6.6 SUMMARY

This report presents an overview of how the coastline would evolve at Eastoke point if all current beach management activities were to cease. The predicted shoreline evolution under a Do Nothing scenario has been derived from the likely shoreline recession rate as presented in the Coastal Processes chapter (Chapter 3) and the condition assessment of the existing defences (Chapter 4). Given the complex nature of the coastal processes acting upon the Eastoke Point frontage it is difficult to predict with certainty what would happen initially, if the current beach management programme was discontinued. For this reason, a constant erosion rate has been applied to the entire frontage. Whilst this does not allow for any accretion or periods of more rapid shoreline recession (for example, if a ness were to form in Defence Length 3 and then rapidly erode), the predicted erosion losses for the frontage as a whole are realistic. The start date for the onset of erosion varies for the five defence lengths, depending on the expected lifetime of the existing defences, as predicted in their condition assessment (see Chapter 4).

The predicted losses for the 100 year duration of the study period were found to exceed £57 million or (£11 million discounted to present values). These losses should however be treated with a degree of caution given that the land lost from the LNR has been assigned a land only value if a Do Nothing policy were to be adopted for this frontage. The habitats that the area contains could not be easily re-created elsewhere, and therefore this policy would damage the status of this designated conservation area, raising the possibility of costs associated with creating a similar area of habitat elsewhere.

Also, no utility (electricity / sewerage etc) losses have been taken into account, and the replacement of these to serve the remaining properties in Eastoke would add significantly to the benefits of a coastal defence scheme for Eastoke Point.

The evaluation of the Do Nothing scenario and the economic losses generated will be used (in conjunction with the results of the Do Nothing flood risk assessment) as a baseline against which all potential coastal defence options will be evaluated including a full cost benefit analysis of the short-listed solutions.

7. *Flood Risk Assessment*

7.1 INTRODUCTION

Flooding of the Eastoke Peninsula during storm conditions has been recorded on a number of occasions since residential development first took place. The first defences were constructed during the late 1930s, but continued erosion of the beaches in front of the sea wall resulted in further overtopping and damage to sea front properties by the late 1970s, with major overtopping events occurring in 1978 and 1979. The major beach recharge scheme completed in 1985 provided significant additional protection against overtopping and since that time, additional coastal defence structures have been constructed in order to maintain beach levels to the required standard. Havant Borough Council have subsequently carried out recycling operations to maintain beach levels, including periodic dredging in the entrance to Chichester Harbour to recover beach sediments lost offshore from Eastoke Point. Despite this, overtopping has again become a problem, for example in 1994, 2005 and 2008, and a further recharge of the beach was carried out in early 2008 to help improve beach levels.

The design crest level of the beach along the study frontage is ~5.6m. This is considered to provide adequate protection from overtopping and extreme storm surges. However, in practice, beach levels drop throughout the year as material is transported alongshore and the frontage becomes increasingly vulnerable to flooding. If the current management activities were ceased, the beach would rapidly become depleted resulting in more frequent overtopping, damage to and eventual failure of the sea wall and significantly increased risk to people and property.

In order to design a sustainable coastal management strategy for the Eastoke Peninsula, it is essential to determine the current level of risk from flooding and to predict what may happen in the future as a result of both sea level rise and failure of the existing defences.

The remainder of this chapter is structured as follows:

- An overview of the assets at risk from flooding is presented in Section 7.2;
- The methodology used to calculate overtopping is given in Section 7.3;
- Section 7.4 describes the RASP methodology and how it was applied in this study;
- The results of the study are presented in Section 7.5; and
- The economic consequences of a Do Nothing Scenario are presented in Section 7.6.

7.2 ASSETS AT RISK

The Eastoke Peninsula is a heavily developed area comprising residential properties, businesses and community, tourism and recreational infrastructure. If sustainable flood and coastal protection mechanisms are not put in place and maintained, the entire community may be destroyed within the next 100 years.

The assets at risk include:

- Over 1000 residential and commercial properties;
- Sandy Point Nature Reserve;
- Access routes to the Peninsula;
- Hayling Island Sailing Club; and
- Holiday accommodation (caravans etc) located along the northern frontage.

Many of these assets are, or have previously been at risk from flooding as a result of waves or tides overtopping the northern and / or the main southern frontages of the Eastoke peninsula as well as the defences around Eastoke Point. The Standard Of Protection (SOP) offered by the flood defences along these other frontages has been improved over time, and the main threat of flooding now stems from overtopping of the Eastoke Point frontage considered in this study.

