is a reasonable excuse, under S.28P WCA or under Regulations 19 and 23 of the Habitats Regulations, for the following actions to be undertaken, which would otherwise be an offence, if the operation was an emergency operation particulars of which (including details of the emergency) were notified to English Nature as soon as practicable after the commencement of the operation; this could include emergency works undertaken immediately prior to and in anticipation of an extreme event, or during or immediately after an extreme event:

A] a S28G authority to have undertaken an operation which caused damage to the interests of a SSSI without complying with S.28H; or

B] an owner or occupier to have undertaken an operation other than in accordance with S.28E;

C] an owner or occupier of a European site to have undertaken a specified operation likely to damage the interests of the site without 4 months having elapsed from the date of notice or without the operation being carried out in accordance with a consent from English Nature or in accordance with a management agreement.

Other statutory provisions and regulatory controls

4.12 We conclude that there are no general implications arising from the statutory provisions for the various Management Agreements in which English Nature may become engaged such as those under the *National Parks and Access to the Countryside Act* 1949, the *Countryside Act* 1968, *Wildlife and Countryside Act* 1981 and Regulation 16 of the *Habitats Regulations* 1994. However, English Nature may need to be aware of any specific provisions that may constrain action in respect of an extreme event that may be contained in any individual agreement.

4.13 English Nature's regulatory (licensing) role in the protection of species under the *Badgers Act* and Habitats Regulations, and English Nature's powers to make byelaws and of compulsory purchase, under the WCA and Habitats Regulations are unlikely to be relevant in this context. The EC Directive on the assessment of the environmental effects of plans and programmes (strategic environmental appraisal) would only be applicable, post June 2004 if English Nature were to contemplate a strategic programme of works rather than a series of individual site projects that may be subject to project EIA if any of the works comprised EIA development.

5. Conclusions and recommendations

5.1 We can find no legal requirement or policy expectation that creates an obligation on English Nature to prevent change occurring to designated areas or to land which English Nature manages or controls as a result of an extreme event.

5.2 This assumes that we are correct in concluding that the Habitats Directive requirement to take "appropriate" steps to avoid deterioration of habitats in classified SPAs and cSACs would not include steps to protect a site from the effects of an extreme event, even where potential effects were predictable and preventable (other than by minor works which could easily be undertaken anyway). Similarly, it assumes we are correct in concluding that, in light of the judgment, in 2000, of the European Court of Justice in C-374/98 *Basses Corbières,* the requirement to take "appropriate" steps to avoid deterioration of habitats in areas that should be classified as SPA, but are not yet so classified, would not include steps to protect such areas from the effects of an extreme event. English Nature may wish to seek confirmation of this advice from their legal advisers.

5.3 We can find no legal requirement or policy expectation that creates an obligation on English Nature to remedy the effects of change that is occurring or has occurred to designated areas or to land which English Nature manages or controls as a result of an extreme event, other than normal civil law obligations to neighbouring landowners and the public.

5.4 There is already a suite of policies, in a wide variety of frameworks, at all levels, which could contribute to minimising effects and risks from extreme events. However, they are heavily (and sometimes exclusively) focused on policy relating to new projects and plans and to regulating and managing change, or threats of change, that are perceived as more obviously imminent, predictable and manageable.

5.5 There are adequate consultation mechanisms in place but the lack of references to extreme events in almost all policy frameworks is likely to be caused by low levels of awareness, lack of perceived priority, uncertainty and unfamiliarity of the issues, perceptions of low risk and lack of resources to prioritise action on dealing with extreme events. English Nature may well find that an effective role would be to facilitate debate, raise the profile and understanding and lead by a responsible, measured and people-sensitive debate whilst taking opportunities through routine consultations to influence policy and projects as necessary.

5.6 English Nature could influence national and regional policy most effectively by continuing to respond to national consultations (draft policies, green papers etc) in the normal way, but perhaps raising the profile of the need to plan for and consider extreme events. The most important policy documents to influence are likely to be: planning policy guidance / new planning policy statements; Defra flood defence guidance and guidance and policy in respect of integrated coastal zone management arising from the EC and national government. Reviews of shoreline management plans, estuary management plans, coastal habitat management plans, local Environment Agency plans, water level management plans, river basin management plans and, of course, the statutory development plans are also important documents to influence. English Nature is already engaged in consultation processes on the production and review of all, or at least the majority of, these plans and strategies.

5.7 It is a time of considerable opportunity to influence the revision of PPGs because the ODPM intends to review and reissue most of the key PPGs, including PPG9 Nature Conservation and PPG20 Coastal Planning. Two other key PPGs to monitor are PPG23 Planning and Pollution Control – (English Nature responded to a recent consultation) which is relevant in respect of the potential for major pollution or contamination arising from flooding or incursion or damage to defences; and PPG 25 Development and Flood Risk.

5.8 Regional Planning Guidance and new Regional Spatial Strategies and Sub-regional Spatial Strategies are likely to increase in influence and whilst detailed proposals are inappropriate they could be useful vehicles for raising the profile and awareness of the risk of extreme events and their land use planning implications etc. They will set out strategic policy for coastal planning and development and identify key locational strategies of major development proposals including infrastructure.