In this part of the present study, we have concentrated on the calculation of the flood risk to the assets at Eastoke as a result of overtopping or breaching of the coastal defences around Eastoke Point alone. To achieve this, we have not allowed for any flooding of the defences along the northern shoreline of the peninsula, nor along the main southern frontage west of groyne 11. The outputs of this flood risk assessment therefore underestimate the overall flood risk to Eastoke, especially when the effects of sea level rise are considered as part of the “forward look” into how flood risks would increase over the next century.

These calculations, however, do provide an assessment of the present Standard Of Protection offered to the residential areas at the eastern end of the peninsula, thus helping in establishing the need for and urgency of improvements to the coastal defences.

The economic case for undertaking such improvements, however, cannot be made purely on the likely costs of improving defences around Eastoke Point and the benefits of reducing the flood risks calculated here. This is because some of the value of properties identified here as at risk of flooding over or through the defences at Eastoke Point has been previously used to justify the defence improvements elsewhere around the Eastoke peninsula. The economic case for improving the defences at Eastoke Point is therefore tackled in a later stage of this study.

7.3 OVERTOPPING CALCULATIONS

Overtopping discharges were calculated for the present day situation and for a breach scenario for joint probability wave and water level return periods from 1 to 1000 years as required by the RASP model. These are described below.

7.3.1 Non breach scenario

Preliminary examination of photographic evidence showing overtopping during storm conditions indicated that the profile does not evolve in the same manner as for a 'typical' shingle beach. Modelling of beach profile evolution using the SHINGLE model and evidence from beaches at other locations shows that in general, overtopping by large waves causes the crest of the beach to build up and ultimately to 'roll back' as shingle is pushed further landwards. At Eastoke, the waves tend to run up the beach, over the crest and down the back face of the profile towards the hinterland. In order to derive realistic overtopping discharges for the frontage, the beach was treated as an embankment with a compound front face for the purpose of this assessment.

7.3.2 Breach scenario

If a Do Nothing policy were adopted for the Eastoke frontage, and no further recycling was carried out, beach levels would drop rapidly within a very short time (<10 years). Where the beach is backed by hard defences, the sea wall would be exposed, eventually down to the toe. At Eastoke Point, where there is no sea wall, the beach would drop to the level of the adjacent hinterland creating a breach in the defences.

In order to calculate the overtopping discharges for the Do Nothing scenario, two methods were employed according to the nature of the backshore defences as presented below.

At the western end of the study frontage where the beach is backed by a buried sea wall, the overtopping discharges were calculated for a vertical wall with no beach. The toe depth of the wall was derived from the original drawings and from calculations based on beach slope and length/depth of the profile, taking into account likely scour at the toe of the wall.

The beach in front of the LNR is backed by a vertical sheet steel piling. Overtopping discharges for this stretch of beach were calculated in the same manner as for the western end of the study frontage. Additionally, further overtopping discharges were calculated for a total breach scenario where the defence had failed completely. In this case, the crest level was reduced to that of the adjacent hinterland. Overtopping discharges for the remaining frontage i.e. From Eastoke Point to Black Point were calculated by assuming that the crest dropped to the level of the adjacent hinterland.

Overtopping discharges were calculated for the following epochs allowing for sea level rise in accordance with the latest figures from Defra.

- Present Day (2007)
- 2055
- 2085
- 2107

The consequences of either overtopping of the defences or the breaching of them, i.e. their crest levels being lower than the tidal level during a storm event, were expressed in terms of the amount of seawater that would flow into the hinterland per metre run of shoreline around Eastoke Point. These calculations were carried out at four different cross-sections that were chosen to be representative of a substantial length of the study frontage, and the cross-sections chosen were Numbers 253, 260, 270 and 279 which have been regularly surveyed by Havant Borough Council (see Chapter 3 for details).

The overtopping seawater discharges are presented in Tables 7.1 and 7.2 below. The discharges are given in m^3/metre of defence per second. These figures were multiplied by the length of frontage for which beach profile was assumed to represent, and then used as input to the RASP flood model. The details of this model are described in the next section of this report.

Table 7.1 Non Breach Scenario

2006						
Section	**1in1**	**1in10**	**1in50**	**1in100**	**1in200**	**1in1000**
279	0.0003	0.0017	0.0038	0.0053	0.0075	0.03
270	0.0004	0.0021	0.004	0.006	0.0085	0.01
260	0	0.0001	0.0004	0.0007	0.001	0.003
253	0	0.0001	0.0003	0.0005	0.0008	0.0024
Total	**0.0007**	**0.004**	**0.0085**	**0.0125**	**0.0178**	**0.0454**
2056						
Section	**1in1**	**1in10**	**1in50**	**1in100**	**1in200**	**1in1000**
279	0.0016	0.007	0.014	0.019	0.026	0.05
270	0.0007	0.006	0.01	0.014	0.02	0.04
260	0.002	0.02	0.04	0.06	0.09	0.22
253	0.002	0.02	0.06	0.08	0.11	0.24
Total	**0.0063**	**0.053**	**0.124**	**0.173**	**0.246**	**0.55**
2086						
Section	**1in1**	**1in10**	**1in50**	**1in100**	**1in200**	**1in1000**
279	0.005	0.02	0.03	0.05	0.07	0.12
270	0.004	0.01	0.03	0.04	0.05	0.1
260	0.01	0.08	0.17	0.2	0.3	0.7
253	0.06	0.31	0.55	0.7	0.93	1.8
Total	**0.079**	**0.42**	**0.78**	**0.99**	**1.35**	**2.72**
2106						
Section	**1in1**	**1in10**	**1in50**	**1in100**	**1in200**	**1in1000**
279	0.01	0.05	0.09	0.11	0.15	0.26
270	0.01	0.04	0.07	0.09	0.13	0.24
260	0.05	0.27	0.51	0.66	0.91	1.88
253	0.25	0.91	1.5	1.85	2.4	4.3
Total	**0.32**	**1.27**	**2.17**	**2.71**	**3.59**	**6.68**

Table 7.2 Breach Scenario

2006						
Section	**1in1**	**1in10**	**1in50**	**1in100**	**1in200**	**1in1000**
279	0.06	0.1	0.12	0.14	0.15	0.2
270	0.06	0.21	0.35	0.44	0.58	1.1
260	0.4	1.7	3.1	5.4	5.4	11.4
253	0.3	1.2	2.8	4.9	5.1	10.9
Total	**0.82**	**3.21**	**6.37**	**10.88**	**11.23**	**23.6**
2055						
Section	**1in1**	**1in10**	**1in50**	**1in100**	**1in200**	**1in1000**
279	0.11	0.17	0.2	0.21	0.23	0.3
270	0.2	0.58	0.92	1.1	1.4	2.5
260	1.8	5.6	9.1	11.2	14.6	29
253	0.11	0.53	0.92	1.1	1.5	2.9
Total	**2.22**	**6.88**	**11.14**	**13.61**	**17.73**	**34.7**
2085						
Section	**1in1**	**1in10**	**1in50**	**1in100**	**1in200**	**1in1000**
279	0.18	0.25	0.3	0.32	0.35	0.43
270	0.19	0.58	0.92	1.12	1.4	2.5
260	8.1	13.7	28	33.2	41.7	81
253	0.46	1.2	2.7	3.5	4.5	
Total	**8.93**	**15.73**	**31.92**	**38.14**	**47.95**	**83.93**
2107						
Section	**1in1**	**1in10**	**1in50**	**1in100**	**1in200**	**1in1000**
279	0.27	0.36	0.42	0.45	0.48	0.58
270	0.3	0.76	1.1	1.4	1.7	2.9
260	31.2	54.9	78.2	90	110	220
253	1.2	2.4	5	6	7.6	13
Total	32.97	58.42	84.72	97.85	119.78	236.48

7.4 EASTOKE POINT FRA – RASP APPROACH

RASP (Risk Assessment of Coastal and Flood Defences for Strategic Planning) is a probabilistic flood risk methodology. The RASP model allows the probability of inundation, expected annual damages (expressed as monetary value) and defence contribution to the expected annual damage (allowing prioritisation of defence maintenance works) to be calculated for a given area of concern (covered by a given 'Impact Zone' or 'Impact Cell' (Figure 7.1)) through integration of the impacts and flood inundation extents of storm events covering a range of return periods. Linear defences are defined as a GIS polyline layer (Figure 7.1) covering the model area and this layer is attributed with key data such as crest level, toe level, standard of protection and ground level behind the defence. Overtopping volumes are determined for each event considered, for each of these defences, under both breach and non-breach scenarios, and the volumes are spread over the floodplain (the Digital Terrain Model extracted from LIDAR (Figure 7.2)) using the Rapid Flood Spreading Model (RFSM), a rapid Monte-Carlo Simulation based hydraulic flood spreading model developed by HR Wallingford. In this case, a 10m grid resolution (corresponding to Impact Cells of 10m by 10m) was used for flood spreading and result presentation. A detailed description of the RFSM, and the role of Impact Zones and Impact Cells in this model, is given in Appendix 6.