5.9 English Nature is a statutory consultee in respect of all Local Plans and Unitary Development Plans and is likely to continue to be a statutory consultee in respect of new Local Development Documents under the *Planning and Compulsory Purchase Bill*. There is a need to build in an increased awareness of these issues when responding to consultations. Also each local authority has emergency planning policies and programmes and these could be 'audited' for potential effects on nature conservation.

5.10 English Nature could consider disseminating key messages to interest groups such as local coastal fora, flood defence groups, EMS relevant authorities etc

5.11 English Nature could consider issuing advice to key stakeholders and partners and could consider preparing internal guidance on the application of English Nature's controls through S.28 WCA and Regs 19 and 23 of the Habitats Regulations in event of an emergency.

5.12 English Nature will need to be vigilant in casework to identify proposed changes (developments, land use change or management change) that could increase risks in storm events or close options in future. In particular English Nature will need to monitor compliance with national policies ensuring that the only development permitted on the coast is that which requires a coastal location and that potentially harmful / hazardous uses / developments are not placed at risk or development will not in the future lead to demands for hard engineering defences etc. However, English Nature teams are already generally aware of these issues and existing consultation arrangements should be adequate to accommodate any increased profile of the consideration of extreme events in consultation responses.

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Appendix 2. Annex I habitat features per region

Generic Habitat Type	Habitat Feature	Region				
		1	2	3	4	5
Offshore seabed	Sandbanks which are slightly covered by sea water all the time	2	4	6	1	2
Mud and sand flats	Mudflats and sand flats not covered by seawater at low tide	2	4	10	2	3
Landform complexes	Estuaries	2	2	3	0	3
Landform complexes	Coastal lagoons	0	5	4	0	1
Landform complexes	Large shallow inlets and bays	1	1	2	0	1
Reefs	Reefs	2	2	4	1	2
Beach: sandy/shingle/ barriers and spits	Annual vegetation of drift lines	0	2	6	0	1
Beach: sandy/shingle/ barriers and spits	Perennial vegetation of stony banks	0	4	5	0	2
Sea Cliff	Vegetated sea cliffs of the Atlantic and Baltic coasts	4	1	12	2	0
Saltmarsh	*Salicornia* and other annuals colonising mud and sand	0	2	4	0	3
Saltmarsh	*Spartina* swards (*Spartinion maritimae*)	0	2	3	0	3
Saltmarsh	Atlantic saltmeadows (*Glauco-Pucfcinellietalis martimeae*)	1	4	5	0	3
Saltmarsh	Mediterranean and thermo-Atlantic halophilus scrubs (*Sarcocornetea fruticosi*)	0	4	1	0	0
Sand dunes	Embryonic shifting dunes	1	4	4	0	3
Sand dunes	Shifting dunes along the shoreline with *Ammophila arenaria*	1	5	4	2	3
Sand dunes	Fixed dunes with herbaceous vegetation	2	2	3	2	4
Sand dunes	Atlantic decalcified fixed dunes (*Calluno-Uicetea*)	0	1	1	0	3
Sand dunes	Dunes with *Hippophae rhamnoides*	1	3	0	0	2
Sand dunes	Dunes with *Salix repens* ssp. argentea (*Salicion arenariae*)	1	0	1	2	3
Sand dunes	Humid dune slacks	1	4	2	2	3
Freshwater	Oligotrophic waters containing very few minerals of sandy plains (*Litttorelletailia uniflorae*)	0	0	2	0	1
Freshwater	Oligotrophic to mesotrophic standing waters with vegetation of the *Litttorelletailia uniflorae* and/or of the Isoëto-Nanojuncetea	0	0	1	0	1
Freshwater	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp	0	1	1	0	1
Freshwater	Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation	0	1	0	0	0
Freshwater	Mediterranean temporary ponds	0	0	1	0	0
Freshwater	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation	0	0	2	0	0
Heath and Scrub	Northern Atlantic wet heaths with *Erica tetralix*	0	1	5	4	0
Heath and Scrub	Temperate Atlantic wet heaths with *Erica ciliaris* and *Erica tetralix*	0	0	2	3	0
Heath and Scrub	European dry heaths	0	2	11	10	0
Heath and Scrub	Dry Atlantic coastal heaths with *Erica vagans*	0	0	1	0	0
Heath and Scrub	*Juniperus communis* formations on heaths or calcareous grasslands	0	0	1	0	2
Grassland	Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*)	1	1	4	4	1
Grassland	* Semi-natural dry grasslands and scrubland facies: on calcareous substrates (*Festuco-Brometalia*) (important orchid sites)	0	1	3	0	0