The joint probability wave and water level analysis gave several combinations of extreme event for each return period considered, all of which are equally valid but potentially having very different consequences in terms of their effect on flood risk. In order to fully account for flood inundation probability arising from both breached and non-breached defence states and hence accurately represent flood risk to the area, it was therefore necessary to run two separate models for each individual output. In the first instance, the Shingle model was used to determine which event would incur the highest probability of failure of any flood defence in the full defence system, for each return period considered; in the second, the event was selected to yield maximum non-breached defence overtopping rate across all defences. The overtopping rates corresponding to each of these events for each defence in both the breached and non-breached state, and for each return period, were then calculated and the fragility curves derived using the Shingle model. The two models were then run and the results integrated: for example, in the case of the present day likelihood of inundation map, the annual probability of inundation presented for each Impact Cell is the maximum probability of inundation for that given flood cell resulting from either of these model runs. Similarly, the expected annual damage to a given impact cell or the defence contribution to expected annual damage for a given defence is taken as the maximum of the outputs for that impact cell or defence from the two model runs.

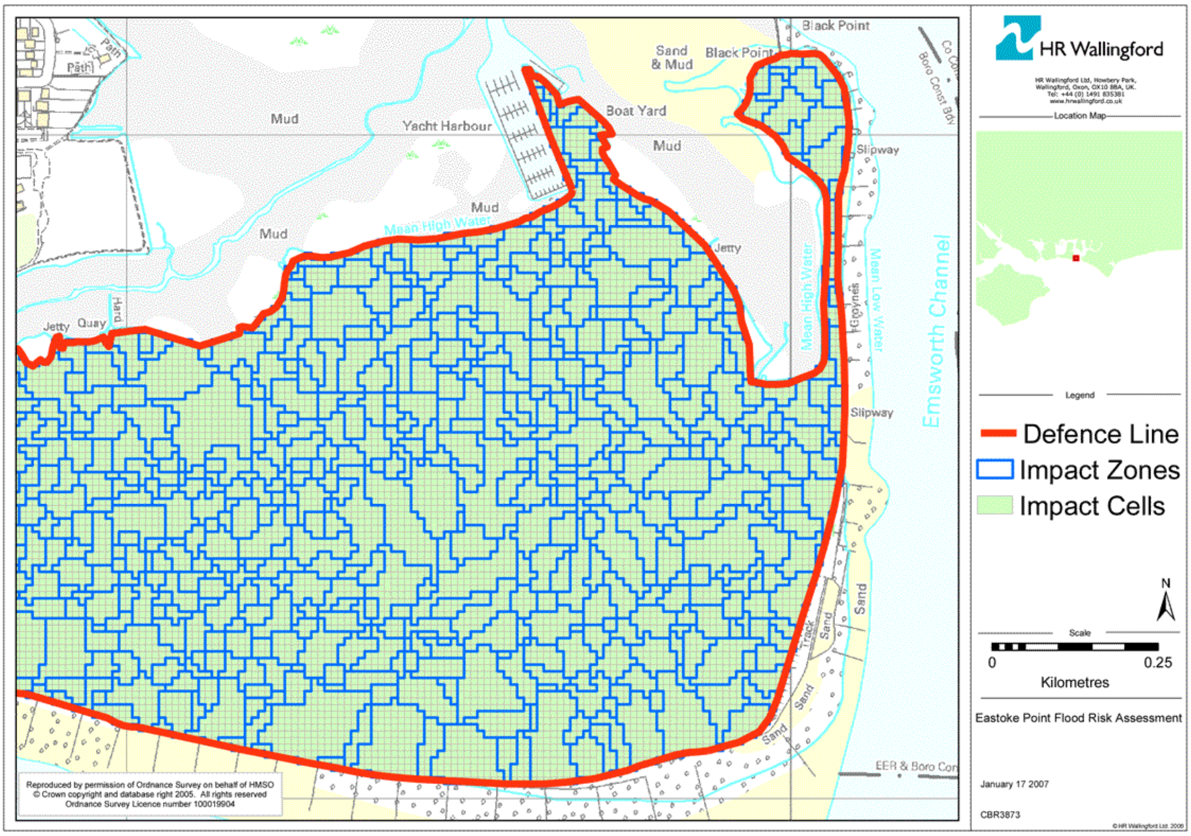

Figure 7.1 Impact Zones, Impact Cells and GIS Defence Polyline

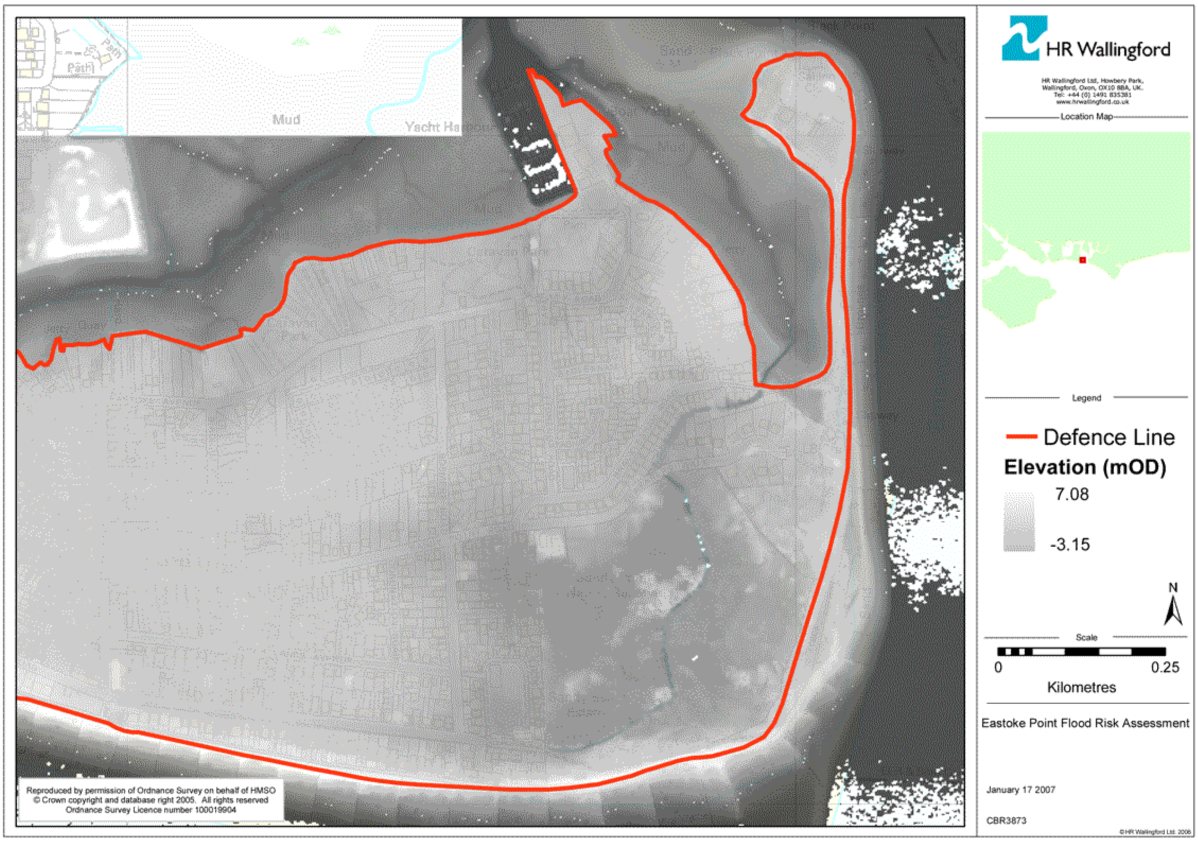

Figure 7.2 LIDAR data used in RASP model setup

It is important to note that the results are only presented for flooding through or over the defences around Eastoke Point, i.e. within the defined study frontage. The economic case for improving these defences is considered in the next stage of this study.

7.5 RESULTS

7.5.1 Present day scenario

The present day inundation map for return periods up to 1000 year is presented in Figure 7.3. This shows that relatively few properties are flooded on a regular basis (2-5 year return periods). The Sandy Point Nature Reserve is also shown to be inundated under high frequency return periods, but this is as expected, given that flood water is known to run down into the reserve and remain there until water levels in the Harbour entrance drop sufficiently to allow drainage. A small number of seafront properties adjacent to the Nature Reserve are flood by 2-5 year events but the majority of properties within the study area would only be flooded during 500 to 1000 year events.

The expected annual damages as a result of the predicted flooding are presented in Figure 7.4. These show that the most extensive damages will occur to properties on the south and east side of the Sandy Beach estate and on Treloar Road, adjacent to the LNR. It is possible to demonstrate the contribution of each defence length to the expected annual damage as shown in Figure 7.5. Note that it is not possible to determine whether ‘flood damage at Point X was caused by overtopping at Point Y’ without further flood route modelling that is outside the scope of the present study. Figure 7.5 shows that overtopping at the end of the promenade and at the corner of Eastoke Point make the highest contribution to property damage. This is due to higher waves and lower crest levels respectively.

7.5.2 Do Nothing scenario

In the event of no further recycling or other management operations along the Eastoke frontage, and subsequent depletion of the beach, overtopping and hence, flooding would increase significantly. In order to quantify the economic impact of adopting a Do Nothing scenario, it was necessary to run the model for a number of different periods between the present day and 100 years hence. The Do Nothing scenario forms the baseline against which all other options will be assessed. As stated previously, the latest predictions of sea level rise were used in the flood modelling, which was then undertaken for the following epochs: 2055, 2085 and 2107.

The flood probability, estimated damages and defence contribution to risk for each of these scenarios is presented in Figures 7.6 to 7.14.

Figure 7.6 clearly shows that by 2055, almost the entire study area will flood under frequent (2-5 year) return period events. This is due to a combination of elevated water levels and degraded defences resulting in higher overtopping and frequent breaching. In the nature reserve, the ground level behind the defences is approximately 3m, so a breach of this defence during anything above a five year event would cause weiring of water through the breach and into the low lying LNR. During a 1000 year event, a head of around 0.6m could occur.

In 2085 and 2107, the defences along the entire study frontage would be frequently breached causing severe and widespread flooding throughout the study area and further to the west along the main Eastoke Peninsula. The figures showing the contribution of each defence to the predicted flood damages show that unlike the present day scenario where certain defences were more susceptible to overtopping and breaching than others, the contribution to risk is far more uniform. The main reason for this is that extreme still water levels would be almost at the crest level of the defences at this time. Under these circumstances, continued habitation of the houses at the eastern end of the Eastoke peninsula would be impossible.

7.5.3 Do Minimum scenario

The probability of flooding and the resultant economic damages have also been predicted for a so called Do Minimum scenario. This case would involve continued management of the beach and existing defence structures until the end of their residual life. After this, no further investment would take place. The Do Minimum option has also been considered in a similar manner and has been used as well as the Do Nothing scenario to assess the economic feasibility of the proposed coastal defence options at a later stage. As may be expected, the flooding and associated damages were initially less than those predicted under the Do Nothing scenario but increased considerably in years 2085 and 2107. The results of this analysis are not presented here but the economic damages are presented in the later Economic Appraisal chapter (Chapter 9).

7.6 DO NOTHING FLOOD LOSSES

As with the economic losses due to erosion that were presented in the previous report (Chapter 6), the predicted annual damages due to flooding have been assessed. The damages have been calculated at 5 yearly increments and the actual damages have been discounted to PV values, as described in Chapter 6. The 5 yearly damages are presented in the following summary table showing incremental and cumulative losses. It is important to note that the damages due to erosion as described in the previous chapter have been subtracted from the flood damages so as to avoid double counting of the benefits of improving the defences around Eastoke Point, i.e. ignoring the damages to properties cased by flooding after they have been lost to coastal erosion.