Generic Habitat Type	Habitat Feature	Region				
		1	2	3	4	5
Grassland	*Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)	0	1	3	0	0
Raised bogs, mires and ferns	Active raised bogs	0	0	0	0	5
Raised bogs, mires and ferns	Degraded raised bogs still capable of natural regeneration	0	1	0	0	6
Raised bogs, mires and ferns	Blanket bogs	0	0	0	1	0
Raised bogs, mires and ferns	Transition mires and quaking bogs	0	1	2	1	1
Raised bogs, mires and ferns	Depressions on peat substrates of the Rhynchosporion	0	1	3	0	0
Raised bogs, mires and ferns	Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*	0	1	3	0	0
Raised bogs, mires and ferns	Alkaline fens	1	1	3	1	0
Limestone pavements	Limestone pavements	0	0	0	0	1
Cliff: caves	Caves not open to the public	0	0	1	1	0
Cliff: caves	Submerged or partially submerged sea caves	2	1	3	2	0
Forests	Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*)	0	0	1	0	0
Forests	*Asperulo-Fagetum* beech forests	0	2	3	0	0
Forests	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*	0	1	0	0	0
Forests	* *Tilio-Acerion* forests of slopes, screes and ravines	0	0	2	1	2
Forests	Old acidophilous oak woods with *Quercus robur* on sandy plains	0	1	3	0	0
Forests	Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles	0	0	0	3	2
Forests	Bog woodland	0	0	3	0	0
Forests	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)	0	3	2	2	1
Forests	*Taxus baccata* woods of the British Isles	1	1	1	0	2

Research Information Note

English Nature Research Reports, No 695

The implications of major coastal floods on nature conservation interests in England

Report Authors: ABP Marine Environmental Research Ltd Date: 2003
Keywords: major storm event; Emergency Response Plan

Introduction

Organisations involved in coastal management need to be prepared for and be able to respond to major coastal floods. Despite their low frequency major floods are of high magnitude with the potential to impact on nature conservation sites. Increasing storm levels are predicted over the next century and there is increasing public awareness of the potential devastation caused by major events stemming from episodes like the 2004 Boxing Day tsunami. It is therefore prudent for English Nature to consider its responsibilities and activities prior to and following major storm events. English Nature seeks to provide clarity and direction in the management of coastal conservation interests before and after a major coastal storm.

What was done

This report provides guidance, advice and recommendations on the management of nature conservation sites in the event of a major coastal flood. The report covers:

- the range of major coastal floods & their generic impacts on conservation sites;
- the range of conservation sites most at risk from major coastal storms;
- implications and options for English Nature prior to a major event;
- policy and planning processes that English Nature can influence;
- a potential Emergency Response Plan; and
- criteria for evaluating which areas will be afforded emergency flood management and which should be left to respond naturally.

Results and conclusions

A regional assessment of risk sources identified the East coast of England as most likely to experience a major coastal storm largely due to the tracks of Atlantic storms.

No legal requirements or policy expectations were found that create an obligation on English Nature to either i) prevent change occurring, or ii) remedy effects of changes that occur (now or in the past) to designated areas as a result of an extreme event.

The main actions that might be considered prior to a major storm might be to:

- undertake a risk assessment at individual sites to determine vulnerability of specific habitats and species;

Continued……

- consider relocating particularly rare/threatened species; and
- discuss with relevant organisations the production of detailed Emergency Response Plans for key sites to minimise damage during emergency works.

English Nature could influence national and regional policy most effectively by continuing to respond to national consultations in the normal way, and in doing so raise the profile of the need to plan for and consider extreme events.

English Nature's viewpoint

English Nature accepts that irregular flooding of conservation sites at the coast is a reality; indeed there is clear evidence that such events were more frequent in the past (as flood defence standards were lower) and that some sites may actually need occasional sea water incursions to sustain their existing conservation interest. An increase in future flood event frequency coupled with increased saltwater percolation as sea levels rise also means that the conservation interest of coastal sites will continue to evolve and this may involve some marked changes to the mosaic of habitats and species; this was recognised in our 2005 'Our Coasts and Seas' strategy document. However most changes tend to be gradual whereas those caused by an extreme storm event will be sudden, dramatic, widespread and probably at a much larger scale.

Clearly following such an event operating authorities (OAs) will have people as a first priority. However they will also need to address the needs of legally protected sites. English Nature is committed to helping OAs in such circumstances and will seek provide pragmatic advice eg the best solution may be to accept permanent change to a site (rather than rebuilding flood defences) with compensation measures elsewhere to address impacts to vulnerable species.

The report suggests three actions that might be considered prior to an event, our initial thoughts on these points are:

- We will offer advice on the vulnerability of individual conservation sites and a preferred response to a major saline incursion as part of our contribution to SMPs.
- Re: translocating species; this may not always be a suitable response. Our position is explained in a joint policy statement on the JNCC website (http://www.jncc.gov.uk).
- Emergency response plans may be useful for key sites. We will further consider this issue.

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Further information

English Nature Research Reports and their *Research Information Notes* are available to download from our website: www.english-nature.org.uk

For a printed copy of the full report, or for information on other publications on this subject, please contact the Enquiry Service on 01733 455100/101/102 or e-mail enquiries@english-nature.org.uk

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Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
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