Table 7.3 Incremental and cumulative losses for each 5 year period

Period	Incremental Losses		Total Losses		Discount Factor
	Un-disc. (£)	Disc.* (£)	Un-discounted (£)	Discounted* (£)	
5	1,200,000	1,083,618	1,200,000	1,083,618	0.90302
10	2,300,000	1,748,741	3,500,000	2,832,359	0.76032
15	3,400,000	2,176,600	6,900,000	5,008,959	0.64018
20	4,400,000	2,371,672	11,300,000	7,380,631	0.53902
25	5,500,000	2,496,129	16,800,000	9,876,760	0.45384
30	6,650,000	2,541,138	23,450,000	12,417,898	0.38213
35	7,700,000	2,512,882	31,150,000	14,930,780	0.32635
40	8,750,000	2,463,221	39,900,000	17,394,001	0.28151
45	9,900,000	2,404,055	49,800,000	19,798,056	0.24283
50	10,948,891	2,293,471	60,748,891	22,091,527	0.20947
55	12,600,000	2,276,708	73,348,891	24,368,235	0.18069
60	14,400,000	2,244,468	87,748,891	26,612,703	0.15587
65	16,000,000	2,151,220	103,748,891	28,763,923	0.13445
70	17,800,000	2,064,422	121,548,891	30,828,345	0.11598
75	19,500,000	1,950,865	141,048,891	32,779,210	0.10004
80	21,205,864	1,856,469	162,254,755	34,635,679	0.08755
85	23,600,000	1,826,100	185,854,755	36,461,779	0.07738
90	25,900,000	1,771,304	211,754,755	38,233,083	0.06839
95	28,300,000	1,710,646	240,054,755	39,943,729	0.06045
100	30,583,672	1,633,971	270,638,427	41,577,700	0.05343

As shown in Table 7.3. The cumulative 100 year flood damages (discounted to present values) are in excess of £41,000,000. The results of this analysis are also presented graphically in Figures 7.15 and 7.16.

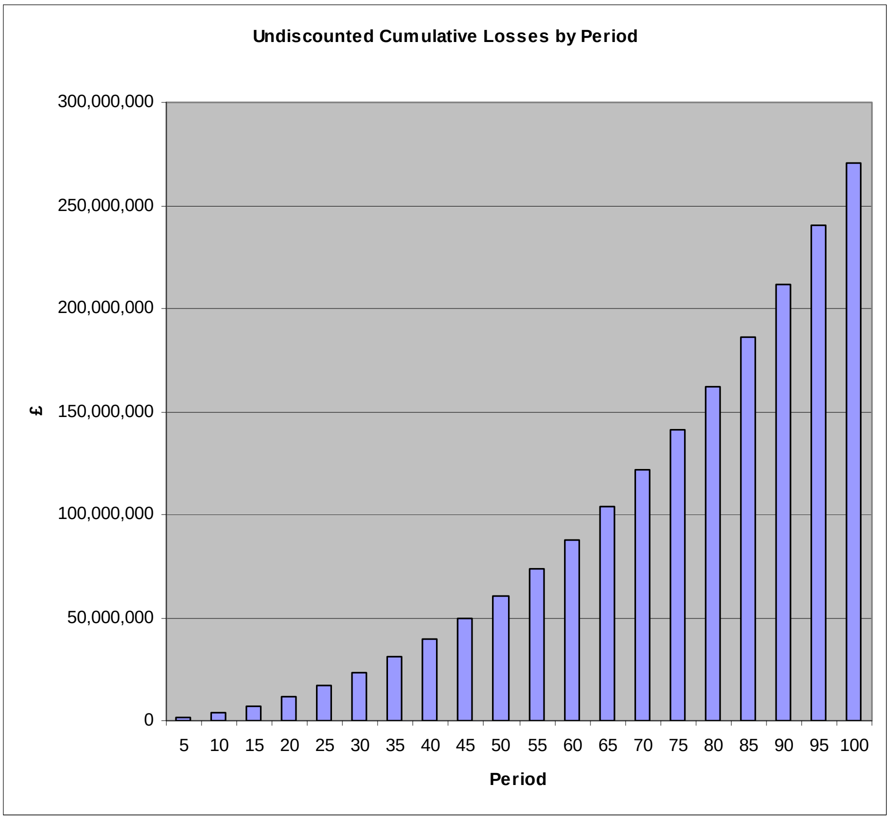

Figure 7.15 Undiscounted Cumulative Losses by Period

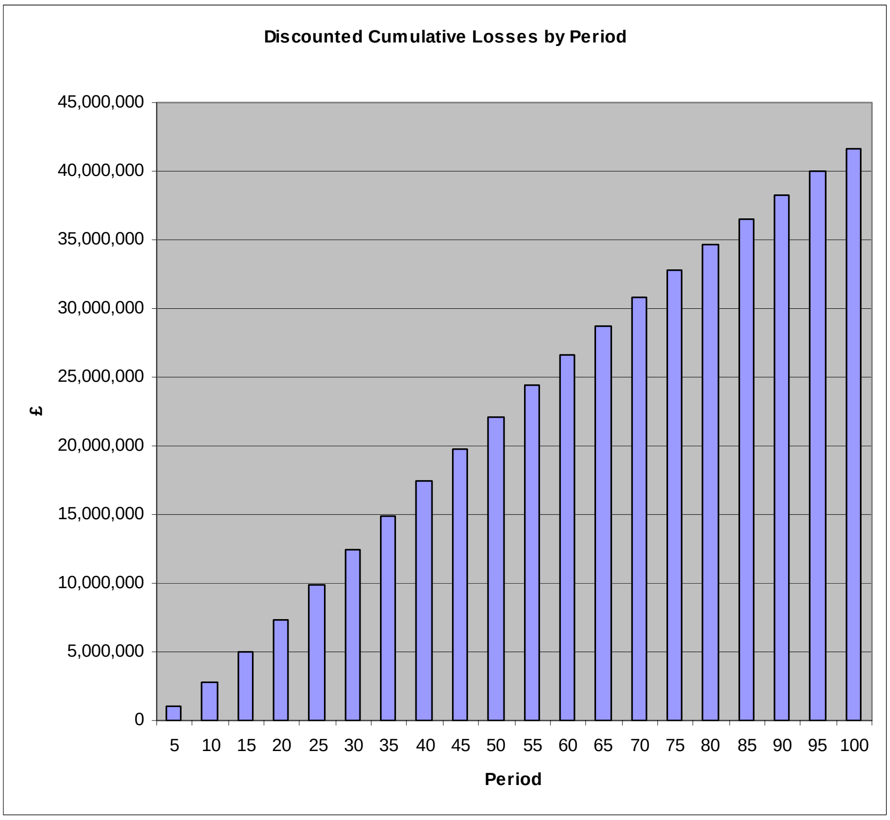

Figure 7.16 Cumulative Damages by Period

7.7 SUMMARY

The results of the flood risk assessment show that overtopping and flood damage to properties can occur even at relatively low return periods with the beach around the Eastoke Point frontage at present day levels. This assessment of the present Standard of Protection (SOP) offered by these defences is consistent with the recent occurrences of flooding, and indicates that a significant number of properties in the eastern part of Eastoke are at risk of coastal flooding even when events with a return period of less than five years occur.

Further, if beach levels are allowed to drop and defences are not maintained, a breach at Eastoke Point will rapidly develop resulting in even more frequent and widespread flooding and extensive property (and amenity) damage. This problem will be exacerbated if sea levels rise in line with the latest predictions rather than the 6mm annual rise given previously. If allowed to continue, this situation will ultimately cause the Eastoke community to become economically unsustainable and a valuable ecological habitat to be destroyed.

Evaluation of the economic consequences of adopting a Do Nothing scenario, as calculated in this section of the study, indicates that over £41,000,000 (discounted) damages will occur over the next 100 years. This assessment of flood risk has therefore shown that there is both an urgent need and an economic case for improvement of the current defences around Eastoke Point. This latter issue is returned to in the next stage of the study, in which the economic case for such improvements is investigated in more detail.

8. *Coastal Defence Options: Generation and Evaluation*

8.1 INTRODUCTION

The overall coastal defence policy for the Eastoke Point frontage, as established in the East Solent Shoreline Management Plan (HR Wallingford, 1996) is to Hold the Line. Subsequently, a Coastal Defence Strategy Study for the whole of the Eastoke peninsula, the Sectoral Strategy Study (Atkins, 2006) considered some options for suitable schemes to achieve this policy at Eastoke Point that would provide an adequate standard of defence to the low-lying residential areas inland from the Sandy Point Nature reserve.

This strategy study first considered alternatives to the Hold the Line decision, established by the Shoreline Management Plan over a decade earlier, to ensure that this was still the appropriate defence policy, and carried out an initial screening of alternatives. This concluded that to Do Nothing was not justifiable because of the economic consequences of the “large loss of properties and amenity”. The present study has carried out a further evaluation of the economic losses that would result from this possible policy, (see Chapters 6 and 7).

The strategy study did, however, decide that it would be sensible to take forward four possible defence options for the Eastoke Point coastline to more detailed consideration, namely Do Minimum, Inland Flood Defence, and two options for Holding the Line, namely schemes involving (a) Beach Management and (b) Revetment / Rock groynes.

This 2006 strategy study then went on to provide costs for three possible of these options, namely Beach Management, Revetment and Groynes and Do Minimum. These three options were briefly described in Appendix 4 of their report, and these descriptions are summarised (and clarified) as follows: