Isle of Grain to South Foreland
Shoreline Management Plan (SMP) Review

Appendix C – Baseline Process Understanding

Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Approved by
1	0	Consultation Draft	01.05.07	S McFarland
	1	Amendments following public consultation	11.03.08	N Pontee
	2	Amendments following QRG review	08.07.09	N Pontee
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Appendix C: Baseline Process Understanding

Contents by Policy Unit

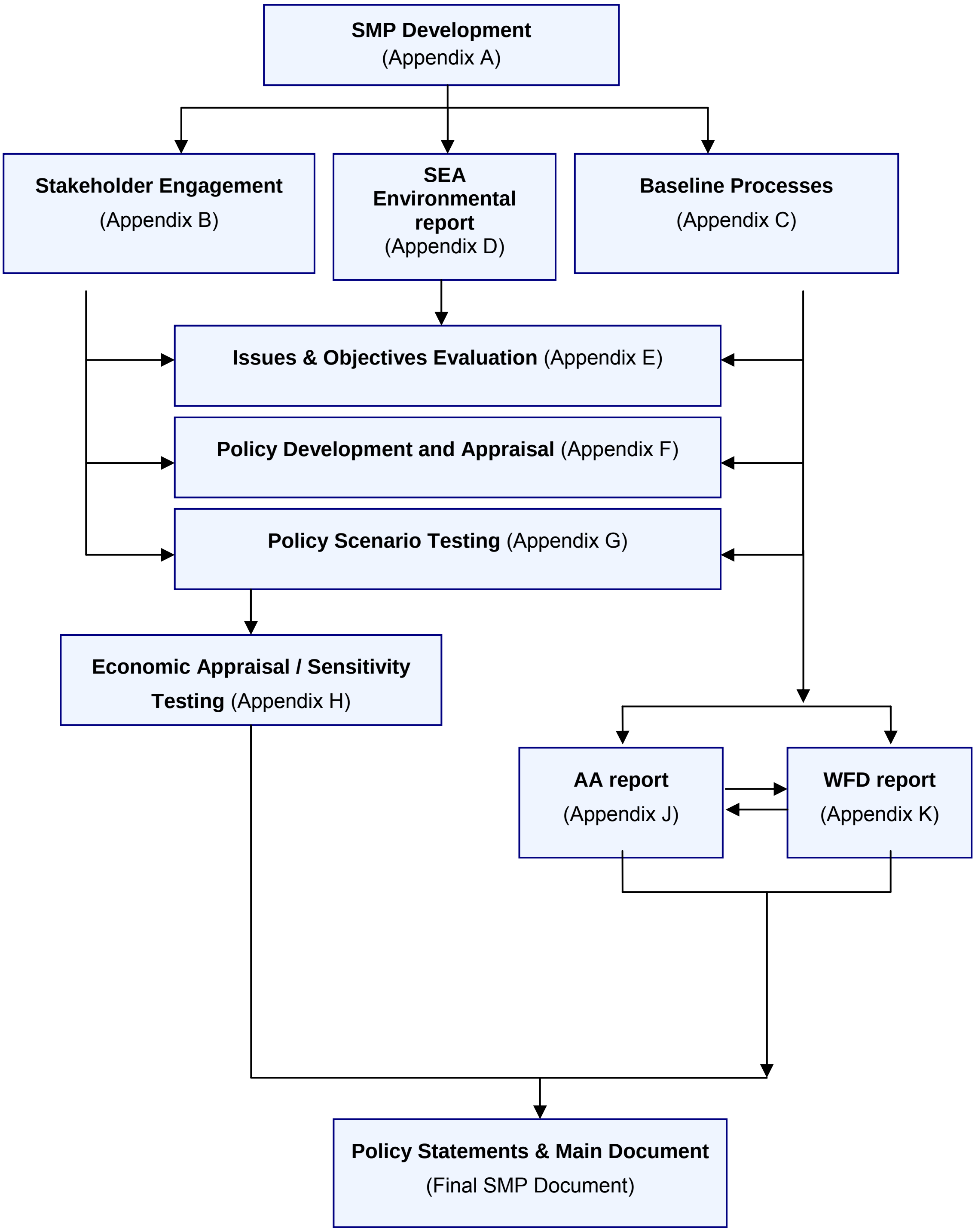
Note the geographic breakdown of the appraisals presented in this Appendix is not necessarily the same as the final Policy Units (PU). In this appendix the breakdown has been based upon coastal process and morphological changes along the shoreline. For ease of reference, the following table identifies the page number on which appraisals relevant to each PU start.

The Supporting Appendices

This appendix and the accompanying documents provide all of the information required to support the Shoreline Management Plan. This is to ensure that there is clarity in the decision-making process and that the rationale behind the policies being promoted is both transparent and auditable. The appendices are:

A: SMP Development	This reports the history of development of the SMP, describing more fully the plan and policy decision-making process.
B: Stakeholder Engagement	All communications from the stakeholder process are provided here, together with information arising from the consultation process.
C: Baseline Process Understanding	Includes baseline process report, defence assessment, NAI and WPM assessments and summarises data used in assessments.
D: SEA Environmental Report (Theme Review)	This report identifies and evaluates the environmental features (natural environment, landscape character, historic environment, land use, infrastructure and material assets, and population and human health).
E: Issues & Objective Evaluation	Provides information on the issues and objectives identified as part of the Plan development, including appraisal of their importance.
F: Initial Policy Appraisal & Scenario Development	Presents the consideration of generic policy options for each frontage, identifying possible acceptable policies, and their combination into ‘scenarios’ for testing.
G: Scenario Testing	Presents the policy assessment and appraisal of objective achievement towards definition of the Preferred Plan (as presented in the Shoreline Management Plan document).
H: Economic Appraisal and Sensitivity Testing	Presents the economic analysis undertaken in support of the Preferred Plan.
I: Metadatabase and Bibliographic database	All supporting information used to develop the SMP is referenced for future examination and retrieval.
J: Appropriate Assessment	Presents an assessment of the effect the plan will have on European sites.
K: Retrospective WFD Assessment	Presents a retrospective Water Framework Directive Assessment.

Within each appendix cross-referencing highlights the documents where related appraisals are presented. The broad relationships between the appendices are as below.



C. Assessment of Shoreline Dynamics

C1.1 Introduction

This report should be viewed as supplementary to information held within Futurecoast (2002) and more specifically the Shoreline Behaviour Statements for the following areas:

- North Coast – Allhallows-on-Sea to North Foreland

- East Coast – North Foreland to South Foreland

It contains relevant information produced post Futurecoast or at a level of detail not included within Futurecoast e.g. alongshore variations in sediment transport rates. The two must be read in conjunction with one another to provide a full understanding of dynamics and behaviour across different spatial and temporal scales.

C1.2 Overview

The coastline between the Isle of Grain and South Foreland has been retreating and changing in orientation over the last millennia in response to sea level rise and the large-scale drowning of the English Channel since the Holocene Marine Transgression (c.10, 000 years Before Present (BP). 8,000 years ago the entire English Channel and Dover Straits area was inundated but there was still shallow land separating this water body from the North Sea. This connection was breached around 7,500 years ago linking the English Channel to the North Sea. Tidal models have shown that the opening of the Dover Straits initiated the strong eastward transport in the eastern Channel (Austin, 1991). More recently, the rate of change has been slowed by the construction and maintenance of coastal defence, which means that much of the coast is not commensurate with the shoreline energy conditions, which has implications for future shoreline management. Foreshore steepening is a prevalent feature of beaches throughout the frontage and this characteristic has been exacerbated by the coastal defences.

A key control on evolution of this stretch of coast is the presence of moderately resistant Chalk geology of North Foreland. It is believed that North Foreland segregates coastal processes between the north Kent and east Kent coast. Waves along the north Kent coast are predominantly from the northeast and southwest whilst on the east Coast waves are from the northeast, east and southwest.[1]

This coastline is susceptible to storm surges, which tend to be caused by two main mechanisms; easterly surges generated in the North Sea and westerly surges generated by depressions in the Atlantic (Bray *et al.*, 1997; Halcrow, 2000a). Surges are the main conditions under which significant amounts of the beach shingle are moved.

There are significant low-lying areas, for example the Isle of Grain, the Isle of Sheppey, Faversham Creek to Seasalter, Reculver Towers to Minnis Bay and Cliffs End to Oldstairs Bay that are dissected by sections of cliff, nominally at Grain, Minster, Warden, North Foreland and South Foreland. There are three estuaries along the Isle of Grain to South

Foreland frontage, two in the north (Medway and Swale) and one on in the east (Stour). Numerous defence works have trained the channels which influences the hydraulic discharge.

There are two distinct types of sediment on the beaches between Isle of Grain to South Foreland (i) shingle-size material and; (ii) medium sized sand. In some places, such as Kingsdown and Walmer, for example, the stability of the shingle beach is closely related to the presence of finer sediments on the lower foreshore. These provide a stable base, with their erosion or deposition being one factor that can alter the form and behaviour of the upper beach. Historically tidal flat and saltmarsh deposits have accumulated in the lee of the shingle barriers, creating platforms onto which the barrier can naturally migrate.

Virtually all (99%) of the shingle along the north and east Kent coast is believed to be composed of flint (silica). The source of this material is a culmination of the erosion of flint from the chalk cliffs between Minnis Bay and Cliffs End and Oldstairs Bay and South Foreland. Shingle input into the sediment budget, both natural and artificial, is not known. However, it is acknowledged that both man-made and natural features interfere with the natural supply and movement of sediment, for example the harbour arms of Dover and further west Newhaven as well as the chalk cliffs of South Foreland, intercepts the longshore supply. Along the frontage itself, the construction of Whitstable Harbour, Herne Bay Breakwater and Ramsgate Harbour significantly affect the longshore movement of sediment.

Offshore banks are believed to be relict features of the Holocene Marine Transgression (10,000 years BP). Sandbanks located off the north Kent coast are believed to influence coastal processes and sediment transport patterns. Sand from these banks feed onshore, naturally replenishing the sand beaches on the Thanet coast and there is some evidence that sand from the Margate Hook may feed onto the beaches as far west as Bishopstone Glen (D'Olier, pers comm.). On the east coast they are believed to exert a key control on the wave climate and sediment supply. Goodwin Sands, located between 4 and 12 km offshore of Deal, is the most notable. Forming a series of natural shallow sandbanks, which are maintained by the tidal currents of the area (Deal to Kingsdown Strategy Study, 2001); Goodwin Sands buffers the offshore wave climate and as such alters the inshore wave climate. Deal Bank is also important, located approximately 7km offshore of Kingsdown it too exerts an influence on the wave climate.

Between Allhallows-on-Sea and North Foreland the predominant movement of sediment is east to west, although there are local exceptions i.e. between Warden Village and Shell Ness and drift reversals i.e. Minnis Bay to Margate. At North Foreland transport is locally reversed, travelling southwards and converging to the south of Ramsgate. Between the River Stour and South Foreland, the dominant waves result in the transport of sediment in an easterly direction.

The study frontage can be split into two main environments: cliffs and low lying land, which over the next 100 years are likely to respond in the following manner:

1. The cliffed sections will generally continue to erode at a rate slightly greater than previously experienced as a consequence of sea level rise and increased sub-aerial weathering. Rates of retreat will depend on geology but they could range from as low as 3 to 50m at North Foreland (D'Olier, 2007) to as high as 75 to 300m at Minster Slopes and Reculver Country Park by 2105. Rising sea levels will force the rocky platforms fronting the cliffs to become increasing less effective, which will increase wave attack at the cliff toe. It is unlikely that cliff erosion will keep pace with sea level rise, which could have increased some 100cm by 2105 (Defra, 2006). The erosion at the cliff toe will trigger further instability, providing predominantly fine sediment to the system, as periodic slumps become more frequent. Initially this will be in the form of foreshore 'cover' before being dispersed downdrift and offshore. Despite an increase in cliff erosion, very little additional beach building material will be released into the system; resulting in little benefit to low-lying downdrift frontages.

2. The low-lying areas are predominantly areas of alluvium (fine sediment) and it is anticipated that they will be inundated in response to sea level rise. The pace and severity at which this occurs is however, dependant on the rate of sea level rise and the topography of the hinterland. Sediment feed to these low-lying frontages is low due to an increase in coastal protection measures, which exacerbates the situation. With time, breaching of the beach is anticipated and this will become more frequent in the future, expanding the area of transitional saline-influenced habitat. This would lead to the development of brackish environments and potentially, in the very long term (+100 years) the creation of a tidal inlet. Such change is intrinsic to a dynamic coastal environment and therefore an important component in delivering sustainable shoreline management.

C1.3 North Coast: Isle of Grain to North Foreland

REGIONAL SCALE: ISLE OF GRAIN TO NORTH FORELAND

Interactions

The open coast shorelines of the Isle of Grain, the Isle of Sheppey and North Kent and Thanet are diverse in nature, composition and orientation. The geology of the coastline is dominated by Cretaceous Chalk (99 to 65 million years ago (ma)) in the east and by Tertiary sediments (65 to 40 ma), primarily London Clay but with some poorly cemented silts and sands, in the west. The Chalk can be found on the foreshore and in cliff sections east of the Wantsum Channel. Between Bishopstone and the Wantsum Channel there is a short section of cliffs comprised of Lower Tertiary sands and silts. West of Bishopstone, London Clay dominates where it can be seen in exposures on the foreshore or in complex landslips on the higher ground.

Tectonic movements in the Miocene (22.5 to 5 ma) resulted in the uplift of the Wealden area of Kent. This created a system of rivers which drained off the higher ground towards the north and east in what is now the Thames Estuary and Southern North Sea. The rivers would have eroded the bedrock providing a good deal of coarse, mainly flint, sediments. As sea levels rose, following the retreat of the ice sheets approximately 10,000 years Before Present (BP), the southern North Sea, together with the old river beds, was submerged. Strong tidal currents gradually swept sediments up into sand banks and shingle barrier beaches.

Low-lying parts of the coastline, for example Whitstable Bay, typically have soft superficial deposits overlying the older geology. These are comprised primarily of mud and alluvium deposits.

The littoral processes that drive sediment along these shorelines are equally diverse because of the variation in water depths and tidal conditions that exist between the two ends of this process unit.

With the exception of the east facing part of Thanet, the forcing conditions that have the greatest influence on this shoreline are those generated by weather systems acting on the relatively shallow southern North Sea. Generally speaking there are two different types of storm event and these are generated from two different directional sectors. Due to the greater fetch from the east and northeast sector, larger waves are generated than from the northwest. However, because the low pressure weather systems that are responsible for generating waves from the northwest are also associated with storm surges and higher water levels, the impact of such events can sometimes be more significant. The low pressure systems that generate strong easterly and north-easterly winds, and hence larger waves from these direction sectors, are therefore not normally associated with large increases in water levels.

This complex pattern in offshore generated conditions results in an equally complex range of wave energy conditions driving the sediment transport processes inshore. Studies and anecdotal evidence have nonetheless shown that along the north facing shorelines the sediment transport rates in both eastward and westward directions are similar, although there is a dominance of wave energy from the northeast which results in a net westward drift of material.

There are, however, examples of localised reversals in this drift direction at locations on the Isle of Sheppey and at Tankerton Bay, although this is generally due to localised changes in shoreline orientation.

There are also a number of locations where the shoreline faces due east and along these lengths the same predominant wave conditions have a quite different effect on sediment transport. With the exception of the east coast of Thanet the remainder of the east facing beaches are relatively sheltered from waves from the south and consequently the general drift direction on these frontages is north to south.

Offshore sandbanks in the east of the area are likely to have an influence on coastal processes and sediment transport patterns along this section of the coast. Sand from these banks is believed to feed onshore, naturally replenishing the sand beaches on the Thanet coast. There is some evidence that sand from the Margate Hook may feed onto the beaches as far west as Bishopstone Glen (D'Olier, pers comm.). The Margate sandbar, located 4km offshore, parallel to the coast, also provides a degree of protection to the north coast, west of Foreness Point.

A critical point about this section of coastline is that there is now almost no natural feed of 'new' sediment into the system. The exceptions being:

- Finer sediments released from eroding clay cliff sections on the Isle of Sheppey and from the silty sand cliffs at Reculver;
- Erosion of bedrock where exposed on the lower foreshore;
- Fine sediment from fluvial sources; and,
- The sand which feeds into the Estuary and onshore in Thanet from the offshore sandbanks.

The shingle beaches which dominate the western frontage are relict beaches, which have been substantially enlarged artificially through beach renourishment. There is very little contemporary feed of coarse material into the area, although the majority of that which currently exists on the beaches does remain within the boundaries of this process unit. It is therefore assumed that for coarse material at least, the system is closed and any losses must be explained by a combination of local sediment sinks and the possibility of losses to abrasion.

The River Medway represents a source of fine sediments, but the River Swale is unlikely to be a sediment source at present: it is more likely to be a sink for fine sediment. These source-sink relationships between the estuaries and the open coast may, however, change with future sea level rise (Futurecoast, 2002).

Movement

Historically the estuaries of the Rivers Thames, Medway and Swale have fragmented the open coast into a series of islands, such as the Isle of Grain, the Isle of Sheppey, Elmley Island and the Isle of Harty. In the past, the intervening channels between these islands became infilled by alluvial deposits resulting in the development of inter-tidal flats and marshes. These were then substantially embanked and reclaimed for agricultural use by the end of the Roman period. The marshes immediately west of Whitstable were reclaimed much later, however, and reclamation there was not completed until the 17th or 18th Century (Futurecoast, 2002).

The inter-tidal flats fronting both the Isle of Grain and the Isle of Sheppey have slowly been accreting vertically due to sediment deposition, despite recorded net loss of area and marsh-edge erosion over recent decades. This plan-form erosion has been caused by coastal squeeze associated with sea level rise (Futurecoast, 2002).

Historically the chalk cliffs and platforms have eroded and lowered at relatively low rates. Futurecoast (2002) specifies a typical erosion rate for chalk cliffs of around 0.1m/year. This will increase where rocks are fractured. Cliff erosion rates of 1m/year are more typical of the Tertiary deposits, although in extreme cases average erosion rates of several metres per year are possible, for example at Studd Hill.

Modifications

There is a long history of modifications of the coastline including extensive land reclamation and drainage of coastal marshes mainly from the 12th and 13th centuries and large scale construction of seawalls and embankments from the late 18th century. More recently beach management practices have had a major impact on the shoreline.

Key anthropogenic modifications are:

- Reclamation and closure to the sea of coastal marshes on Isle of Sheppey, Whitstable Bay and the Wantsum Channel;
- Construction of seawalls and promenades to protect the toe of the chalk cliffs from erosion in Thanet;
- Stabilisation through toe protection and regrading of the London Clay slopes at Minster, Seasalter, Tankerton, Studd Hill and Herne Bay;
- Construction of Hampton Pier and Whitstable Harbour which both impede westward transport of shingle; and,

- Widespread construction of timber groynes that restrict alongshore transport of shingle along the bulk of the study frontage.

LOCAL SCALE: ALL HALLOWS-ON-SEA TO MINSTER

Interactions

This section of frontage comprises of a low lying section of open coast, intersected by Yantlet Creek and the River Medway. The villages of All Hallows and Grain both sit on localised areas of high ground, and are fronted by a narrow steep beach composed of shingle. The hinterland contains large areas of agricultural land that was once saltmarsh, but has been enclosed and reclaimed from the sea. The Isle of Grain is fronted by wide inter-tidal flats. Lappel Bank, on the Isle of Sheppey, was reclaimed from the sea relatively recently.

Sediment transport processes are dominated by cohesive sediment. Consequently, the frontage receives input from the outer Thames estuary, although understanding of these processes remains poor (Futurecoast, 2002). There may be a southward drift into the Medway Estuary. Coarse sediment transport in this area has not been studied in any detail, however it is expected that there will be a small transport in an east to west direction along this frontage. Groynes have been constructed with the intent of slowing alongshore transport of coarse sediment.

Movement

SMP1 (Halcrow, 1998) looked at historical mapping of mean low water (MLW) and the coastline dating from 1897. These maps showed that between Yanlet Creek and River Medway, apart from around the mouth of Yanlet Creek where the approach channels have varied in location, the position of mean low water has changed little since 1897, with fluctuations in position rather than a net trend evident. In terms of the coastline position, changes again have generally been quite small.

There have been changes in the coastline position in the vicinity of Sheerness Docks, which can be related to land reclamation projects along the Lappel Bank. There has also been a net retreat in both the MLW and coastline position along the Sheerness frontage. The SMP (Halcrow 1998) also identified that aerial photographs showed that the sand and mudflats fronting this length of coastline are eroding fairly rapidly.

Present defences along this section are currently holding the plan position of the coastline. However, it is likely that the foreshore is narrowing in response to coastal squeeze; the result is a net loss of surface area of the inter-tidal flats and a reduction in wave energy, therefore increasing the vulnerability of the defences.

Predictions of Shoreline Evolution

For an unconstrained scenario, Futurecoast (2002) predicted that large scale tidal inundation of extensive areas would occur, dramatically changing the plan form of the coastline, and ultimately leaving the high ground of Grain as an island. Similarly, the mouth of the River

Medway Estuary would be re-defined, resulting in higher areas of Sheppey becoming islands.

The existing hinterland would revert to inter tidal area, allowing lower mudflat and saltmarsh species to dominate. It is envisaged that these areas could act as sinks for fine grained sediment, potentially allowing vertical accretion and therefore the development of higher zone saltmarsh and mudflat species.

The Futurecoast (2002) prediction for a ‘with present management’ scenario is for coastal squeeze to occur as a result of sea levels rising, whilst the backshore position of the shoreline is held by defences. This would ultimately result in a net loss of surface area of the inter-tidal flats, despite their continued vertical accretion. In turn, this would result in increased pressure on the present defences.

LOCAL SCALE: MINSTER TO LEYSDOWN-ON-SEA

Interactions

This frontage is dominated by London Clay sea cliffs that are capped in places with Claygate and Bagshot Beds. The Claygate Beds consist primarily of silts and clays with subordinate sands, whilst sands are more common in the Bagshot Beds. Where these beds overly the London clay they give rise to springs and clifftop ponds. The springs and ponds in turn are a major contributor to seepage erosion and landslides in cliffs along this part of the coastline (Canterbury City Council, 2002).

There is a distinct sediment transport divide at Warden Point. West of Warden Point, transport is westward; whilst to the south and east, transport is southward. West of Warden Point, the potential net shingle transport rate has been estimated at between 1,000 to 3,000m^3/year (Canterbury City Council, 2002). Where there are groynes, the actual net transport may be less.

In the vicinity of Warden Bay shingle movement is southward, at a potential rate of 3,000 to 4,000m^3/year (Canterbury City Council, 2002). Timber groynes have been constructed to retain a larger protective shingle beach and reduce alongshore transport rates. However, as the cliff retreats, the groynes are becoming outflanked and as a result are becoming less effective.

On a wider scale, the fine material released from the cliffs along this frontage is transported in suspension into the Outer Thames Estuary where it contributes to the large volume potentially available for deposition on the inter-tidal flats and marshes elsewhere within the coastal / estuarine system. The volume of coarser material (sand and shingle) released is insufficient to build up a protective foreshore. Instead, this material is primarily transported westwards along the Sheppey frontage towards Garrison Point, although due to the littoral drift divide at Warden Point some coarse grained material also moves towards Shellness.

Movement

The foreshore along this frontage is comprised of a narrow shingle beach sitting on top of a shore platform, cut into the London Clay basement (Futurecoast, 2002). The lower foreshore slopes gently seawards providing a wide shallow offshore platform. Sediment cover on the lower foreshore is characterised by muds, silts and fine sands.

The cliffs vary in height from 8 to 52 m and are subject to extremely rapid erosion, caused by landsliding, with the debris material being rapidly removed by tidal action (Futurecoast, 2002). The bulk of this material is fine and is washed into the estuary. A small amount of coarse material is released but the bulk of this is claystones or nodules, which tend to break-up on the beaches relatively soon after release.

There are 3 main mechanisms causing cliff instability at this location:

1. **Seepage erosion** – occurs when the flow of water through permeable stratum comprising head gravel, head brickearth, Claygate and Bagshot beds at the cliff top is large enough to dislodge and remove soil particles when water discharges at the cliff face;

2. **Surface erosion** – Occurs as a result of high intensity storms, where raindrop pressure and surface water run off dislodge soil particles; and,

3. **Toe Erosion by Wave Attack** – The cliffs and landslide debris are eroded by abrasive wave action during storm events.

The London Clay cliffs at this location are subject to extensive deep seated rotational slip failures affecting the whole slope. This has been observed and reported by Hutchinson, who discovered that at Warden Point, the intensity of toe erosion is such that it exceeds the rate at which mudslides and landslide debris from the slope discharge to the foreshore, which gives rise to rapid erosion.

Historically, the shore platform, beach and cliffs were stripped for septaria nodules and iron pyrite from the London Clay up until the early 20th Century. This resulted in relatively rapid cliff recession (Futurecoast, 2002).

Analysis of historical Ordnance Survey maps for this section of coast (undertaken for SMP1; Halcrow, 1998) show that there has been a general trend of retreat for both MLW and the coastline. The rate of MLW retreat has been greater than the rate of coastline retreat suggesting that there has been steepening of the foreshore over the period of mapping (1897 to 1974).

Predictions of shoreline evolution

Where the cliffs along this frontage are defended, the likelihood of landsliding is reduced, but not completely eliminated. Where undefended, cliff recession will continue potentially at an increasing rate due to accelerated sea level rise. SMP1 (Halcrow, 1998) predicted that under a ‘do nothing’ scenario ‘significant erosion’ would occur by 2070.

Material released from eroding cliffs would be washed away from the base of the cliffs, leaving them susceptible to further instability. There would however be a beneficial impact from the additional predominantly fine sediment available in the coastal / estuarine system. The foreshore platform would be likely to experience continued steepening, enabling greater wave energy to attack the cliff base.

The future evolution of this section of coast will be dependent upon any changes within the Swale estuary, particularly if large-scale inundation of the Isle of Sheppey were to occur, which would result in areas of higher ground within this frontage becoming subject to marine influences on both the northern (presently sea-facing) and southern (presently land-locked) sides (Futurecoast, 2002).

LOCAL SCALE: LEYSDOWN-ON-SEA TO SHELLNESS

Interactions

The geology of this part of the Isle of Sheppey, like much of the North Kent coast, is dominated by London Clay. The foreshore consists of muddy tidal flats, which form a wide offshore platform. This platform is important as it places limitations on the maximum height of waves incident on the coastline. The beach consists of a steep ridge, comprised of sand and shell fragments, with a small proportion of shingle.

Limited studies on sediment transport appear to have been carried out along this section of the coastline. At Warden Bay to the north, shingle moves in a southward direction, through a timber groyne field. Actual transport rates are not known but it is expected that relatively small quantities of shingle are currently transported into this section of coast from the north. The major sediment input to this frontage, however, is from offshore shell banks (Futurecoast, 2002).

Movement

Historical map analysis undertaken for SMP1 (Halcrow, 1998) indicates that there has been a net retreat in MLW position over time. The coastline position has not changed, due to the presence of defences along this stretch.

Shell Ness represents a depositional area created by south-eastward drift of sand and gravel sized sediments from Warden Point as well as large quantities of shell material derived from the tidal flats. Saltmarshes have developed in the lee of Shell Ness (Futurecoast, 2002). Historically, there has been accretion of shell fragments, sand and shingle at Shell Ness itself, despite a general tendency for landward movement further to the North. Historical Ordnance Survey maps show that that Shell Ness has evolved as a spit feature into the estuary mouth, further enclosing the area of saltmarsh in its lee.

Predictions of shoreline evolution

For a ‘with the present management’ scenario Futurecoast (2002) predicted that the position of the coastline would remain fixed, resulting in foreshore lowering and squeeze of the tidal flats between a rising sea level and a static backshore structure.

The beach ridge, between Leysdown and Shell Ness could respond to rising sea levels by thinning / migrating landward across the low-lying backshore. There is a risk that the ridge could be breached, over time the frequency of this occurring will increase and eventually inundation is anticipated. In this instance a change in the dynamics of the open coast system to an estuarine system is anticipated. It is likely that the Swale estuarine system would expand and new areas of inter-tidal habitats would be created. There is also the potential for the Isle of Harty to become separated from the Isle of Sheppey during this epoch, providing the Swale estuary with an additional outlet. SMP1 (Halcrow, 1998) predicted that under a ‘do nothing’ scenario flood defences would be lost resulting in extensive areas being prone to inundation, but that under a 1:200 year event the Isle of Harty would not be flooded.

The future evolution of this stretch of coast is in turn dependent upon changes within the Swale estuary itself.

LOCAL SCALE: FAVERSHAM CREEK TO WHITSTABLE

Interactions

This frontage forms an important zone of interaction between the Swale estuary and the open coast and is fed by fine-grained material supplied from the outer Thames estuary (Futurecoast, 2002).

At Whitstable the shoreline is orientated at a sharp angle to the natural equilibrium and as a consequence has a strong unidirectional drift from east to west. The potential drift rate for the shingle beaches is estimated to be as high as 10,000 m^3/year (Canterbury City Council, 1994), however, the presence of a large and closely spaced groyne field effectively locks the shingle beach in place. The potential alongshore transport rate decreases westward (typically 2,500 m^3/year at Admiralty Walk, 1,000m^3/year at Faversham Road and no more than a 500m^3/year at Cleve). This is partly because the shoreline orientation is closer to the natural equilibrium position and partly because the lower foreshore levels rise to the west, resulting in reduced wave energy.

The actual shingle transport rates, however, increase from east to west as a result of the varying size and condition of the controlling groyne fields. In the east the groynes are large and well maintained and allow no alongshore transport. Along Seasalter the groynes are smaller and thus some material bypasses west (around 700 m^3/year). Between Faversham Road and Faversham Creek the groyne conditions vary from adequate to poor with unconstrained movement of shingle in some areas where the groyne fields are completely dilapidated.

Alongshore transport of coarse material terminates at Castle Coote. At this location, approximately 1 km east from Faversham Creek, the beach separates from the sea wall and extends westwards forming a mixed shingle / sand / shell spit. Rapid growth of the spit in recent years is probably attributable to increased alongshore transport resulting from progressive decay of the beach control structures to the west of the frontage.

Little is known about the movement of finer sediment in the area, however it is noted that finer sediments do seem to be accreting in the mouth of the Swale Estuary particularly on the south side of the Isle of Sheppey.

Seawalls and beaches between Whitstable Harbour and Seasalter Slopes are in good condition. It is worth noting however that the seawall at Whitstable is relatively low in relation to the anticipated extreme water level. This will become an increasingly important factor over time as sea level rise results in a reduction in the “freeboard” and increase in exposure to wave energy.

Movement

London Clay slopes and foreshores with a veneer of more recent superficial deposits dominate the geology of this section of coast. Its nature lends to rapid coastal erosion and slope instability.

West of Graveney marshes, there are extensive tidal flats backed by large areas of former marsh that have been enclosed and reclaimed from the sea for agricultural use. The inter-tidal area, which extends 2 to 3km seawards, is dominated by mussel beds and small banks of sand and shells. The foreshore here is stable or accreting (Canterbury City Council, 2004).

Between Seasalter Slopes and Seasalter Levels, the lower foreshore is showing strong erosional tendencies. Where exposed, the London Clay exhibits thermal cracking on the surface layers; this leads to an acceleration of the foreshore lowering process.

The foreshore at Whitstable now comprises just a thin layer of finer sediment overlying London Clay, the alluvium and saltmarshes having been lost around 100 years ago.

Despite slow vertical accretion of the tidal flat surface, the shoreline is thought to have historically retreated landward, although the Castle Coot spit is a depositional landform (Futurecoast, 2002). Historical evidence has shown that defences were first constructed to protect the area of Graveney Marshes against flooding in the 13th century (Halcrow, 1998). However, it was not until the late 1890s that frequent breaching of these defences was stopped (Halcrow, 1998). Historical maps, dating back to the 1890s, therefore show no discernible change in the coastline position. Changes in the MLW position do, however, suggest retreat of this line over time (Halcrow, 1998).

Predictions of shoreline evolution

In the short term little change is expected at Whitstable other than a gradual loss of beach volume estimated at 0.5 m^3/m/year (Canterbury City Council, 2004), and a decrease in the seawall freeboard as described above. Beach erosion would be expected to increase once wave action was able to reach the seawall during high tide, at which time the threat to the town from flooding via overtopping and/or seawall failure would be significant.

West of Seasalter Levels, the present pattern of rapid lower foreshore erosion is expected to continue and perhaps spread westwards particularly if the beach levels decrease. The present policy of small injections of shingle at the Blue Anchor and the Sportsman are unlikely to keep pace with the combined effects of lower foreshore erosion, sea level rise and further deterioration of the groyne field. Probably within the 20 to 50 year period the existing beach sediments would be expected to have been moved alongshore to Cleve Marshes and Castle Coote leaving the Seasalter Levels and Graveney Marshes frontage devoid of coarse sediment, at least until such time as failure of the groyne fields to the west would introduce a fresh injection of material.

The Whitstable to Faversham Creek Strategy (Canterbury City Council, 2004), predicts that a 20 year return period storm would currently breach the sea defences at the Sportsman and thus affect a number of properties along Faversham Road through erosion of the beach. As time progresses the intensity of the storm required to breach the defences all along the frontage will becomes less.

Futurecoast (2002) predicted that for an ‘unconstrained’ scenario, there would be large-scale tidal inundation of extensive areas of previously reclaimed low-lying backshore, creating changes to the existing plan-form of the River Swale estuary. The existing backshore area would revert to inter-tidal, but due to topographical differences between the present foreshore and the present backshore, there would be an initial tendency for mudflats and some lower saltmarsh species to dominate much of the newly-created inter-tidal area.

There are strong linkages between evolution of this shoreline and future evolution of the Swale estuary.

LOCAL SCALE: WHITSTABLE TO RECULVER

Interactions

The coastline between Whitstable and Reculver can be divided into four sections:

(1) Tankerton (a wide bay between Whitstable harbour and Long Rock);

(2) Swalecliffe Bay, a wide bay between Long Rock and Hampton Pier;

(3) A relatively straight section of coastline between Hampton Pier to Bishopstone including the town of Herne Bay; and,

(4) A short section of eroding cliffs between Bishopstone and Reculver.

At Tankerton shingle transport is predominantly east to west with a maximum average potential transport rate of 8,000 m^3/year, at the beach nearest to the Harbour Quay. A small quantity of material bypasses the east quay into the harbour but this is estimated to be less than 100m^3/year.

Along the remainder of the western half of Tankerton the net westward transport potential is less than 8,000m^3/year, whilst the presence of groynes reduces the actual transport rate to less than a few hundred m^3/year. Due to the shelter provided to the eastern part of Tankerton Bay, by the Long Rock headland, there is a reversal in drift direction such that there is a net movement of material towards Long Rock (i.e. west to east). The position of this divide is not fixed and varies depending on the wave climate.

The majority of Swalecliffe Bay is very similar in nature to Tankerton Bay, with an east to west potential transport of shingle of between 2,500 and 7,000 m^3/year. However, at the eastern part of the bay a drift reversal may occur due to the presence of Hampton Pier. Actual transport rates are low, due to the presence of groynes, and therefore the maximum rate of movement is in the region of 2,500 m^3/year at Swalecliffe. The groynes along this frontage are older and as they decay further, actual transport rates are likely to increase with time.

Long Rock itself is a sediment sink with material transported into the area from Swalecliffe and to a lesser extent from Tankerton. On average 3,000m^3/year of shingle is recycled annually from the mouth of Swalecliffe brook where it enters the sea on the western flank of Long Rock. This material is distributed mostly east to Swalecliffe although a small amount is moved west onto the Tankerton frontage. The presence of a shingle bank in Swalecliffe Bay is likely to have some impact of wave patterns and sediment transport, but this is still to be quantified.

Along the Herne Bay frontage, transport is consistently from east to west and varies from a maximum potential of 12,000m^3/year at Herne Bay to zero at Hampton pier. Typical potential rates are 3,000 to 5,000 m^3/year but the actual transport rates are currently reduced by timber groynes.

The Reculver to Bishopstone Glen coastline is mostly unprotected sandstone cliffs with a thin shingle beach. Interestingly, the lower foreshore east of Bishopstone Glen rises to +1.7mAOD compared to -1mAOD to both the east and west. This rise in foreshore levels is caused by the gentle east to west dip of the Tertiary sandstones which brings more resistant strata to the surface. There are no groynes along this section of coastline and alongshore transport rates are low. Apart from along the eastern end of the section where there is a weak east to west transport, there does not appear to be a strong drift in either direction.

Sea defences have been implemented throughout the majority of this frontage with the present structures dating from the 1950s. Cliff protection works has significantly reduced the amount of sediment which naturally feeds from the cliffs onto the foreshore. Most of the eroded sediment is fine sand or silt; although very small quantities of round black pebbles (from the Oldhaven Beds) and angular flints (from the glacial deposits) are transported onto the beaches. Beach replenishment is widely employed along this section of the coast to maintain the protective beach.

Movement

Tertiary deposits primarily London Clay interspersed with thin glacial and more recent deposits of gravel, silts and muds dominate this section of coastline which is noted for its history of complex cliff / slope instabilities. For the most part, the coastal slopes have been stabilised through the provision of toe weighting and drainage measures.

The oldest Tertiary rocks exposed on this coastline can be found to the West of Reculver. These are the Thanet sands, the Woolwich Beds and the Oldhaven Beds. The Thanet Sands are comprised of fine grained clayey sands and coarser shelly sands. There are occasional bands of harder calcareous cemented sands (doggers) exposed in the cliff section and on the foreshore, which distinguishes the Thanet Sands from the overlying Woolwich beds. The Woolwich Beds are 7.5 m maximum in thickness and comprised of shelly sands and fine clayey sands. Overlying the Woolwich Beds, are the Oldhaven Beds. A prominent feature of the Oldhaven Beds is a layer of very well rounded black flint pebbles. Overlying these are fine sands and silty clays which grade up into the basal layers of the London Clay. All the cliff exposures are very soft and easily eroded by wind or by water with the clayey silts and the hard cemented doggers offering most resistance.

Glacial deposits (formed around 1.8 million to 10,000 years ago) can also be found along this section. Intermediate head gravels and head brickearths are particularly common in the cliffs to the West of Reculver, and at Swalecliffe Brook.

Sea defences have been implemented throughout the majority of this frontage with the present structures dating from the 1950s. As a result, the foreshore has generally lowered in front of the defences due to the reduced input of mud, sand and shingle to the foreshore.

The Tankerton frontage has had a history of cliff erosion, due to the clay nature of the cliffs, but historical maps show little change since the 1870s, when protection measures were introduced (Halcrow, 1998).

Retreats of up to 6 m/year were observed at Studd Hill following the construction of Hampton Pier in 1846 (Canterbury City Council, 1993). The construction of the pier cut off the feed of shingle to Studd Hill and in doing so removed the beach toe protection to the clay slopes. The historical maps suggest that the position of MLW has fluctuated over this frontage, with no clear trend evident (Halcrow, 1998).

Along the frontage of the town of Herne Bay, there have been no changes in the coastline position over the last century due to the presence of defences. There is, however, some evidence to suggest that the village of Herne Bay, which existed before the 1820s, was located on a small promontory, which was subsequently lost to the sea (Halcrow, 1998).

The coastline between Bishopstone and Reculver is noted for its history of slope instability and landslides and this is also evident from the historical OS maps (Halcrow, 1998). The MLW positions for this frontage show a fluctuation rather than a discernible trend.

Predictions of shoreline evolution

The presence of London Clay within the Whitstable to Reculver frontage means that this stretch is susceptible to relatively rapid cliff erosion and lowering of the shore platform. SMP1 (1998) predicted that by 2070, there would be 'significant' erosion of the coastline, with potential inundation around Whitstable Harbour and Swalecliffe.

Without the presence of sea defences along the coast, erosion rates of the cliffs and coastal slopes would be around 1 to 2 m/year based on historic records (Canterbury City Council, 1992). For London Clay slopes, retreat would be expected to occur as a combination of major landslips followed by erosion of the slumped material.

At Studd Hill, the clay cliffs could become reactivated, triggering landslides. Without the continued management of the drainage systems in the coastal slopes, this would result in an earlier onset to erosion than would be predicted by condition assessment of the sea walls.

A continuation of the present management will result in further foreshore lowering and the need to maintain the shingle by beach recharge. Maintenance and renewal of the slope drainage will also be required.

Landslides resulting from unmanaged drainage would be the most likely cause of erosion at Bishopstone and East Cliff. The erosion of the cliffs would release some sediment to the coastline however the amount of coarser shingle released would be limited due to the low percentage of coarse material in the cliffs.

Breaching of the defences in Herne Bay itself would probably not occur in the short term, because of the protection afforded by the rock breakwater to the beach. Overtopping flooding may however occur due to the tendency of the beach to lower between the pier and the bandstand.

LOCAL SCALE: RECULVER TO MINNIS BAY

Interactions

Reculver lies on what was the west bank of the northern entrance to the Wantsum Channel; an ancient waterway linking the north and east coasts of Kent. The channel was navigable up to the 17th Century. Plumpudding Island is situated on what was the east bank of the channel. During Roman times the coastline was an estimated 2 km to the north giving an erosion rate of around 1m/year (So, 1967). There are outcrops of Thanet Sands on the foreshore at Reculver and Cretaceous Chalk at Minnis Bay. The whole of the central area which was the Wantsum Channel is comprised of alluvium.

The foreshore along this section consists of a shingle beach ridge, which fronts low lying marshland, much of which is classed as a Site of Special Scientific Interest (SSSI) and Special Protection Area (SPA) due to the presence of many designated birds and wildlife.

West of the Reculver Towers transport rates reach up to 6,000m^3/year and historically there has been little or no beach present at this location. East of the Towers, the potential transport rate for shingle is 1,500m^3/year to the west. The stone apron which protects the Towers from erosion acts as a barrier to westward transport except in times of prolonged easterly winds.

East of Reculver the coastline is fronted by the Northern Sea Wall, a concrete structure built in 1953 after the original clay embankment was breached in three places. Fourteen rock groynes were added in 1995 to help maintain the shingle beach. Sediment transport patterns along this section are somewhat complicated probably as a result of the presence of Margate Sands. Depending on the coastal orientation, material shows net movements to both the east and west. In the last two years there has been a general pattern of erosion in the west and accretion in the east, however, over longer time periods there have been reversals in this pattern. St. Augustine's Bank (to the west of Plumpudding Island) is an important sink for shingle. There is seepage of shingle through the eastern-most rock groyne into Minnis Bay (estimated to be 2,000m^3/year).

Movement
Wantsum Channel is a former tidal channel between north and east Kent, which was on average 2 miles wide and used to separate the Isle of Thanet from mainland Kent. Approximately 2000 years BP the dynamics of the channel started to change and a shingle spit, known as 'Stonar Neach', developed across the eastern extent of the channel. Over time, the continued deposition of shingle at 'Stonar Neach' caused the gradual silting up of the channel and by the 9th century it was no longer to possible to reach Canterbury. In terms of the modern day appearance of the now dry Wantsum Channel, this commenced in the twelfth and thirteenth century, when Augustinian monks constructed drainage systems, walls and counter-walls to claim land from the sea. However, in 1953 the Northern Sea Wall was breached, leading to wide-scale inundation of the backshore prior to its structural repair (Futurecoast, 2002). Following defence improvements the area was further improved for agriculture in the late 1950s and 1960s, by draining areas of marsh and wet grassland.

The foreshore sediment has experienced a slow net loss since cessation of sediment supply from the chalk cliffs to the east of this frontage (Futurecoast, 2002). The historical map analysis of MLW and coastline positions, undertaken for SMP1 (Halcrow, 1998), showed no discernible trend in either MLW or coastline position.

Predictions of shoreline evolution
The low-lying nature of the backshore along the Reculver to Minnis Bay frontage means that this stretch of coast is potentially susceptible to breaches. The most vulnerable coastal sections are in the central area, where a narrow beach barrier shows strong erosive tendencies and would breach if not rebuilt on an annual basis. Even under present management practices, it is expected that the barrier would breach under a 20 year storm. A

seawall backs the barrier beach, so in the short term flooding would be likely to be contained within the lagoon between the two (Canterbury City Council, 1997).

Under an ‘unconstrained scenario’, Futurecoast (2002) predicted that the shingle beach ridge could roll back across the low-lying hinterland in response to sea level rise. However, as the cliffs further to the east of this frontage would retreat relatively slowly, they would not contribute significant new volumes of shingle to this frontage. Due to this, the ridge could be liable to segmentation and breaching. It would result in tidal inundation of large areas of low-lying backshore contained within the Stour Valley and could ultimately lead to the isolation of the Isle of Thanet from the mainland. Current defences prevent landward migration of the shingle ridge, leaving the foreshore vulnerable to coastal squeeze under sea level rise.

LOCAL SCALE: MINNIS BAY TO NORTH FORELAND

Interactions

Throughout the Isle of Thanet, the cliffs and foreshore consist almost entirely of Upper Cretaceous chalk, varying from 10 to 25 m in height. Three specific chalk zones can be found in the cliffs along this section, these are Marsupites, Offaster and Pilula. These all consist of soft, white, blocky, very pure chalk, which contain very few flints, and therefore these cliffs contribute little to the beach sediment budget. Outcrops of Tertiary Rocks can be found in some areas, overlying the chalks. These include Thanet sands, Woolwich beds, Oldhaven beds and London clay.

The cliffs along the Thanet coastline are characterised by groups of joints and faults cutting through the chalk. Water percolates through these fissures, softening the chalk and rendering the rock more susceptible to erosion over time (D’Olier, 2007). Bays have formed in areas where pre-historic surface channels have created deep stream valleys, in combination with active wave erosion of the chalk where joints and faults are closely spaced. The valleys, which extend offshore, are now in filled with sand (D’Olier, 2007).

The remaining foreshore consists of a chalk platform, varying in width up to 250m and covered by a thin and highly mobile layer of sand and occasional shingle (Futurecoast, 2002). The sand is believed to be derived from offshore sources and is mainly retained within the bays in the chalk cliffs (Halcrow 1998); elsewhere the platform is bare of sediment. Very little sediment for natural beach replenishment is derived from any of the bedrock units in this area, the primary supply being the few small flints from the chalk cliffs and foreshore platforms (Halcrow, 1998).

Not much is known about the movement of material around the Isle of Thanet. North of this coastline (in close proximity to the Margate sands), sand moves from the sandstream under the influence of strong sustained winds with an easterly bias, and under the force of the ebb tide which draws water and sand into the inshore zone off Joss and Botany Bays.

Further west, the sand circulation is quite complex. On the northern side of the Margate Hook dominant movement is towards the west. However, on the southern side (on the edge of the South Channel), transport occurs in an eastward direction. As a result, there is an elongated anticlockwise circulation of sand around the eastern end of the Margate Hook (Halcrow 1998).

Due to the presence of a sediment drift divide at North Foreland, there is no feed of littoral material to this frontage from the East Kent coast; therefore the only source for North Foreland is from offshore.

Movement

Large sections of the chalk cliffs are jointed and faulted, and where undefended, these structural weaknesses have been exploited by wave action, leading to the creation of arches and caves undermining the cliff base. In general, however, rates of cliff retreat have been low due to the relatively resistant nature of the chalk cliffs and the presence of defences, which prevent any toe erosion (Halcrow, 1998).

There has been a net loss of sand from the foreshore because westward drifting foreshore sediment has not been replaced at the same rate by the input of material released from sea cliffs erosion along this frontage. This is due both to their protection with coastal defences and to the fact that natural rates of recession would have been relatively low: this progressive loss of foreshore sediment leads to shore platform lowering, albeit at a slow rate (Futurecoast, 2002).

Predictions of shoreline evolution

The rate of shoreline evolution is geologically controlled along this frontage. The chalk shore platform will continue to erode, but at very low rates. It is anticipated that the chalk sea cliffs will not experience any major change; although where they are undefended the cliffs will recede with erosion occurring primarily along joints and faults, in periodic local falls along short lengths of cliff, leading to an indented coastline with stacks, arches and sea caves. Only very small volumes of flints would be released to the foreshore, probably insufficient to keep up with natural losses, and it is likely that any sediment would tend to largely remain contained within the various indentations that characterise this frontage, rather than providing a significant volume of sediment to beaches elsewhere.

The wave cut chalk platform will continue to erode over time and as a consequence of the defences remaining in place and the effects of sea level rise, the platform will become ‘squeezed’ against the seawalls. The lack of a chalk platform to reduce wave energy in front of the bays will result in rapid erosion of local cliffs if they are undefended.

C1.4 East Coast: North Foreland to South Foreland

REGIONAL SCALE: NORTH FORELAND TO SOUTH FORELAND

Interactions

Cliffs composed of resistant Upper Cretaceous Chalk (99-65 million years ago) extend south from North Foreland to Ramsgate (West Cliff). West of Ramsgate (West Cliff) the Chalk cliffs give way to low-lying hinterland composed predominantly of superficial Pleistocene deposits (i.e. gravel and sand). This stretches down through Pegwell Bay, Sandwich, Deal and Kingsdown. The Upper Cretaceous Chalk cliffs outcrop again just south of Kingsdown and extend to South Foreland, the study area's southern boundary.

Historically the chalk cliffs and platforms in the north (North Foreland to West Cliff) and south (Kingsdown to South Forelands) have eroded and lowered at relatively low rates, supplying fine material as it has done so. Futurecoast (2002) specify a rate of <0.1m/yr. In contrast the superficial Pleistocene deposits that occupy the central section of the frontage have undergone significant change; the gravel in particular has, over time, lengthened rapidly. Initially occupying the area around Kingsdown it has extended northwards and presently it extends across the mouth of Sandwich Bay.

Offshore banks, also believed to be a relict feature of the Holocene Marine Transgression (10,000 years BP) along this section of the coast, are believed to exert a key control. Goodwin Sands, located between 4 and 12 km offshore of Deal, is the most notable. Forming a series of natural shallow sandbanks, which are maintained by the tidal currents of the area (Deal to Kingsdown Strategy Study, 2001); Goodwin Sands buffers the offshore wave climate and as such alters the inshore wave climate. Deal Bank located approximately 7km offshore of Kingsdown is also of importance to the study site, again exerting an influence on the study frontage.

Movement

This section of the frontage is exposed to coastal processes operating both within the southern North Sea and the English Channel. The Deal to Kingsdown Strategy Study (2001) and Futurecoast (2002) assert that the predominant wave direction is from the north-east (inshore wave direction) and the south-west (offshore wave direction); as such alongshore sediment transport is both north and southwards. Between North Foreland and Cliffs End the net littoral drift is south whereas between Cliffs End and South Foreland the net littoral drift is north; as such a drift convergence exists at Pegwell Bay. However under storm conditions, which are mainly south-easterly events, then sediment transport is unidirectional i.e. towards the south.

Cross-shore sediment transport also takes place along this section of the study frontage. However, evidence suggests that this is not the 'classic' offshore berm construction, during storm conditions, but more a general flattening of the beach profile (Deal to Kingsdown Strategy Study, 2001).

Based on existing data, the Deal to Kingsdown Strategy Study (2001) proposed a best estimate of the sediment budget:

- The net movement of sediment out of the study frontage is approximately 12,000 m^3 per year;
- Sediment movement into the area, from the south, is about 4,000m^3/year;
- There is net accretion of material along the Deal and Walmer frontage, which is calculated of being in the region of 9000m^3/yr;
- There is net erosion at Kingsdown, this is calculated as being in the region of 18000m^3/yr;
- Other 'losses' amount to approximately 1000m^3/yr;
- The amount of material lost and gained from the offshore is small.

Modifications

Anthropogenic constraints have greatly influenced the morphology and coastal processes of the study frontage. The most notable example of intervention is at Sandwich Bay. The inter-tidal areas were constrained via reclamation, in the twelfth and thirteenth century. This, along with the northward migration 'Stonar Neach' caused gradual silting up / closure of the Wantsum Channel; a tidal waterway that once extended from north Kent to Sandwich Bay and separated the Isle of Thanet from the mainland.

More recent modifications along the North Foreland to South Foreland coastline have included:

- Seawalls being constructed along the Chalk cliffs between North Foreland and Ramsgate, St Margaret's Bay and Oldstairs Bay. Constructed to prevent cliff toe recession they have also reduced the amount fed from the cliffs to the sediment budget.
- The construction of Ramsgate's harbour and pier resulted in an accumulation of sediment on the eastern (updrift) side of these structures.
- The construction of sea defences at Deal, Walmer and Kingsdown afford the settlements protection however, they also hold the shoreline seawards of its natural position. As such the fronting gravel barrier/beach has denuded.
- Defences at Deal have caused the shoreline to stand 'proud', thus creating an artificial headland.
- The construction of flood embankments along the low-lying coast i.e. between Pegwell Bay and Walmer, provide a secondary defence to marine inundation. As the low-lying hinterland is a single flood cell the embankments provide the backing assets with fundamental protection.

LOCAL SCALE: NORTH FORELAND TO CLIFFS END

Interactions

Cretaceous chalk cliffs dominate the coastline between North Foreland and Ramsgate (West Cliff). Along this eastern section of the north Kent coast, the cliffs contain a number of flint rich bands which when eroded become erosional tools themselves, increasing wave erosion potential (D'Olier, 2007). These cliffs are also characterised by groups of joints and faults cutting through the chalk. Water percolates through these fissures, softening the chalk and rendering the rock more susceptible to erosion over time (D'Olier, 2007).

Bays have formed in areas where pre-historic surface channels have created deep stream valleys, in combination with active wave erosion of the chalk where joints and faults are closely spaced (D'Olier, 2007). These valleys, which extend offshore, are now in filled with sand and therefore the wide chalk platforms, which characterise the Thanet coastline, are not present in front of the bays (D'Olier, 2007).

At Ramsgate (West Cliff) however, the chalk cliffs give way to sandstone cliffs, which run to Cliffs End in the west. The sandstone cliffs are part of the Thanet Sand formation (Haynes, 1956)[1] and date from 64-38 million years ago. In front of the Sandstone cliffs there are sand and mudflats, which merge to become part of the Pegwell Bay deposits.

This frontage has a history of development; Ramsgate, for example, has been a port since Roman times and remains today an important ferry port; with links to the continent as well as retaining a fine Marina. The seawalls at the base of the chalk cliffs between North Foreland and Ramsgate (West Cliff) were constructed to reduce cliff toe recession from marine erosion. However, sub-aerial weathering of the chalk cliffs still takes place, which results in erosion of the cliff top. The only exception to this is at Ramsgate where the cliff face has been sheathed with concrete and thus erosion prevented.

Various studies acknowledge that there is a general lack of contemporary sediment entering the system (Deal Strategy, 2001; Futurecoast, 2002). The headland at North Foreland acts as a natural boundary thus little to no sediment is known to enter from the north. Limited recession of the chalk cliffs, between North Foreland and Ramsgate (West Cliff) because of the toe protection measures, yields only a small amount of flinty gravel and chert to the foreshore. This however, only has the potential to be transported westwards under storm conditions. Between Ramsgate (West Cliff) and Cliffs End there is a small amount of contemporary sediment being added to the system and this is derived from two sources: 1) from alongshore and 2) from the River Stour (which exits into Pegwell Bay).

Movement

The chalk cliffs are actively receding, albeit at a very slow rate (Futurecoast, 2002; D'Olier,

[1] Haynes, (1956) - Thanet Sand Formation comprises: 1) Reculver Silts, 2) Pegwell Marls, 3) Kentish Sands, 4) Stourmouth Clays and 5) Bullhead Flint Conglomerate. At Pegwell Bay all but the Kentish Sand are present.

2007). They are susceptible to sub-aerial weathering and periodic slumps. The cliffs also have a low block failure potential i.e. <10m (<0.2ha), which can result in falls from the cliff face and the formation of aprons containing boulders and chalk rubble (Futurecoast, 2002).

The sandstone cliffs at Cliffs End have experienced low recession rates, typically in the region of 0.1 to 0.5m/yr (Futurecoast, 2002); their landslide potential is however on a similar scale to the chalk cliffs i.e. low <10m/0.2ha (Futurecoast, 2002).

Futurecoast (2002) stated that Goodwin Sands, a sand bank system located offshore of the east-facing Kent coast, is a remnant of a former tidal delta, which was present during the early stages of the Holocene (10,000 years/BP) and attributed to tidal flows from the Dover Straits and southern North Sea. However as sea levels rose, under the Holocene Marine Transgression (10,000 years/BP to the present), tidal flows sweeping around from North Foreland modified the form and functionality of the original delta; reducing its dimensions considerably. As such, the present functionality of Goodwin Sands exerts a large-scale control on the development of Sandwich and Pegwell Bay. Nominally Goodwin Sands supplying fine material (sand) to the foreshore as well as protecting the shoreline against direct incident wave attack.

Predictions of shoreline evolution

Slow rates of shore platform lowering and cliff top recession are expected to continue in the future. Chalk rubble released from periodic local rock falls will accumulate initially at the cliff toe until it is broken down and then transported alongshore by coastal processes.

It is envisaged that erosion of the Sandstone cliffs near Cliffs End would feed the fronting sandy foreshore, thus providing a local, contemporary sediment source. Elsewhere however, it is envisaged that the existing sediment stock would be re-worked and moved either offshore or south into Pegwell Bay (Futurecoast, 2002).

LOCAL SCALE: CLIFFS END TO SANDOWN CASTLE

Interactions

This section of the coast contains the embayments of Pegwell Bay, in the north, into which the Stour Estuary, a ‘single-spit enclosed estuary’ (Futurecoast, 2002) exits and Sandwich Bay, in the south. The backing hinterland is composed predominantly of alluvium and fine-grained marine sediment, which has led to the formation of tidal flats and marshes. However, south of Sandwich Flats the low-lying hinterland gives way to relict sand dunes and gravel deposits. The relict sand dunes rise to a maximum height of 5.6mOD, whilst the gravel barrier stretches down to Sandown Castle, the local unit boundary. The southern end of the gravel spit contains a considerable amount of blown dune sand. Futurecoast (2002) speculated that this material is likely to be ‘dune decoration’, which basically overlies the main shingle body. The source of this sand has however, yet to be verified. Futurecoast (2002) suggested that it may have been recycled from Goodwin Sands or released, as a ‘pulse’, from the sea bed following the ‘Little Ice Age’ (a period of climatic deterioration between the 1500s and 1800s). The mixed gravel and sand spit is fronted by a veneered gravel beach, which gives way to sand in the nearshore and continues out to the offshore.

Sediment from North Foreland and South Foreland converges at Pegwell Bay. As sediment moves alongshore transport rates reduce, so that fine sediments collect at Sandwich Flats and Pegwell Bay.

The main conurbation within this section of the frontage is Sandwich, located approximately two miles inland of the open coast, other settlements worth mentioning are Great Stonar and Cliffs End. However, a vast proportion of this frontage is devoted to ecological and recreational interests; a nature reserve and golf courses (Prince's Golf Links and the Royal Cinque Golf Links) respectively.

Movement

This section of the coast has experienced a significant amount of change. The depression that is Pegwell Bay may, Futurecoast (2002) speculates, have been initiated by drainage from the Thames Estuary into the English Channel, during a period of lower sea levels in the early Holocene (10,000 – 5,000 yrs/B.P.). However as sea levels rose and prior to Sandwich becoming a 'Cinque Port', the ancient Saxon town of Stonar, located on the opposite bank of the Wantsum Estuary, at the mouth of the River Stour, was well established and remained a place of considerable importance until it disappeared almost without trace in the 14th century. Reclamation at Sandwich, which extended approximately 250 years, between the 14th Century and mid-16th Century; significantly altered the regions coastal processes. Reclamation, for example, reduced the tidal flow of the River Stour, increased sediment deposition and initiated the Wantsum Channel, which used to separate the Isle of Thanet from mainland England, to close. Amalgamated with the mixed gravel and sand spit, which had lengthened and migrated north, since the 9th Century, it forced the mouth of the River Stour to exit further north and left Sandwich two miles inland of its original coastal position. Today the spit extends from Deal in the south to the northern bank of Pegwell Bay. Alluvium and fine-grained marine sediment have been deposited in its lee, which has resulted in the formation of tidal flats and marshes.

Futurecoast (2002) stated that Goodwin Sands, a sand bank system located offshore of the east-facing Kent coast, is a remnant of a former tidal delta, which was present during the early stages of the Holocene (10,000 years/BP) and attributed to tidal flows from the Dover Straits and southern North Sea. However as sea levels rose, under the Holocene Marine Transgression (10,000 years/BP to the present), tidal flows sweeping around from North Foreland modified the form and functionality of the original delta. As such, the present functionality of Goodwin Sands exerts a large-scale control on the development of Sandwich and Pegwell Bay. Nominally Goodwin Sands supplying fine material (sand) to the foreshore as well as protecting the shoreline against direct incident wave attack.

Predictions of shoreline evolution

Over the recent historic past (>100 years) the shoreline has not been heavily modified or constrained by defences and as such coastal processes, along this stretch, have not been exacerbated, although they have been influenced by structures updrift. However, under a scenario of predicted, accelerated sea level rise (6mm/yr) there is not a sufficient amount of material in the shingle beach to allow roll back and it is predicted that the embankment at the back of the beach, will constrain a landwards migration. Thus, as soon as the embankment between Sandown Castle and Sandwich Bay breaches then it is likely that it will remain breached. This coupled with the embankment north of Sandown Castle (remains of) would result in a significant change in dynamics. In the northern section of this frontage erosion and flooding, in the vicinity of Cliffs End, is expected. Similarly sediment stored within the dunes, which "decorate" the shingle ridge between Shell Ness and Sandwich Flats will also be prone to breach. Once a significant breach occurs, the new opening is likely to be inundated on normal tides, resulting in flooding of the low-lying hinterland. There is also the potential that the dynamics of the River Stour could change, if the river broke through the tight meander around Richborough; the impact of this would be a realignment of the river's mouth.

It is predicted that flooding in the north could combine with flooding from the south (Sandwich Bay Estate (south) to Sandown Castle (remains of)), which in turn could combine with inundation from the north Kent coast, from the Reculver to Minnis Bay frontage. Should this occur then the former tidal channel, the Wantsum Channel, between north and east Kent would be re-activated. In the long term (beyond the scope of the SMP) there is the potential for either an ebb tidal delta or flood tidal channel to form, depending on the dynamics of the River Stour, sea level and the tidal currents (Futurecoast, 2002).

LOCAL SCALE: SANDOWN CASTLE (remains of) TO OLDSTAIRS BAY

Interactions

Between Sandown Castle (remains of) and Walmer Castle storm gravel beach deposits rest on top of Head Brickearth (from the Pleistocene), which overlies Upper Cretaceous Chalk. Between Walmer Castle and Oldstairs Bay the hinterland rises, as the storm gravel beach deposits rest on the Upper Cretaceous Chalk before giving way to a relict chalk cliff line at Kingsdown that finally joins the shore at Oldstairs Bay (BGS, 1977 – Sheet 290). Fronting this is a relatively low-lying shingle beach; allegedly sourced from offshore banks and local geological outcrops; thus flints and cherts are common composites (Deal to Kingsdown Strategy Study, 2001). It is acknowledged that the cross sectional area of the shingle beach fluctuates along its length; being reasonably narrow at Sandown Castle (remains of), wide at Walmer (100m) and narrowing again towards Oldstairs Bay (25m).

As a vast majority of the hinterland is low-lying and the foreshore vulnerable to change, flood and erosion protection/prevention measures have been implemented, nominally an embankment between Sandown Castle and Sandwich Bay Estate and a seawall between Sandown Castle and Kingsdown.

Wind and wave direction along this section of the coast is predominantly from the south east, however there is also a smaller proportion of wind / waves from the north-east and east as Figure 1 demonstrates. As such littoral drift has the potential to move both north and south along this section of the frontage.

Generally though, it is agreed, (Deal to Kingsdown Strategy Study, 2001; Futurecoast, 2002) that the net drift direction, along this section of the coast, is north. The hydrodynamic flow model set up for the original North Kent Shoreline Management Plan (Halcrow, 1996) concurs with this; stating that the net tidal residual movement along this coast is northwards. Halcrow (1996) also determined that the tidal streams (currents) along the Deal and Kingsdown coastline have the potential to reach a maximum of 2.3 knots on spring tides. Thus, Halcrow (1996) concluded that despite the currents along this stretch of the coast being fairly strong, generally they are not strong enough to move gravel sized material.

It is acknowledged that the contemporary supply of sediment to the frontage is very small. Chalk deposits, composed of gravel and fines enter the system from the south; however this input, to the system and more importantly as beach building material, is negligible. As previously elucidated little material enters from the north, although it is possible for material within this frontage, to move south, under a north-easterly storm, thus reversing the predominant littoral drift direction.

In the Deal to Kingsdown Strategy Study (2001), annual potential and actual drift calculations were established. These are presented below:

Location	**Orientation of the Coastline**	**Potential Drift Rate m^3/year**	**Actual New Drift m^3/year**
North of Deal	081	23,000	12,000
Deal Pier	086	12,000	12,000
Lower Walmer	086	20,000	20,000
Walmer Castle	086	22,000	22,000
Kingston Seawall	090	22,000	4,000*
Rifle Ranges	090	10,000	4,000*

*derived from calibration of evolution model (strategy)

The potential drift is that which would occur on an open natural beach.

The actual drift includes the structures and beach height.

Source: Strategy (2001)

The Deal to Kingsdown Strategy Study (2001) also calculated beach volume losses and gains, using National Rivers Authority (NRA) beach survey data (1978 to 1990), down to -1.0 ODN. Over the 12 year period and following was concluded:

- Deal/Walmer: +ve 9,000 m^3/year; and,
- Kingsdown: -ve18,000 m^3/year.

However, the above figures may be biased due to the 1990 storm event, which would have increased sediment transport volumes significantly. Thus, as a comparison the Deal to Kingsdown Strategy Study (2001) also reviewed more recent, and potentially more accurate, survey data, for the period between June 1994 and February 1996. The following rates were calculated:

- Deal/Walmer: +ve 6,100 m^3/year; and,
- Kingsdown -ve 26,400 m^3/year.

From the aforementioned data it is transparent that more sediment is transported under storm conditions than ‘normal’ conditions, that there is accretion in the north and erosion in the south and that this trend appears to be fairly constant over time.

The Goodwin Sands, sand bank system, also exerts some control over this frontage, affording the shoreline some protection against direct wave attack. Similarly Deal Bank, offshore from Deal Pier, has a very local impact on the inshore wave diffraction. Both features are considered relatively stable and thus it is envisaged that they will continue to afford protection to this section of the coast for the foreseeable future.

Goodwin Sands has also exerted a control on anthropogenic activity; the Downs, the water between the town of Deal and Goodwin Sands, provides a naturally sheltered anchorage. As such, the town of Deal grew to become a significant shipping and military port, despite the absence of a harbour. The advantage this water affords is still in use today.

Settlements along this frontage include the aforementioned town of Deal along with the town of Walmer and the village of Kingsdown. Each settlement is low-lying and therefore coastal protection measures have been implemented. Structures built perpendicular to the shoreline (groynes), like those at Deal, impede alongshore transport by retaining drifting material, whereas linear structures (seawalls), which are also present at Deal, have two functions: 1) to protect the low-lying areas from flooding and 2) protect the more elevated areas from erosion.

In the case of the latter artificial headlands can develop, due to the shoreline being fixed and held seawards of its natural alignment. This has happened at Deal, a small promontory has formed, which has the potential to restrict, to an extent, the northward movement of beach-sized sediment.

Movement

In response to the early Holocene Marine Transgression (10,000 to 5,000 yrs/BP) and the predominant hydrodynamic conditions, at the time, the gravel spit extended north from Kingsdown. As the spit augmented in length it thinned in width.

Approximately two hundred years ago there was a change in process dynamics, which caused the build up of beach at Deal and the erosion at Walmer to reverse. It has been recorded that between 1741 and 1884 the shingle bank at Walmer Castle increased in width by one hundred and fifteen metres, while the bank at Sandown receded by sixty metres. There is evidence to suggest that this reversal was due to a change in the orientation of the Goodwin Sands and the Downs channel in-shore of the banks.

Since then there has been a rotation of the coastline between Walmer and Deal of about three degrees in an anti-clockwise direction. Thereafter the hydrodynamics have remained unaltered, as such the erosion to the north of Deal and accretion to the south has continued.

More recently the introduction of defences in the south has modified this effect. As such there is now evidence that the 'null-point' (the point at which accretion gives way to erosion) is moving southwards. Presently this point is just south of Deal Pier. Conversely erosion at Kingsdown is moving northwards, due to the reduction in the rate of supply of material from the south.

Thus, in an attempt to maintain the fluctuating barrier, the beach at Deal has been subjected to a series of coastal protection measures (i.e. a seawall and groynes), which has retained a suitable standard of protection although it has resulted in the creation of an artificial promontory. For the past 200 years the shingle beach at Walmer has had a history of relative accretion, hence its relative width today. There are no formal protection measures along this stretch, as the wide shingle beach affords a suitable standard of protection. Unlike Walmer the gravel beach at Oldstairs Bay has a history of volatility and erosion. Over the last 50 years the retreat rate has been rapid, with 70m (1.4m / annum) of beach has been 'lost' from this frontage (Deal to Kingsdown Strategy Study, 2001).

It has been observed that during storm events significant change to the shoreline takes place; significant quantities of material are moved and sometimes the predominant sediment transport direction is reversed, from the north to the south. Furthermore, in reviewing previous significant flood events, it appears that they are becoming more frequent i.e. 1953, 1978, 1990 and 1996. Shoreline response to extreme events was evident during the 1990 storms. At the northern end of the Kingsdown seawall, significant erosion was experienced, the Deal to Kingsdown Strategy Study (2001) estimated that 20,000m^3 of material, north of the seawall, was 'lost' alongshore during this event. It was also noted that the post-storm beach profile was one of a shallower slope. In essence severe storms cause the beaches along this section of the coast to flatten in profile and the crest to, where possible, roll back.

Predictions of shoreline evolution

With no defences in place shoreline response will differ from today as the coastline functions naturally. It is predicted that material will continue to be transported northwards, providing the hydrodynamics remain as they presently are or indeed very similar. Generally it is envisaged that there will be flooding north of Deal, whilst between Deal and Walmer (south) / Kingsdown (north) it is predicted that the gravel beach will roll back, in response to sea level rise (6mm/yr) and the finite sediment supply. Using the Bruun Rule (CIRIA/CUR 1994) and governmental predictions, for sea level rise (6mm/year (Defra/UKCIP)), to calculate the rate of retreat the Deal to Kingsdown Strategy Study (2001) concluded that generally the shingle beach could recede by 0.5m/year. However, having reviewed a number of data source Halcrow postulate that between Deal Castle and Walmer Castle, the shoreline position will remain more or less similar to its present form, due to its present volume and predicted feed from updrift frontages.

Erosion of the gravel foreshore is predicted for Kingsdown. Initially the ability for the beach to re-profile and / or roll back is restricted, due to the presence of defences; the crest can not move laterally. As such the foreshore will steepen and narrow. However, when the defences fail it is speculated that a more natural beach profile will form and that the backing hinterland, despite being generally higher than that to the north, has the potential to experience flooding under extreme /storm conditions.

LOCAL SCALE: OLDSTAIRS BAY TO SOUTH FORELAND

Interactions

Near-vertical Cretaceous chalk cliffs, fronted by a Cretaceous chalk shore platform, extend all the way down from Oldstairs Bay to South Foreland, the southern limit of the study area.

The Chalk headland affords protection to St Margaret’s Bay against south-westerly waves; however the headland also limits sediment supply from updrift frontages (South Foreland).

The sea cliffs are largely unprotected, albeit for a rock revetment, a seawall and intermittent groynes at Oldstairs Bay as well as a short seawall at St. Margaret’s Bay. With limited toe defences in place the cliffs respond naturally, eroding via chalk falls and thus providing a small amount of feed to the frontage. When broken down the material is transported alongshore to feed frontages further north.

With the exception of St Margaret’s Bay there is little in the form of settlements along this section of the coastline, albeit for a few cliff top residential properties and a golf course. Previously the frontage (at Oldstairs Bay) was used primarily by the Ministry of Defence. Today, however recreational and environmental interests are the main drivers. The golf club, at Kingsdown, occupies a favourable cliff top position whilst the cliffs are awarded with a number of designations i.e. Kingsdown to Dover Cliffs SAC and SSSI for its geology and ecology, as a key BAP habitat (supporting rare and protected species) and as heritage feature, forming part of the White Cliff coast.

Movement

Futurecoast (2002) stated that the chalk cliffs have eroded at a relatively low rate. As the cliffs eroded slowly landwards a chalk platform has been left at the level of the low water mark. This platform is not vulnerable to erosion due to wave attack being concentrated on the area between high and low water mark. Episodic events like cliff falls will have taken place. Occasionally the cliffs will experience falls, whereby a 'slab' of chalk will separate itself from the cliffs and resulting in the supply of chalk As such the cliffs along this section of the coast are vegetated in many places and thus of ecological importance.

At Oldstairs Bay the shingle beach, which fronts the chalk cliffs, has been susceptible to erosion. In viewing historic photographs it is clear that a significant amount/volume of foreshore material has been 'lost'. Between 1949 and 1999, for example, 70m of the beach was eroded and transported alongshore – in a northwards direction (Atkins, 2001). However, it is acknowledged that this rate would have been lower if there had of been defences in place to 'constrain' sediment movement. At St Margaret's Bay the seawall and groynes reduce erosion in the low-lying area that has formed from collected sediments in the natural indent in the cliff line that forms the bay. Erosion of the cliff line at the rear of the bay has been significantly reduced by the presence of the sediment in the bay and the seawall and timber groynes that were constructed to stabilise this area.

Predictions of shoreline evolution

Futurecoast (2002) predicted that the relatively slow rates of marine and sub-aerial cliff recession and platform lowering would continue. Chalk rubble released from future rock falls would continue to accumulate at the cliff toe until it is broken down and transported alongshore by marine processes. In areas presently protected by defences, for example Oldstairs Bay and St. Margaret's Bay, it is predicted that there will be erosion of the foreshore; resulting in the beach profile steepening and narrowing. When the defences fail it is predicted that the amount of foreshore material available for protection and to be transported alongshore may not be sufficient for the time frame of the SMP (due to updrift defence structures) and as such assets at Oldstairs Bay and St Margaret's Bay will be at risk.

Elsewhere cliff recession will continue, albeit at a slightly higher rate than the present one, in response to sea level rise and submergence of the fronting chalk platform.

C1.5 References

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C.2 Defence Data

The Tables overleaf provide a summary of the existing defences along the SMP frontage together with an assessment of their residual life. An assessment of residual life under a ‘no active intervention’ policy was undertaken using the condition data together with NADNAC *condition deterioration curves* (CDC), using the Table below (Defra, 2006) as a guide.

Defence Description	**Estimate of residual life (years) under NAI policy**				
	Existing Defence Condition Grade				
	Grade 1	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 5**
Seawall (concrete/ masonry)	25 to 35	15 to 25	10 to 15	5 to 7	0
Revetment (concrete/ rock)	25 to 35	15 to 25	10 to 15	5 to 7	0
Timber groynes and other timber structures (e.g. breastwork/ revetments)	15 to 25	10 to 20	8 to 12	2 to 7	0
Gabion	10 to 25	6 to 10	4 to 7	1 to 3	0
Note: Grade 5 is not used in the CPSE, but is included here as a measure of failure.					

Source: Defra, 2006 (Shoreline Management Plan guidance Vol. 2 Appendices, March 2006)

Location	**Defence History**	**Present Defence Form**	**Condition**	**Residual Life (under NAI)**	**Approx. Standard**	**Foreshore Features**
Specific to information presented. Could include NG co-ordinates.	*Any information on history of defence, which helps understanding of the influences upon past evolution.*	*Brief description of the type of defence present.*	*Grades 1-5*	*<5* *<20* *<50* *<100*	*<5* *>5 to 20* *>20 to 50* *>50 to 100* *>100*	*Brief description foreshore and shoreface as contribute to defence performance & condition.*
Yantlet Creek to Horseshoe Point (588440, 174130)	No information on defence history	The defences here comprise a number of clay embankment type, seawalls with concrete / concrete block front slopes. There are timber groynes at Grain to the north of which is a short section of eroding coastline with no hard defences	2-3	< 20	50-100	Locally shingle beaches / barriers form an effective defence in front of the embankments and others where the shingle beach is sparse. Mud dominates the lower foreshore and there are sparse areas of saltmarsh locally in sheltered locations.
Garrison Point (590810, 175660) to Scrapsgate (593980, 174930)	No information on defence history	The defences along this frontage comprise mainly of concrete seawalls fronted by shingle beaches most of which have been improved since the 1980's. The defences at Barton Point comprise a seawall fronted by a rock revetment. From Barton Point to Scrapsgate there is a shingle barrier.	2	< 20	50-100	Shingle beach forms an important part of the overall defences at this location
Scrapsgate (593980, 174930) to Warden Village (602350, 171830)	Minster defences date from the 1980s although it is not clear how much of the frontage was defended prior to this. There are some old defences (groynes) at Eastchurch which are derelict and ineffectual	Mainly undefended coastline from Warden Point to Minster. Minster and its slopes are protected by a sea wall and groyned beach.	2	< 20	50-100	Mudflats/ cliffed frontage with slumps. Shingle beaches in Minster.

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
Warden Village (602350, 171830) to Shellness (605370, 167660)	Warden defences constructed in 1964.	Shellness is protected by embankments and shell beaches with wooden groynes. This continues up the coastline to Leysdown-on-Sea, where a concrete sea wall and groyned beach protect adjacent residential properties in the town. Barrier beach protects the area between Leysdown and Warden. The town of Warden Bay is fronted by a groyned beach and concrete revetment, with a sea wall to the southern end edge.	4	< 20	20-50	Shingle beaches.
Faversham Creek (601730, 164220) to Blue Anchor Public House (608240, 165090)	Along Faversham Road, the main defence is in the form of a clay embankment behind the road, built in 1953/54. From Faversham Road to the Sportsman Inn is a sea wall built in the 1950's. Between the Sportsman and Faversham Creek, the defences are in the form of concrete sea walls, again built in the 1950's, with the exception of the area immediately West of the Sportsman, where a clay embankment is set back from the main defence line.	A clay embankment runs behind the properties at Faversham Road. Otherwise concrete sea wall of a recurved nature with a lower blockwork. Mostly groyned but beach sparse in places due to lack of maintenance of wooden groynes.	3	< 20	Generally 50-100, but 5-20 at the Sportsman, and less than 5 at Faversham Road.	Small shingle beach, with silty or muddy foreshore. Sand, shingle and shell beach at Castle Coot.

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
Blue Anchor Public House (608240, 165090) to Whitstable Harbour (610680,167140)	East Quay of Whitstable Harbour forms a terminal groyne, constructed in 1958. Around the Harbour itself, are various perimeter sea walls built since the 1980's. Throughout the Whitstable frontage, the existing sea walls were built in the 1950's, although there is a long history of defences prior to this. Preston Parade is protected by a sea wall built in the late 1970's, and wooden groynes also front this section, built in the late 1980's.	The sea walls that front most of this section are constructed of recurved concrete, and topped with a concrete promenade. Railway Wall consists of a low concrete wall on piles, with a pitched back-slope. The large shingle beaches that can be found along this frontage are maintained with timber groynes.	Generally 2, but 3 in parts, especially, the Harbour perimeter.	< 50. Except for golf course wall which is <20	> 100	Large Shingle beach maintained throughout.
Whitstable Harbour (610680,167140) to Long Rock (613874,167785)	Long Rock is an unprotected Natural Spit formation. A clay bund was built to the rear of Long Rock in 1986. The majority of the Sea Wall along the Tankerton frontage was originally constructed in 1958, with extensions and improvements made to the central section in 1975 with the exception of the East end, which was built in 1986. At Harbour Beach, the front sea wall was built in 1952 and the rear wall in 1955.	Bund wall comprised of concrete path, with grasscrete on adjacent sides. The sea wall that runs along the rest of this section is of a mass concrete nature, with a partly curved wall. Beach re-grading and recharge occurs along much of this section.	1	< 50	50-100	Shingle beach.
Long Rock	Hampton Jetty extends	Partly recurved mass	Generally 2,	< 20	< 20	Shingle beach fronts the

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
(613874,167785) to Hampton Pier (615782, 168236)	into a sea wall (built in 1948) Rock revetment, put in place in 1994, fronts this stretch. A partly curved sea wall, topped with concrete promenade (built in 1983) runs around Hampton Boating lake, and extends along the Studd Hill (1960) and Swalecliffe (1967) frontage. The cliffs at Studd Hill have been graded and drainage implemented.	concrete structures comprise the sea walls along the whole of this stretch. Rock revetment at Hampton. Rock Gabions were placed within the beach material along the Swalecliffe frontage in the mid 1980's. Wooden groynes are present along the entire section.	but 3 in parts where shingle has abraded the sea wall.			sea wall along the entire section.
Hampton Pier (615782, 168236) to Herne Bay Pier (617287, 168330)	From Herne Bay Pier to Lane End, the initial sea wall was implemented in 1930, and updated in 1955. From Lane End to Hampton Pier a sea wall is present in places, fronted by a promenade. To the West of the section, there are no active forms of defence until the jetty is reached, which was constructed in 1940.	Sea wall promenade constructed of concrete blockwork, with partly curved walls in places. Groyned beaches present here.	Generally 2, but 3 in parts.	< 20	20-50	Shingle beach maintained by wooden groynes.
Herne Bay Pier (617287, 168330) to Herne Bay Harbour (617854, 168444)	The front sea wall originally present along this section was constructed in 1930, and the rear wall in 1959. Herne Bay Central area defences were then updated in 1992 when a rock armour breakwater was constructed, and the	3-6 tonne rock armour revetment, topped with concrete promenade. The main seawall is comprised of vertical concrete walls fronting the promenade.	1	< 100	50-100	Sand/shingle beach, maintained with beach recharge.

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
	sand/shingle beach recharged.					
Herne Bay Harbour (617854, 168444) to Bishopstone Glen (620705, 168730)	A sea wall was constructed to the West of Bishopstone Glen in the 1950 / 60's. This wall stretches to Herne Bay Harbour. The cliffs along this stretch were also graded, and drains installed.	Partly curved concrete Sea Wall topped with promenade for accessways. Wooden groynes have been built all along this section of frontage to maintain the shingle beach. Short section of Rock Armour at Eastcliff.	2	< 20	> 100	Shingle beach maintained by wooden groynes, present throughout this section.
Bishopstone Glen (620705, 168730) to North Mouth Outfall, Reculver (622959, 169440)	East of the Reculver Towers, the sea wall was built between 1953 and 1979. Repairs were carried out following failure in 1996. The Reculver Towers first defences were built in 1809. Directly West of the Towers is a sea wall built in the 1950's. With the exception of Bishopstone Glen, the remainder of this section is undefended. At Bishopstone Glen, Rip Rap revetment protects the toe of the cliffs, and the cliffs themselves have been graded and grassed over, to prevent further slumps. This was carried out in the 1980's.	Various concrete structures, fronted by rock armour comprise the sea walls along this section. Small shingle beaches are also present here. At Reculver Towers themselves is a flange apron comprised of ragstone blocks laid on a fill of beach material.	1	< 50	50-100	Shingle beaches fronting sea walls, and unprotected cliffs.
North Mouth Outfall, Reculver (622959, 169440) to Minnis Bay	Defences here date back to 1809 in the form of wooden groynes. The first sea wall (the Northern Sea Wall) was built following	The Northern Sea Wall has been constructed in the form of a series of cellular boxes, approximately 3 metres square. The box has been	2	< 20	>100 yr	Shingle beach, with a silty lower foreshore, becoming sandy towards the East.

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
(628450, 169510)	the 1953 storm surge, replacing a clay embankment. It stretches for a distance of 4.5km from the West of the Reculver Towers, through to Plumpudding Island (Minnis Bay). More metal and wooden groynes were also implemented at this time. 1996 saw the construction of 14 rock groynes along this stretch and, in 1999, the wall was repaired in a number of areas.	infilled with shingle and topped with a concrete access way surfaced with bitumen macadam. Thousands of tonnes of massive rock boulders comprise the 14 rock groynes and a large shingle beach is present in front of the wall, maintained with beach replenishment.				
Minnis Bay to Margate	No information on defence history although it is thought most of the defences date from the 1950's to 1970's	With the exception of a small gap in the defences around Epple Bay, the coastline here is protected by concrete seawalls and promenades. At Grenham Bay and St Mildred's Bay seawall copings and promenade slabs are moving. The seawalls are founded directly on the chalk foreshore and there are signs of toe undermining.	3-4	5 to 20 years	20 - 50	Chalk platform with some thin patches of sand forming beaches in embayments
Margate Harbour	Margate Pier was constructed in its present form in 1815. Repair works have been carried over the years to rectify bomb and storm damage. Its believed to be founded on chalk. The seawall construction date is not	The pier is constructed from 2 gravity retaining walls built directly on the seabed and infilled with chalk. There is evidence of the chalk fill being washed out during storms. The seawall comprises a stone block gravity retaining wall	3 to 4 for the pier and 2 for the seawall	5 to 20 years for the pier and 20 to 50 years for the seawall	20--50	The pier holds a stable sandy beach in place in front of the seawall which in turn protects the seawall from wave action and undermining. Loss of the beach would reduce the residual life / standard of protection of the seawall.

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
	known but it was raised in 1960	founded on timber piles in alluvium fill to an old stream bed. Condition of the foundations is not known but the wall itself appears to be in reasonably condition.				
Margate to Foreness Point	No information on defence history although it is though most of the defences date from the 1950's to 1970's.	Between Foreness point and Joss Bay there are no defences except for a short section at Kingsgate which is protected by a concrete seawall and concrete slab promenade. The coastline between Margate and Foreness Point is defended by concrete seawalls and promenades except for a short gap in the defences east of Walpole Bay. At Palm Bay seawall copings and promenade slabs are moving. The seawalls are founded directly on the chalk foreshore and there are signs of toe undermining.	3-4	5 to 20 years	20 - 50	Chalk platform with some thin patches of sand forming beaches in embayments
Foreness Point to Stone Bay TR384717 to TR399 688	Mainly undefended coastline	There are no formal defences along this section apart from around the promontory at Kingsgate.	2	<50		Sandy beaches embayed between outcrops of the wave-cut chalk platform
Stone Bay to Ramsgate TR399 688 to TR386 647	The seawalls at Stone Bay were constructed in 1969. The seawalls between Broadstairs and Dumpton Gap were built in 1963. The majority of the remaining defences	Erosion protection to the chalk cliffs is provided by a mass concrete and stone block vertical seawalls founded on the chalk platform. Behind the seawall is a wide apron with chalk	2	<50		Sandy beaches embayed between outcrops of the wave-cut chalk platform. Wide sandy beach north of the harbour.

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
	between Dumpton Gap and the harbour were constructed in 1936.	and granular fill material under the concrete slab.				
Ramsgate Harbour TR386 647 to TR377 642		Substantial harbour arm structures. The East Pier is constructed from stone/masonry blocks. The outer harbour arm is a rock armoured breakwater.	2	50-100		The sandy beach to the north of the harbour wraps around the east pier. No foreshore in front of the remainder of the harbour.
Ramsgate Harbour to Pegwell TR377 642 to TR361 641	The western undercliff defences were constructed in 1935	Vertical stone block seawall founded on chalk platform. Sand beach with timber groynes provide protection to the seawall.	2	<50		Wave cut chalk platform. Sandy beach perched on top of this at eastern end of section.
Pegwell to Cliffs End TR361 641 to TR343 639		Undefended chalk cliffs	n/a	n/a	n/a	Extensive tidal mudflats of Pegwell Bay
Cliffs End to River Stour TR343 639 to TR340 622		Along the low-lying section where the road is at its closest to the MHW line there are no formal defences. Further south, within the boundaries of the nature reserve, there is an embankment which is revetted with rock along the sections exposed to wave action.	2	<50		Saltmarsh and extensive tidal mudflats of Pegwell Bay
River Stour to Sandwich Bay Estate TR340 622 to TR363 577		No formal defences. The only protection against flooding and erosion are the extensive sand dunes	n/a	n/a		Wide sandy foreshore, narrowing to the south.
Sandwich Bay Estate TR363 577 to TR366 570	The Seabee revetment was constructed in the early 1990s	An earth/colliery shale embankment that has been revetted with SeaBee concrete armour units.	1	<50	100	Narrow sandy foreshore

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
Sandwich Bay Estate to Sandown Castle TR366 570 to TR376 543		An unrevetted earth/colliery shale embankment. The shingle beach provides the only protection against damage and breach caused by wave overtopping and erosion	2	<25	<20	Narrow sandy foreshore turning to shingle in south.
Sandown Castle to Deal Castle TR376 543 to TR378 522		Concrete seawall comprising a recurved lower section, above which is a promenade and an upstand wall. Protection to the seawall is provided by the groyned shingle beach.	2	25 to 50	<20	Shingle
Deal Castle to Kingsdown TR378 522 to TR380 488		There are no formal defences along this section; the only protection against erosion is the wide shingle beach.	n/a	n/a	50	Shingle
Kingsdown Village TR380 488 to TR381 485		A vertical concrete wall founded on steel sheet piles. Reinforced concrete slab and secondary wave return wall behind. Groyned shingle beach provides protection to the seawall.	2	25	<20 (erosion)	Shingle and sand
Kingsdown to Oldstairs Bay TR381 485 to TR381 478		Between Kingsdown and the north of Oldstairs Bay the only formal defence is a vertical timber wall that has been constructed along the back of the beach. At Oldstairs Bay a rock revetment, timber groynes and a timber upstand wall provide erosion protection.	1	25 to 50		Shingle and sand on a wave-cut chalk platform
Oldstairs Bay to St	The seawall around the	Predominantly undefended,	3	<25		Wave-cut chalk platform

Location	Defence History	Present Defence Form	Condition	Residual Life (under NAI)	Approx. Standard	Foreshore Features
Margaret's Bay TR381 478 to TR374 452	MoD Rifle Ranges was first constructed in the 1930s and then raised by 2m in the 1960s.	although the MoD Rifle Range is at the foot of the cliffs along the northernmost 600m. This is defended by a mass concrete wall founded on the chalk platform.				
St Margaret's Bay TR374 452 to TR368 443		Vertical concrete seawall with a groyned shingle beach providing additional protection to the seawall.	2	25 to 50		Shingle beach on a wave-cut chalk platform
St Margaret's Bay to South Foreland TR368 443 to TR363 433		Undefended chalk cliffs	n/a	n/a	n/a	Wave-cut chalk platform

C.3 Climate Change and Sea Level Rise

Introduction

The global climate is constantly changing, but it is generally recognised that we are entering a period of change, particularly with respect to rising sea levels and the anticipated implications of climate change and sea level rise present a significant challenge to future coastal management. Over the last few decades, there have been numerous studies into the impact of potential changes in the future, however, there remains considerable uncertainty both within the science of future climate modelling and associated with future global development patterns.

There are no detailed studies outside of existing strategies on the precise effects of climate change on this coastline. The text contains general comments on the likely effects on different types of shoreline as well as general implications for each process unit. In terms of sea level rise the coastal process work was undertaken before the latest Defra guidance was issued and hence the reference to 6mm pa. However, sensitivity checks carried out at the time suggested that the policies were not sensitive to precise estimates of sea level rise. The pressures on the shoreline from sea level rise are considered to be similar over the three epochs.

Sea level rise

The South coast is believed to be still responding to changes during the last 10,000 years when sea levels rose rapidly, flooding the North Sea Basin and Solent area, but there is now concern over human-induced acceleration in sea level rise due to climate change. Relative sea level change depends upon changes in global sea level (eustatic change) and in land-level (isostatic change).

Isostatic change is the change in land level as the crust slowly readjusts to unloading of the weight of the ice since the last Ice Age c.125, 000 years BP (this phenomenon is also known as crustal forebulge). Therefore, areas which were covered by ice, i.e. northern England and Scotland, have been experiencing a rise in land levels over the last few thousand years, whereas the south-east coast of England has been subsiding at a rate of 0.9mm/year (regional isostatic subsidence: UKCIP, 2002).

Eustatic change can be influenced by climatic changes (e.g. increased temperature causes an increased volume of water through thermal expansion and melting ice). Evidence suggests that global-average sea level rose by about 1.5mm/year during the twentieth century; this is believed to be due to a number of factors including thermal expansion of warming ocean waters and the melting of land (alpine) glaciers[2], but after adjustment for natural land movements, it has been calculated that the average rate of sea-level rise during the last century around the UK coastline was approximately 1 mm/year[2].

[2] Hulme,M., Jenkins,G.J., Lu,X., Turnpenny,J.R.,Mitchell,T.D., Jones,R.G., Lowe,J., Murphy,J.M., Hassell,D., Boorman,P., McDonald,R. and Hill,S. (2002) Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK. 120pp

Over the last 2,000 years sea level rise has continued, but at much lower rates resulting in ongoing, but less dramatic, changes at the shoreline. However, we are now entering a period of accelerating sea level rise, which will result in changes to the present coastal systems. Defra (2002) predicted that sea level rise would increase from the present rate of 2mm/yr to 6mm/yr by 2105. Following the Third Assessment Report from the Intergovernmental Panel on Climate Change (IPCC) the figures have been revised (2006). The new allowances are highlighted in the table below.

Administrative or Devolved Region	Assumed vertical land movement (mm/yr)	Net Sea Level Rise (mm/yr)				Previous allowances
		1990-2025	2025-2055	2055-2085	2085-2115	
SE England	-0.8	4.0	8.5	12.0	15.0	6 mm/yr constant *

Table 3.1 Updated figures now reflect an exponential curve and replaces the previous straight line graph (Defra, 2006).

Storminess

It has been postulated that climate change may increase storminess around the UK, but although the UKCIP02) studies indicate some increase in storminess, there is a high degree of uncertainty and little agreement between models, regarding changes in mid-latitude storm intensity, frequency and variability. Therefore although this is recognised as an uncertainty within the predictions, no detailed analysis of potential impacts has been undertaken.

Precipitation

In addition to sea level rise and storminess, the other climate change factor that is important to coastal evolution is precipitation. UKCIP02 predictions suggest that winters will become wetter but summers may become drier throughout the UK. However, there is potential for heavy winter precipitation to become more frequent. This may have an impact on the soft cliffs along this coastline could increase the likelihood of large-scale slope failures, but although this is recognised as an uncertainty this has not been directly taken into account in the shoreline evolution predictions, as effects are likely to be localised, but where large-scale failure are a potential hazard this has been recognised in the scenario assessments.

C.4 Baseline Case 1 – No Active Intervention (NAI)

C4.1 Introduction

This report provides analysis of shoreline response conducted for the scenario of No Active Intervention. This has considered that there is no expenditure on maintaining/ improving defences and that therefore defences will fail at a time dependent upon their residual life and the condition of the beaches. This report also assumes that where there is beach recharge and/or beach recycling it will cease immediately; a result of no further expenditure.

The analysis has been developed using the understanding of coastal behaviour from both Futurecoast (2002) and the baseline understanding report produced, existing coastal change data and information on the nature and condition of existing coastal defences.

C4.2 Summary

Chalk Cliffs: The chalk shore platform would lower at relatively low rates, and the backing Chalk sea cliffs would continue to recede, with erosion preferentially occurring along joints and faults. Due to the relatively slow rates of Chalk erosion, only small volumes of shingle would be released to the foreshore and consequently, the existing foreshore stock would not significantly increase in volume (Futurecoast, 2002).

Clay Cliffs: The London Clay shore platform would experience lowering and although the foreshore beach would receive new sediment input from eroding cliffs, the debris material would be moved by longshore transport processes. This would restrict the ability of the foreshore to dissipate incoming wave energy and, as a consequence, the sea cliffs would experience basal undercutting. As a consequence of this instability, the sea cliffs would continue to experience landsliding behaviour. Fine-grained material released from the cliffs would be transported both offshore and into the Medway and Swale estuaries where it would contribute to the slow vertical sedimentation of the tidal flats and marshes (Futurecoast, 2002).

Alluvium Low-lying areas of alluvium i.e. Reculver Towers to Minnis Bay, would be inundated with tidal water. It would result in tidal inundation of large areas of low-lying backshore enabling its reversion to tidal flat and, in areas topographically higher within the tidal frame, to salt marsh. On the Isle of Grain a second mouth for the Medway could form, as could another for the Swale, whilst there is the potential for the Isle of Thanet to be isolated from the mainland (Futurecoast, 2002).

Shingle The shingle would roll back across the low-lying hinterland in response to sea level rise. However, as the cliffs further to the east of this frontage would retreat relatively slowly, they would not contribute significant new volumes of shingle to this frontage. Due to this, the ridge could be liable to segmentation and breaching. It would result in tidal inundation of large areas of low-lying backshore contained within the Stour Valley, enabling its reversion to tidal flat and, in areas topographically higher within the tidal frame, to salt marsh. This could lead to the isolation of the Isle of Thanet from the mainland (Futurecoast, 2002).

Fluvial There exists a potential break-through in the tight meander in the River Stour at Richborough, leading to re-alignment of the river and, possibly, the river mouth (Futurecoast, 2002).

Estuary The mouth of the River Medway estuary would be substantially re-defined. (Flooding of the low-lying areas of the Isle of Sheppey would also occur via the River Swale estuary, leaving higher areas of Sheppey, such as the cliffs between Minster and Warden Point and the Isle of Hardy, isolated as islands). The existing backshore would revert to an inter-tidal area. The lower areas of newly-created inter-tidal may acts as sinks for fine-grained sediment and, if sheltered from wave activity and supplied with sufficient quantities of sediment, could potentially accrete vertically, ultimately enabling more widespread colonisation by mid and higher zone salt marsh species (Futurecoast, 2002).

C4.3 No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
(Allhallows-on-Sea to Grain)	Clay embankment / seawalls with concrete block front slopes protect the majority of the frontage (<20 years). At Grain there are timber groynes, along a section of coast which is known to erode (<20yrs). Raised ground/cliffs protect Grain.	No defences	

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	This is a low lying section of the open coast that is backed predominantly by low lying reclaimed marshland (that has agricultural and environmental importance). The villages of Allhallows and Grain both however, sit on localised areas of high ground (gravel slopes). The Yantlet Creek intercepts the open coast in the north whilst in the east the River Medway separates Grain from Sheerness. The area of undefended gravel slope north of Grain village will continue to erode at an average rate of 0.5-1m/yr, localised falls may also occur periodically. It is predicted that with the continued presence of defences (mainly embankments) the shoreline will continue to respond in a similar manner to the present day. Therefore little change is predicted during this epoch. The mouth of the Medway will continue to be constrained by the presence of defences and highland. The power station at Grain will continue to be protected by the revetments and seawalls during this epoch and as such no change in shoreline alignment or risk of flooding is predicted. Continued sedimentation on the tidal flats, resulting in their further vertical rise is	During this epoch the failure of the defences at the end of the last epoch, will result in large scale inundation of the central area of this frontage (and the area south of Grain village i.e. the Power Station area). Should this take place; the plan form of the present coastline will change dramatically. It is predicted that there will be large scale inundation of the low lying land leaving the high ground, of Grain, an island. Erosion of the undefended gravel slopes will continue, while erosion of previously defended slopes would be re-activated during this epoch; average rates could be in the region of 0.5-1.0m/year (Futurecoast, 2002). It is also anticipated that the mouth of the River Medway estuary would be substantially re-defined. Defence failure would increase the size of the estuary channel and encourage the creation of inter-tidal habitats. Flows into and out of these new intertidal areas are likely to create new channels or result in the expansion of the existing creek network.	Without defences in place and a predicted increase in sea level rise (6mm/year), further tidal inundation of the low-lying land, is anticipated. Again this will alter the plan form of the coastline. It is envisaged that the second mouth of the River Medway, at what was Yantlet Creek, will become more established during this epoch. The exact nature of the dominant sedimentary dynamics i.e. ebb or flow, at this second mouth and the existing, primary mouth is difficult to postulate, for this is dependent on sea level rise, tidal flows, sediment supply and the channels cross sectional area. The gravel slopes at Grain are predicted to erode at a higher rate than at present, due to sea level rise. The cliffs will continue to release predominantly coarse material to the foreshore, which will be transported west and south-eastwards respectively.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze along embankment sections, average erosion of undefended slopes is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 20 = 10-20m (15m mean).	Large scale flooding is predicted for the majority of this frontage, especially in the Yantlet Creek region. It is predicted that the previously defended slopes at Grain will erode at an average rate of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 15-30m (mean 22.5m) from the current shoreline (i.e. 30 yrs of erosion). Average erosion rate of the undefended slopes are predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 25-50m (mean 37.5m) from the current shoreline (i.e. 50 yrs of erosion).	A large proportion of the Isle of Grain will be experiencing estuarine conditions, with the exception of Grain slopes, which will continue to erode. The average erosion rate is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 40-80m (mean 60m) from the current shoreline for defended sections (i.e. 80 yrs of erosion) and 50-100m (mean 75m) in undefended sections by year 100 (i.e. 100 years of erosion).

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Sheppey West **(Sheerness to Scrapsgate)**	A seawall and groyned shingle beach protects Garrison Point to Barton's Point Between Barton's Point and the western edge of Minster is a shingle barrier beach. There are no retaining structures along its length but beach recharging would cease immediately.	No defences	

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	The port at Sheerness and the east bank of the River Medway dominates this section of the coast. The presence of the port and its associated construction has affected the boundary of the coastal processes between the open coast and the estuary. Nonetheless some material will continue to by-pass these structures and as such Garrison Point (in the extreme west of this frontage) will continue to accrete (silt, mud and sand). The predominant drift direction, along this section of the coast, will remain east to west. The permanence of defence structures throughout this epoch will reduce flood potential.	With the collapse of the defences at the end of the last epoch, low lying land along much of this frontage, is at risk of flooding. Inundation at this location would also result in changes to the systems dynamics; changing from open coast to estuarine. As such the mouth of the River Medway estuary (on the eastern side) would be substantially re-defined. The situation is likely to be exacerbated by the predicted rise in sea level (6mm/yr), thus potential exposure to wave and tidal action is predicted to increase. Flooding of the low-lying areas would encourage new inter-tidal areas to develop, along Sheerness and Scrapsgate frontage. These newly-created inter-tidal areas may act as sink for fine-grained sediment. Widening of the Medway's primary estuary mouth could change the transport dynamics. For example the present, predominantly westwards alongshore transport regime, could change to something far more complex. Nonetheless it is predicted that an input of coarse sediment from the updrift frontage of Sheppey Central will continue throughout this epoch.	During this epoch there is the potential for the frequency and severity of flooding to increase, in response to the predicted rise in sea level (6mm/year). Thus further changes in the dynamics of the system are anticipated. It is envisaged that the open coast processes will continue to give way to estuarine processes. As sea level rise predicted to continue throughout this epoch, tidal flats created in the previous epoch are likely to become more established and experience a landwards transgression. Their establishment will however, be governed by the rate of sea level rise and the availability of sediment to allow their vertical accretion within the tidal frame. It is envisaged that during this epoch sediment will still be supplied from the east.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze of the foreshore/inter-tidal area.	The whole of the frontage will experience flooding	The whole proportion frontage will be experiencing estuarine conditions

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Sheppey Central **(Scrapsgate to Warden**	Minster is protected by a sea wall and rock revetment (<20 years). Minster Slopes is protected by a sea wall and a groyned beach (<20 years).	No defences	

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Point)	This frontage is dominated by London Clay sea cliffs, which vary in height (8m to 52m). In the west the cliffs are heavily defended and as such the town of Minster will remain defended throughout this epoch. Along the remainder of the frontage the cliffs are unprotected and will continue to erode, predominately in the form of landslide events. Fine material released from cliff erosion is transported in suspension into the outer Thames estuary. The volume of coarser material (sand and shingle) released from the eroding cliffs will remain insufficient to build a protective foreshore cover. This material is transported westwards towards Garrison Point. As such the foreshore will remain as a narrow shingle beach sitting on top of a shore platform cut into the London Clay basement. During this epoch the fronting shore platform will also continue to degrade. There is no risk of flooding, during this epoch, due to the presence of the backing cliffs.	With the failure of the defences, at the end of the previous epoch, a period of rapid readjustment, of the previously defended frontage, in the west, will ensue. Thus the cliffs in the west will initially (5-10 years) experience high rates of erosion prior to settling for a rate that is more commensurate with the forcing factors and in line with the cliffs, in the east, which have always been undefended. Debris material, from the landslide events, will be removed by tidal action relatively quickly. Therefore no/little protective cover will remain at the cliff toe, which will induce further instability. Fine sediment will continue to be transported in suspension into the outer Thames estuary, although the volume of material would increase during this epoch, on account of additional cliff erosion. Coarse sediment will continue to be transported westwards, towards Garrison Point, again the volume may increase due to accelerated erosion of the cliffs.	Response during this epoch will be a continuation of the previous epoch, albeit at an accelerated rate. There will be increased cliff erosion, and an increased probability of landslides, fine sediment will continue to be released to the system (and transported alongshore – in a westwards direction). It is possible that during this epoch there would not only be an erosion risk but also a flood risk. Cliffs landslides at Minster could in turn, increase flood risk to the adjacent policy unit (4a 02) by potentially opening up a new flood pathway. During this epoch there may also be squeeze of the foreshore if sea level rise outpaces cliff erosion.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze where defences remain. Average erosion rate of undefended cliffs is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 20 = 10-20m (mean 15m). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years (Futurecoast, 2002).	Average erosion rate of reactivated cliffs will be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 15-30m (mean 22.5m) from the current shoreline (i.e. 30 yrs of erosion). Average erosion rate of the undefended London Clay Cliffs is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 25-50m (mean 37.5m) from the current shoreline (i.e. 50 yrs of erosion). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years (Futurecoast, 2002).	Average erosion rate of reactivated cliffs is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 40-80m (mean 60m) from the current shoreline (i.e. 80 yrs of erosion). In addition, the position of the top of the landslide by year 100, allowing for an average landslide width of 107m could be in the region of between 147-187m (mean 167m) from the current shoreline. Average erosion rate of the undefended London Clay Cliffs is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 50-100m (mean 75m) from the current shoreline (i.e. 100 yrs of erosion). In addition, the position of the top of the landslide by year 100, allowing for an average landslide width of 107m could be in the region of between 157-207m (mean 182m) from the current shoreline. Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
			years (Futurecoast, 2002).

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Sheppey East **(Warden Point to Shell Ness)**	The town of Warden is fronted by a groyned beach and concrete revetment, with a sea wall to the southern end. In 'The Bay' area, protection is afforded by a barrier beach. A concrete sea wall and groyned beach protect Leysdown-on-Sea. At Shellness the frontage is protected by embankments, wooden groynes and the fronting shell beach. All defences have a residual life (<20 years).	No Defences	

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	The northern part of this frontage is dominated by London Clay sea cliffs, which vary in height (8m to 52m). The majority of the frontage is heavily defended and as cliff erosion in the north is limited, the entire plan form of the shoreline is fixed, the towns of Warden and Leysdown-on-Sea are defended and there is little risk of the low-lying land, between Warden and Leysdown, being flooded. Thus, a continuation of this is trend is predicted, until the groynes fail, which will take place during this epoch. Pockets of sandy beaches punctuate the foreshore. The groynes at Warden Village between Leysdown-on-Sea and the nose of Shell Ness will continue to maintain a sandy beach, although some degree of narrowing is anticipated during this epoch. It is believed that material fed to this frontage, comes predominantly from offshore shell banks (the rate has yet to be established). The other source of sediment is via alongshore transport, despite the continued presence of defence's. Material is moved alongshore, in a south-eastwards direction between Warden Point and the nose of Shell Ness and in a south-westwards direction in the lee of Shell Ness. Thus the sand/shell spit will continue to accrete, extending in south-west direction, into the outer reaches of the River Swale.	Failure of the groynes will allow the sediment to move freely with the predominant drift direction i.e. south-eastwards. The movement of material will result in increased exposure of the revetment, which will ultimately lead to its demise. With no defences in place a readjustment phase will take place. This will involve rapid retreat of the shoreline until a plan position more commensurate with the forcing factors, is reached. Defence failure along with a predicted acceleration in sea level rise (6mm/year) will result in the area south of Warden Point cliffs becoming increasingly vulnerable to flooding. The beach ridge, between Leysdown and Shell Ness would respond to rising sea levels by migrating landward across the low-lying backshore. There is a risk that the ridge could be breached. However, this risk may be countered by an increase in sediment feed, due to defences failing updrift and material being fed from offshore.	With sea level's continuing to rise (6mm/yr) and sediment continuing to be transported in a predominantly south-eastwards direction, the foreshore at Warden Point will reduce. As such cliff erosion, at this location, will increase. The small amount of beach building material (sand and shingle) released from the cliffs will provide temporary protection to the cliff toe however, this will be transported alongshore. During this epoch it is predicted that the low-lying land between Warden and Leysdown-on-Sea will be inundated. The presence of this mini-inlet could affect the alongshore transferral of sediment, thus reducing the sediment inputs to the Leysdown frontage. The area of land between Leysdown Country Park and Shell Ness will also be inundated. In this instance a change in the dynamics of the open coast system to an estuarine system is anticipated. It is likely that the Swale estuarine system would expand and new areas of intertidal habitats would be created. There is also the potential for the Isle of Harty to become separated from the Isle of Sheppey during this epoch – providing the Swale estuary with an additional outlet. Should this take place then the exact nature of the dominant sedimentary dynamics i.e. ebb or flow, at this second mouth and the existing

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze of the defended sections. Rollback of the shingle ridge at ‘The Bay’.	Average erosion rate at Leysdown-on-Sea is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 15m-30m (mean 22.5m) from the current shoreline by year 50 (i.e. 30 years of erosion). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years (Futurecoast, 2002). Rollback of the shingle ridge at ‘The Bay. Flooding predicted at ‘The Bay’ and between Leysdown-on-Sea (south) and Shellness.	Further erosion Leysdown-on-Sea is predicted at an average rate of 0.5-1m/y (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 40m-80m (mean 60m) from the current shoreline (i.e. 80 yrs of erosion). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years (Futurecoast, 2002). Permanent inlet created at ‘The Bay’ and the area south of Leysdown-on-Sea will be experiencing estuarine conditions.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Graveney Marshes (Faversham Creek to Seasalter - PH)	Faversham Creek to Faversham Road comprises an assortment of defended lengths including: a re-curved seawall, block-work apron and dilapidated wooden groynes. Backing Faversham Road (in the east) is a clay (1953/54) embankment behind the road and properties, which are built on the beach (<20years).	No Defences	

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Extensive tidal flats backed by large areas of former salt marsh that have been enclosed and reclaimed from the sea for agricultural use dominate this section of the coast. During this epoch it is envisaged that the low lying frontage and backing hinterland of Graveney Marshes will continue to be controlled by the shoreline defences and shoreline infrastructure. Thus no flood inundation is predicted during this epoch. The foreshore comprises shell fragments, in the west (washed onshore from the extensive shellfish beds in the mouth of the River Swale estuary) and a small volume of shingle (flints, black pebbles and claystone on the upper beach) in the east. Despite a westwards transport of material this diversion of sediment types and sizes will be maintained throughout this epoch, although the barrier beach and clay bund west of the Sportsman Pub could breach under a severe storm. Groynes along the frontage will continue to restrict the east to west transport of sediment. Similarly Faversham Creek, at the western end of this frontage, will continue to act as a barrier to sediment and as such the sandy beach, with high shell content, will continue to accumulate on the east bank of the creek. Once at this location the strong ebb flows, of the River Swale, will continue to push the sediment north to Pollard Spit; on the south side of the River	With the failure of the defences and the predicted increase in sea level rise (6mm/yr) the marshes of Cleve, Graveney and Seasalter Levels will be susceptible to flood inundation; properties along Faversham Road will be lost. Initially this may be countered by sediment inputs from updrift sources (i.e. Whitstable Bay West) and the ability of the sediment to move alongshore freely. However, it is speculated that over time the input will not keep pace with sea level rise and subsequently large scale flooding of the backing hinterland will take place. However, towards the close of this epoch changes to the existing plan-form of the River Swale estuary are to be expected. Ultimately this frontage will change from one with ‘open coast’ processes to one of ‘estuarine’ processes.	Change from the previous epoch will establish itself during this epoch. The marine transgression is likely to expand the estuarine extent by increasing the width the Swale’s channel. As such the inter-tidal habitats might migrate landwards. With a predicted change in dynamics from open coast to estuarine, it is difficult to define the exact nature and impact upon coastal processes. It is predicted that sediment will still be fed to this frontage from updrift section of the coast (further east). It is also speculated that the newly-created inter-tidal areas could act as a sink for fine-grained sediment, which may encourage further development of saltmarsh and mudflats. In light of the former predicted response inter-linkages with the Medway and Swale SMP will become increasingly prevalent.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze of inter-tidal area.	Large scale flooding predicted	The entire frontage will be experiencing estuarine conditions

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Whitstable Bay West **(Seasalter PH to Whitstable Harbour)**	Re-curved sea walls topped with a concrete promenade front the majority of this coast. Groynes and recharge sustain the fronting shingle beaches. At the quays and around the harbour are various perimeter sea walls built in the 1980's. Seawalls, groynes and beach recharge protect Seasalter slopes.	By the close of this epoch there will be no groynes. Thus the previously retained beach will be rapidly 'transported' westwards.	No Defences

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	The updrift and shoreline structures will continue to influence the morphodynamics along this section of the coast. New timber groynes and beach recharge works were completed along most of the frontage in September 2006. However, with no further beach recharge scheduled the foreshore will narrow during this epoch. Due to the updrift defences, the throughput of sediment (sand and silt) from the east is restricted. Thus the mudflats immediately downdrift of Whitstable Harbour will continue to deplete. Some material does bypass the defences and will continue to do so, at a potentially greater rate, as the groynes updrift and along this frontage deteriorate. It is envisaged that the slight promontory around Lower Island will be maintained.	The groynes and the harbour arms will continue to affect alongshore transport and updrift sediment inputs. At some time during the 20 to 50 year period, the groynes would be expected to fail. Once this happens, the shingle beach would move freely to the west, leaving the seawall exposed. With limited foreshore cover the foundations of the seawalls will come under attack and ultimately they will collapse. This section of the coast has a long history of coastal defence (13^{th} Century) thus a period of rapid readjustment is anticipated. In conjunction to this, Whitstable is built on low-lying land, which is composed of alluvium. Alluvium is susceptible to erosion thus it is predicted that a large proportion of Whitstable would be lost to flood inundation whilst Whitstable slopes (composed of clay) will be subjected to erosion (up to 1 m/yr is predicted, although during the 'readjustment stages' this may be higher.) Flood inundation and coastal erosion will change the plan position of the shoreline. Therefore it is predicted that the inter-tidal area could increase during this epoch as the shoreline migrates landwards.	During this epoch it is predicted that sea level will continue to rise (6mm/yr) thus at Seasalter cliff erosion will accelerate (as will the frequency of landsliding), whilst the area around Lower Island will be inundated. It is postulated that the feed of sediment, from the east, will increase initially during this epoch, on account of the harbour arms failing previously. However, this increase will not be constant due to the supply being finite and sea level rise countering the affect. It is speculated that areas of newly-created inter-tidal habitat could acts as sinks for fine-grained sediment, which may encourage the development of saltmarsh and mudflats.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze	Assumed seawalls will fail in Year 30. Average erosion rate along the western section of this frontage is predicted to be in the region of 0.5m-1.0m/year (Futurecoast, 2002). Erosion by year 50 = 10m-20m (mean 15m) from the current shoreline (i.e. 20 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years (Futurecoast, 2002). Flooding is predicted in the east.	Further erosion in the west: Average erosion rate is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 35m-70m (mean 52.5m) from the current shoreline (i.e. 70 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years (Futurecoast, 2002). Permanent saline inundation is predicted in the east.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Whitstable Bay East (Whitstable Harbour to Long Rock)	A seawall protects Harbour Beach and the Tankerton frontage. Beach re-grading and recharge also occurs along the majority of this coast. At Long Rock the natural spit is backed by a clay bund.	The harbour arms will fail as will the groynes. By the end of the epoch no defences will remain.	No defences

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	The majority of this frontage is low-lying except for the shoreline at harbour beach Whitstable and around Swalecliffe Brook/Long Rock. This section of coastline is high ground backed by London clay cliffs. The foreshore comprises a mixed shingle and sand beach which overlies the London Clay shore platform. During this epoch beach recharge /and beach recycling will cease immediately. Thus, despite the continued presence of groynes the beach will narrow and the amount of protection the foreshore affords will reduce, impacting on the remaining defence structures. Nonetheless a slightly reduced beach will be held at Whitstable and Tankerton by the continued presence of groynes. During this epoch the eastern harbour arm at Whitstable will continue to act like a terminal groyne. Thus sediment moving west via alongshore coastal processes, will continue to build up in front of the harbour arm. The old pipeline at Whitstable Street will continue to restrict, albeit on a very small scale, the movement of sediment alongshore. By the close of this epoch all the groynes will have failed.	With a long history of coastal management (13th Century) it is predicted that with groyne failure, an immediate readjustment phase will take place. Sediment previously held will be swept westwards with the predominant drift direction. The transferral of sediment will initially be countered by the increased input of sediment from the east (due to updrift defences failing). However, as time progresses the foreshore cover will thin to a point where the seawalls will be undermined by wave attack, which will ultimately lead to their demise. Again a period of rapid readjustment is predicted. It is envisaged that towards the end of the epoch: 1) The plan form position of the shoreline will rapidly migrate landwards, to a position more commensurate with the forcing factors and 2) The London Clay shore platform will continue to experience lowering, albeit at a slightly accelerated rate. With a lack of defences in place and a predicted rise in sea level (6mm/year) erosion of the previously defended cliffs at Tankerton would be re-activated. Thus, the foreshore will receive new sediment however; this will be at the expense of the cliffs experiencing basal undercutting and the associated landsliding behaviour. Flooding is predicted only for the extreme east and western sections of this frontage. Sea level rise will also influence the degree of flooding in the Swalecliffe area, in particular at Swalecliffe Brook. Flooding in the west	During this epoch a continuation of the previous epoch is envisaged. Thus, further and accelerated erosion of the cliffs is predicted, as is a landwards migration of the shoreline, continued feed of sediment from the east (although the supply will be insignificant to build beaches) as well as further flooding of the low-lying areas/river area. Expansion of the inter-tidal area; could result in the growth of salt marshes and mudflats. If this was to be the case and sea level was predicted to rise continuously, then the saltmarsh and mudflats would migrate landwards, across the low-lying backshore, to counter the change. This would enable the tidal flat and marsh profile to maintain its position relative to the tidal frame.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze	Initially coastal squeeze, followed by erosion when defences fail in year 30. Average erosion rate is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 10m-20m (mean 15m) from the current shoreline (i.e. 20 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years (Futurecoast, 2002). Flooding is predicted in the west (Whitstable – harbour beach) and in the east (Swalecliffe).	Continued erosion along the frontage at an average rate of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 35-70m (mean 52.5m) from the current shoreline (i.e. 70 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years (Futurecoast, 2002). Further flooding predicted around the harbour beach and Swalecliffe / Swalecliffe Brook.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Herne Bay **(Long Rock to Herne Bay Harbour)**	A seawall, groynes and rock gabions (built in the mid 1980's) revetments, protect the Long Rock to Herne Bay frontage (<20 years). Between Herne Bay Pier and Herne Bay Harbour breakwater is a sea wall, a shore attached breakwater arm and a recently recharged beach (<100yrs).	The breakwater and defences behind the breakwater at Herne Bay will be intact, elsewhere all defences will have failed towards the end of this epoch.	No Defences

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Again this frontage is dominated by London Clay sea cliffs whilst the foreshore comprises a predominantly shingle beach, although there is some sand and mud, which overlies a London Clay shore platform. The continued presence of defences throughout the majority of this epoch will see a continuation of the present shoreline processes. 1) The dominant drift direction will remain westwards. 2) The terminal groyne at Hampton Pier will continue to have a major controlling influence; sustaining a wider beach updrift of the structure and a narrower one in its lee (due to the structure continuing to interrupt sediment movement alongshore). 3) The harbour arm at Herne Bay will continue to provide some degree of protection to the town's frontage. As such the sand / shingle beach, in its lee, will remain reasonably wide. However, as one moves west along the frontage the sand beach thins irrespective of the groyne field and the westward transferral of sediment, therefore further thinning of the foreshore is envisaged.	With total defence failure in the west (Long Rock to Herne Bay) or a rapid readjustment of this section of the coast is anticipated. Reactivation of the backing London Clay cliffs is envisaged at an accelerated rate due to 1) the shoreline being held seawards of its natural alignment and 2) the predicted rise in sea level, which will accelerate basal undercutting of the cliffs and induce landsliding behaviour. Sediment previously held by the groynes and at Hampton Pier will be transported alongshore, in a westwards direction, to frontages downdrift (Whitstable Bay East). The presence of defences at the eastern end of the frontage will remain throughout this epoch thus similar processes to the present day are predicted. The foreshore will however, thin as a result of coastal squeeze. With a reduction in foreshore cover and sea level predicted to increase, the harbour arm and backing defences will come under increased attack and may fail towards the end of this epoch.	Until the defences in the east (Herne Bay Pier to Herne Bay Harbour) fail a continuation of the previous epoch is predicted. Thus the shoreline will continue to retreat in the west whilst the foreshore continues to thin in the east. At this point the shoreline will be stepped, the east being a promontory in comparison to the west. However, as soon defences fail 1) the shoreline will retreat rapidly, until it reaches a position more commensurate with the forcing factors and 2) the central section of Herne Bay will be inundated with flood water. Sediment will be fed into the frontage from updrift sources; however sediment will also leave the frontage, supplying a finite amount of sediment to downdrift frontages. Material eroded from the London Clay cliffs will not provide beach building material (the majority being too fine to do this).
	As time passes the foreshore will continue to erode and ultimately all the defences in the west (Long Rock to Herne Bay) will fail.		

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze	Area not behind Herne Bay Breakwater, average erosion rate is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Assuming defences fail in this location by year 30, erosion by year 50 = 10m-20m from the current shoreline (i.e. 20 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years (Futurecoast, 2002).	Further erosion along the majority the frontage not behind Herne Bay. Average erosion rate in this location is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 35-70m (mean 52.5m) from the current shoreline (i.e. 70 years of erosion). The shoreline backing the now failed Herne Bay Harbour (Herne Bay Harbour and Herne Bay Pier assumed to fail in year 70) is predicted to erode ant an average rate of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 15-30m from the current shoreline (i.e. 30 years of erosion), with some flooding. Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years (Futurecoast, 2002).

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Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Herne Bay Harbour to Reculver	Herne Bay Harbour to Bishopstone Glen: a seawall/ promenade and groynes. The backing cliffs are graded, grassed and drained. There is a short section of rock armour at Eastcliff (<20 years). Bishopstone Glen to Reculver. There is a block ragstone apron at Reculver Towans.	Herne Bay to Bishopstone Glen: a seawall backs the beach (<50years). Between Bishopstone to Reculver is a short section of rock, thereafter no defences until Reculver Towans: block ragstone apron and rock protection (<50 years).	No Defences

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	This frontage is dominated by London Clay slopes, however between Bishopstone Glen and Reculver there is a short section of rock armour but mainly freely eroding cliffs, composed of Tertiary sand and some gravel sized sediments (in the cliff base). The plan form of the shoreline is defended with seawalls in the west and rock armour in the east, except for the eroding section. Beach recharge would cease immediately at Reculver headland. Increasing the pressure on the remaining defences. There is limited through-put of material alongshore materials, from the west, due to the 'terminal groyne-like' affect of Reculver Towers. However, the cliffs at Bishopstone afford some beach material (sand). Whilst downdrift structures i.e. Neptune's Arm, at Herne Bay, will continue to restrict sediment moving alongshore thus retaining material updrift. The continued presence of groynes along this frontage will hold a large proportion of the sand and shingle beach material, whilst seawalls will continue to fix the plan position of the shoreline. As such a small amount of coastal squeeze is predicted in this epoch.	Groyne failure at the close of the previous epoch will release beach sediment (sand) and be transported alongshore (westwards). With failure of the seawall the London Clay Cliffs and the cliffs between Bishopstone Glen and Reculver will experience accelerated erosion and landsliding. Material provided from the cliffs eroding will provide some foreshore cover, however it will not be sufficient to build beaches and/or counter sea level rise (6mm/yr). Some sediment may enter the system from the updrift frontage of Reculver to Minnis Bay, providing it can bypass Reculver headland. It is predicted that the offshore source, from Margate Sand, will continue throughout this epoch. Thus, some form of thin sand cover is envisaged throughout this epoch. By the close of this epoch all defences will have failed.	Accelerated rates of London Clay cliff erosion and sand and gravel cliffs between Bishopstone Glen and Reculver. The sea cliffs will be susceptible to large landsliding events. Erosion and landsliding will provide mixed sediment (gravel, sand and clay) to the foreshore. The fronting London Clay platform will continue to lower. Flooding of the Wantsum Channel via Reculver village. The westward transport of littoral sediment will continue throughout this epoch. However, transport rates will remain low due to a limited volume of sediment entering the system and a limited volume of sediment remaining on the foreshore.

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Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze along defended sections. Undefended cliff erosion rate (Reculver CP) is predicted to be, on average, in the region of 0.1-0.5m/yr (Futurecoast, 2002). Erosion by year 20 = 2-10m (6m mean).	Assumed defences will fail in Year 35 (Herne, Beltinge and Bishopstone). Thereafter, average erosion rate is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 7.5-15m (mean 11.25m) from the current shoreline (i.e. 15 years of erosion). Periodic localised landslide events may also occur in this location, with a frequency of around 10-50m in 10 years (Futurecoast, 2002). At Reculver CP: average erosion rate is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). Erosion by year 50 = 5-25m (mean 15m) from the current shoreline (i.e. 50 years of erosion).	Average cliff erosion along previously defended sections (Herne, Beltinge and Bishopstone) is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 32.5-65m (mean 48.75m) from the current shoreline by (i.e. 65 years of erosion). Periodic localised landslide events may also occur in this location, with a frequency of around 10-50m in 10 years (Futurecoast, 2002). At Reculver CP: average erosion rate is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 10-50m (mean: 30m) from the current shoreline (i.e. 100 years of erosion).

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Reculver to Minnis Bay (west)	Sea wall topped with a concrete access way, 14 rock groynes, and the large shingle beach is maintained with beach replenishment (<20 years) at both the west and eastern sections. Reculver Towers: block ragstone apron and a rock armour revetment (<50 years).	No Defences	

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	A narrow strip of drift deposits (alluvium and head brickearth) from the Quaternary (125,000 to 10,000 yrs BP) dominant the foreshore. The beach in the west is composed of shingle and sand, which gives way to mainly shingle and a sparse covering of sand on the lower foreshore in the east. This front's a low-lying alluvium hinterland, which once was part of the Wantsum Channel, Due to the continued presence of defences little change in coastal processes and geomorphological response is envisaged during this epoch. For example the stone apron will continue to protect Reculver Towers rock revetment from erosion, as well as act as a barrier to the alongshore (east to west) transport of material. Without the input of replenished material, the vulnerability of the central section would increase, thus further narrowing of the foreshore is envisaged. This in turn will put increased pressure on the backing earth embankments, which protects the marsh hinterland from extensive flooding. Sediment transport patterns along this section are somewhat complicated, due to the presence of offshore banks. Thus, despite the dominant movement of material along this	With the demise of the defences significant change along this frontage is predicted. The coastline would become free-functioning and as such a landwards migration of the plan form position is anticipated. Breaches are predicted, initially attacking the vulnerable sections of the coast i.e. east of Reculver and Brooksend outfall. Tidal conditions, the degree of sea level and storm frequency will dictate the degree of flooding but some standing water occupying the backing hinterland is envisaged. Depending on the location of the breaches along with the forcing factors i.e. wave energy, sea level and sediment supply, there is the potential that the breaches may seal, albeit temporarily. With time and under a scenario of continued sea level rise, it is predicted that the breaches are likely to widen, particularly during storm events, eventually leading to the development of a tidal lagoon. During this epoch there is also the potential, for flooding from this frontage to combine with inundation from the east Kent coast (between Cliffs End and Deal north). Should this occur then the former tidal channel between north and east Kent would be re-created. This has the potential to leave the Isle of Thanet separated from the mainland. It is possible to postulate the processes involved for the re-activation of the Wantsum Channel, despite not being able to define their exact duration and	During this epoch it is likely that flood depth and flood extent will increase due to the predicted rise in sea level and further breaching i.e. of the Sarre Wall into Sandwich Bay flood area is also predicted for this epoch. Inundation of the former Wantsum Channel could result in the flooding of up to 9500 hectares of low lying land and 1500 hectares of erosion (SMP1, 1996; Reculver to Minnis Bay Scheme, 2001). Change on this scale, will result in the naturally functioning coastline being completely different from the present day coastline. Depending on the dynamics of the River Stour and the tidal currents of the North Sea, there is the potential for either an ebb tidal delta or flood tidal channel to form. As such wave attenuation (height, direction) could change, leading to changes in coastal processes (i.e. drift reversals, alongshore transport being interrupted). The presence of a permanent inlet could also, quite obviously, affect the present day coastal processes regime as well. Throughout this epoch the cliffs at Reculver Towans will continue to erode, occupying a retreated position more commensurate with the forcing factors. Cliff toe erosion will provide some beach feeding material to the foreshore. This material will however be transported westwards by alongshore coastal processes

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze	Inundation (Wantsum Channel)	Inundation (Wantsum Channel)

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Margate **(Minnis Bay to Fulsam Rock)**	Harbour arms, seawall, groynes Epple Bay to Westgate Golf Course – No defences	Harbour arms Other defences fail by yr 35 Epple Bay to Westgate Golf Course – No defences	No Defences

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Upper Cretaceous chalk cliffs (10-25m in height), are protected by seawalls, which rest on chalk platforms that can be up to 250m wide in places. Seawalls prevent erosion of the cliff toe and as such the plan position of the shoreline will remain fixed. The towns of Birchington and Westgate-on-Sea are not at risk from erosion during this epoch. At Margate the harbour arms and groynes along the frontage will continue to retain the mobile layer of sand and shingle. However, some narrowing of the foreshore is expected despite sediment inputs from offshore being predicted to continue. Throughout this epoch the harbour arms and the groynes will continue to exacerbate the alongshore transport of material westwards. The undefended section of shoreline between Epple Bay and Westgate Golf Course will experience low rates of erosion in the region of 1-2m by year 20, as the series of joints and small faults are eroded by storm wave action (D'Olier, 2007).	Groyne failure is predicted to take place at the start of this epoch. Thus movement along the frontage, with the exception of the harbour arms, will be free functioning. Wave attack and scour of the remaining seawall is predicted in response to sea level rise and coastal squeeze. Failure of the seawall is predicted to take place before the close of this epoch. Thus, until failure, the plan form of the shoreline will remain in its present position. However upon failure, a readjustment period is envisaged. The reactivation of cliff toe erosion is likely to result in cliff instability. Erosion rates for cliffs between Minnis Bay and Fulsum Rock have been calculated by D'Olier (2007). *Assuming no defences*, erosion from the current shoreline by year 50 is predicted to be in the region of 2 -9m between Minnis Bay and Epple Bay; 1.5 – 7.5m between Westgate Golf Course and the Western end of Westbrook Bay; and 2 – 9m between the Western end of Westbrook Bay and Fulsam Rock. Along the undefended section, between Epple Bay and Westgate Golf Course, erosion will continue, in the region of 1.5 – 7.5m from the current shoreline by year 50 (D'Olier, 2007).	With the accelerated rise in sea level predicted (6mm/yr) to continue the pressure and impact on the remaining defence structures will increase, eventually resulting in their demise. Upon defence failure sediment (sand) retained by the groynes and the arms of the harbour will released and transported alongshore (westwards). It is anticipated that erosion of the backing chalk cliffs will be reactivated and as such a small amount of flint but mainly fines will be added to the system. *Assuming no defences* (i.e. 100 years of erosion by year 100), D'Olier (2007) predicts cliff erosion from the current shoreline at year 100 to be in the region of: 5 -17m between Minnis Bay and Epple Bay; 5 – 15m between Westgate Golf Course and the Western end of Westbrook Bay; and, 5 – 17m between the Western end of Westbrook Bay and Fulsam Rock. Along the undefended section, between Epple Bay and Westgate Golf Course, erosion of between 5 – 15m from the current shoreline is predicted by year 100 (D'Olier, 2007). The cliff top road will therefore be at risk in places, during this epoch.

<table>
<tr><th colspan="4">No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland</th></tr>
<tr><th rowspan="2">Location</th><th colspan="3">Predicted Change</th></tr>
<tr><th>Years 0-20 (2025)</th><th>Years 20-50 (2055)</th><th>Years 50-100 (2105)</th></tr>
<tr><td>Shoreline Movement</td><td>Coastal squeeze

Along the undefended section, between Epple Bay and Westgate Golf Course, cliff erosion is predicted to be between 1 – 2m (mean 1.5m) by year 20.</td><td>Between Minnis Bay and Epple Bay and between Westgate Golf Course and Fulsam Rock defences are assumed to fail in year 35 (with the exception of the Margate Harbour arms) i.e. 15 years of erosion.

Therefore, from D'Olier's (2007) figures, assuming 15 years of erosion, it is predicted that erosion (from the current shoreline) will be in the order of:

• 0.75 – 2.7m (mean 1.7m) between Minnis Bay and Epple Bay;
• 0.75 – 2.25m (mean 1.5m) between Westgate Golf Course and the Western end of Westbrook Bay; and,
• 0.75 – 2.7m (mean 1.7m) between the Western end of Westbrook Bay and Fulsam Rock.

Along the undefended section, between Epple Bay and Westgate Golf Course, erosion of between 1.5 – 7.5m from the current shoreline (mean 4.5m) by year 50.</td><td>From D'Olier's (2007) figures, assuming 65yrs of erosion by yr 100, erosion (from the current shoreline) is predicted to be in the region of:

• 3.25 – 11.7m (mean 7.5m) between Minnis Bay and Epple Bay;
• 3.25 – 9.75m (mean 6.5m) between Westgate Golf Course and the Western end of Westbrook Bay; and,
• 3.25 – 11.7m (mean 7.5m) between the Western end of Westbrook Bay and Fulsam Rock.

Along the undefended section cliff erosion is predicted to be 5 – 15m (mean 10m) from the current shoreline between Epple Bay and Westgate Golf Course by year 100.</td></tr>
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No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Cliftonville **(Fulsam Rock to White**	Seawalls protect steep chalk cliffs along most of coastline; however the cliffs at Palm Bay and Botany Bay and between White Ness and Botany Bay are undefended.	Failure of the defences.	No defences.

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Ness)	This coastline is characterised by sleep chalk cliffs whilst the foreshore consists of a chalk platform, which varies in width up to 250m and is, in places, covered by a thin and highly mobile layer of sand and shingle. Seawalls along the majority of the frontage, with the exception of Palm Bay, Botany Bay and White Ness, will continue to afford the toe of the cliff with protection. Thus restricting further geological exposures as well as a small supply of sediment. Along the undefended sections the chalk platforms and the fronting beaches will continue to provide protection to the cliffs. Thus any erosion which does occur will do so slowly. At Palm Bay and Botany Bay erosion is predicted to be in the region of 1-2m; and 2-6m between Botany Bay and White Ness, due to numerous joints in the chalk, by year 20 (D'Olier, 2007). The dominant westward movement of material along this frontage will continue throughout this epoch, thus creating a drift divide at North Foreland (and as such no feed to the East Kent coast). Most material is supplied from the offshore sources i.e. Margate Sands.	During the majority of this epoch a continuation of the processes identified in the previous epoch is anticipated. By year 35 it is assumed that all defences will have failed. Failure of defences will mean the reactivation of erosion of the cliff joints. Erosion rates for cliffs between Fulsum Rock and White Ness have been calculated by D'Olier (2007). *Assuming no defences*, erosion from the current shoreline by year 50 is predicted to be in the region of 1.5-7m between Fulsam Rock and Foreness Point; 3.5 – 12m at Foreness Point, due to the susceptibility of erosion along the numerous joint planes; 1.5 – 4m at Botany Bay; and 4-15m between Botany Bay and White Ness, again a section where erosional activity is increased due to the number of joints in the chalk. During this epoch only the recreational areas currently located on top of the cliffs will be affected.	During this epoch the frontage will enter an unconstrained and gradual phase of retreat. Chalk cliff recession and chalk platform lowering is likely to increase during this epoch in response to a predicted acceleration in sea level rise (6mm/yr) and increased storminess. *Assuming no defences* (i.e. 100 years of erosion by year 100), D'Olier (2007) predicts cliff erosion from the current shoreline at year 100 to be in the region of 5 -15m between Fulsam Rock and Foreness Point; 10 – 30m at Foreness Point; 3 – 7m at Botany Bay; and 12-40m between Botany Bay and White Ness. Again, most erosion is predicted to occur in locations where there are an increased number of joints and faults in the chalk and where the shoreline is most exposed to storm wave attack, i.e. at Foreness Point and White Ness. It is envisaged that erosion of the chalk cliffs will yield a very small supply of mainly fine sediment to the foreshore and therefore will not contribute to the beach building sediment budget. During this epoch there may be the potential for an increase in the frequency of single landslide events. This could contribute to <0.2ha in any given event. Again this will yield mainly fine, non beach building material to the sediment

No Active Intervention Scenario Assessment Table - North Coast: Isle of Grain to North Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Along the undefended sections at Palm Bay and Botany Bay erosion is predicted to be between 1 – 2m (mean 1.5m) and 2-6m between Botany Bay and White Ness (mean 4m) by year 20. No change along the defended sections.	Along the undefended sections, erosion from the current shoreline, by year 50, is predicted to be in the region of: • 1.5 –7.5m (mean 4.5m) at Palm Bay; • 1.5 – 4m (mean 2.75m) at Botany Bay; and, • 4-15m between Botany Bay and White Ness (mean 9.5m). Along the remaining sections defences are assumed to fail in year 35, i.e. 15 years of erosion by year 50. From D'Olier's (2007) figures it is predicted that erosion from the current shoreline, by year 50, will be in the region of: • 0.75 -2.25m (mean 1.5m) between Fulsam Rock and Foreness Point; and , • 1.5 – 3.75m (mean 2.6m) at Foreness Point.	Along the undefended sections, erosion from the current shoreline, by year 100, is predicted to be in the region of: • 5 – 15m (mean 10m) at Palm Bay; • 3 – 7m (mean 5m) at Botany Bay; and, • 12-40m (mean 26m) between Botany Bay and White Ness. Along the remaining sections, defences are assumed to have failed in year 35, therefore 65 years of erosion is assumed by year 100. From D'Olier's (2007) figures it is predicted that erosion from the current shoreline, by year 100, will be in the region of: • 3.25 -9.75m (mean 6.5m) between Fulsam Rock and Foreness Point ; and, • 6.5 – 18.5m (mean 12.6 m) at Foreness Point.

C4.4 No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
White Ness to Ramsgate Harbour (East Cliff)	An engineered promontory at Kingsgate, a small harbour at Broadstairs and a seawall founded on the chalk platform at Stone Bay. There are also remnants of older erosion protection and cliff stabilisation structures south of North Foreland.	The natural chalk promontory at Kingsgate is likely to collapse (<50 years RL), as would the seawall at Stone Bay (<50years)	No Defences

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Chalk sea cliffs, which rise to a height of 15-30m (Futurecoast, 2002) are fronted by a chalk shore platform and separated by small bays. The cliffs will continue to erode, along the undefended sections. By year 20, D'Olier (2007) predicts erosion to be in the region of 2-6m between White Ness and Captain Digby Inn; 1 – 2.5m at Joss Bay; 1.5 – 3.5m between the crumbling defences and Stone Bay; and between 3 – 7m between Dumpton Gap and the northern end of Winterstoke Undercliffe, the fastest eroding section on the Thanet coast due to well defined joints/faults in the chalk. The variations in these rates are related to differences in bedding and/or changes in shoreline alignment between Foreness Point and Ramsgate; alignment changes from north-west to south-east to north-south respectively. As such the cliffs would be subject to variations in wave approach and thus changes in incident wave energy, with the former being subject to the more aggressive northerly wave climate. Along the defended frontages i.e. Kingsgate, Broadstairs and Stone Bay only limited erosion of the cliffs caused by natural weathering would take place during this epoch. Chalk platforms front the cliffs between North Foreland and Ramsgate. During this epoch it is envisaged the platform will continue to respond	During the majority of this epoch a continuation of the processes identified in the previous epoch is anticipated. By year 35, defence failure, at Kingsgate, Broadstairs and Stone Bay is predicted. Erosion rates for cliffs between White Ness and Ramsgate Harbour have been calculated by D'Olier (2007). *Assuming no defences*, erosion from the current shoreline by year 50 is predicted to be in the region of 4-15m between White Ness and Captain Digby Inn; 2–4.5m between Captain Digby Inn and Joss Bay; and at Joss Bay; 3-7m between the crumbling defences and Stone Bay; 2-5m between Stone Bay and Bleak House, between Louisa Bay and Dumpton Gap and between Winterstoke Undercliffe and northern Marine Esplanade; <4 – 10m at Broadstairs Harbour and between the northern end of Marine Esplanade and the western end of Western Undercliffe; and 5-20m between Dumpton Gap and the northern end of Winterstoke Undercliffe. The highest erosion rates are therefore predicted for those sections of cliff where joints and faults are numerous and well defined (i.e. between Dumpton Gap and the northern end of Winterstoke Undercliffe and between White Ness and Captain Digby Inn). Despite the frontage being free functioning, by the close of this epoch, it is envisaged that uninterrupted erosion of the chalk cliffs will not provide any	Chalk cliff recession and chalk platform lowering is likely to increase during this epoch in response to a predicted acceleration in sea level rise (6mm/yr) and increased storminess. *Assuming no defences* (i.e. 100 years of erosion by year 100), D'Olier (2007) predicts cliff erosion from the current shoreline at year 100 to be in the region of 12-40m between White Ness and Captain Digby Inn; 3.5-12m between Captain Digby Inn and Joss Bay; and at Joss Bay; 5-12.5m between the crumbling defences and Stone Bay; 3.5-8m between Stone Bay and Bleak House, between Louisa Bay and Dumpton Gap and between Winterstoke Undercliffe and northern Marine Esplanade; <7-18m at Broadstairs Harbour and between the northern end of Marine Esplanade and the western end of Western Undercliffe; and 15-50m between Dumpton Gap and the northern end of Winterstoke Undercliffe. It is envisaged that erosion of the chalk cliffs will yield a very small supply of mainly fine sediment to the foreshore and therefore will not contribute to the beach building sediment budget. Additionally, during this epoch there may be the potential for an increase in the frequency of single landslide events. Again this will yield mainly fine material with limited contribution to

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Along the undefended sections, by year 20, erosion is predicted to be in the region of: • 2-6m (mean 4m) between White Ness and Captain Digby Inn; • 1-2.5m (mean 1.75m) at Joss Bay; • 1.5 – 3.5m (mean 2.5m) between the crumbling defences and Stone Bay; and, • 3 – 7m (mean 5m) between Dumpton Gap and the northern end of Winterstoke Undercliffe. No change along the defended sections.	Along the undefended sections, erosion from the current shoreline, by year 50, is predicted to be in the region of: • 4-15m (mean 9.5m) between White Ness and Captain Digby Inn; • 2 – 4.5m (mean 3.25m) at Joss Bay; • 3 – 7m (mean 5m) between the crumbling defences and Stone Bay; and, • 5 – 20m (mean 12.5m) between Dumpton Gap and the northern end of Winterstoke Undercliffe. Along the remaining sections defences are assumed to fail in year 35 (i.e. 15 years of erosion by year 50). From D'Olier's (2007) figures it is predicted that erosion from the current shoreline, by year 50, will be in the region of: • 0.75-1.95m (mean 1.35m) at Castle Hotel, between Stone Bay and Bleak House, between Louisa Bay and Dumpton Gap and between Winterstoke Undercliffe and northern Marine Esplanade; and, • <1.5 - <3.75m (mean <2.63m) at Broadstairs Harbour and between the	Along undefended sections erosion from the current shoreline, at year 100, is predicted to be in the order of: • 12-40m (26m) between White Ness and Captain Digby Inn; • 3.5 – 12m (mean 7.75m) at Joss Bay; • 5 – 12.5m (mean 8.75m) between the crumbling defences and Stone Bay; and, • 15 – 50m (mean 32.5m) between Dumpton Gap and the northern end of Winterstoke Undercliffe. Along the remaining sections, defences are assumed to have failed in year 35, therefore 65 years of erosion is assumed by year 100. From D'Olier's (2007) figures it is predicted that erosion from the current shoreline, by year 100, will be in the region of: • 3.25 – 8.45m (mean 5.85m) at Castle Hotel, between Stone Bay and Bleak House, between Louisa Bay and Dumpton Gap and between Winterstoke Undercliffe and northern

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
		northern end of Marine Esplanade and the western end of Western Undercliffe.	Marine Esplanade; and, • <6.5 - <16.25m (mean <11.4m) at Broadstairs Harbour and the northern end of Marine Esplanade and the western end of Western Undercliffe.

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Ramsgate Harbour	Harbour arms, with a rock armoured breakwater (that protect the cliff toe). The chalk cliffs are sheathed with concrete in places to reduce sub-aerial weathering.	Harbour arms and rock armoured breakwater. The chalk cliffs are sheathed with concrete in places to reduce sub-aerial weathering (predicted residual life 30 years).	The harbour arms and rock armoured breakwater will fail at some point during this epoch (failure assumed in year 70).

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	The present management practises at Ramsgate, prevents erosion of the shoreline. The protection the defences provide will continue throughout this epoch. The present management practice precludes the alongshore transport of sediment as well as the presence of a foreshore along this frontage.	The present management practises at Ramsgate will continue to prevent shoreline erosion along this section of the coast; therefore no change in shoreline position is predicted during this epoch. Despite a predicted increase in sea level (6mm/year) the shoreline dynamics are predicted to remain similar to what they presently are. Therefore the defence structures will continue to prevent alongshore transport and as such material will continue to be retained updrift of Ramsgate. The concrete sheathing that protects the cliff face from weathering is expected to fail in this epoch and as such some erosion will take place.	With an accelerated rise in sea level predicted (6mm/yr) pressure/impact on the remaining defence structures will increase, eventually resulting in their demise. Until defence failure, shoreline recession and alongshore sediment transport will continue to be prevented. Upon defence failure, assets within the harbour will be lost, sediment (sand) retained updrift of the harbour will be transported alongshore (towards Pegwell Bay) and erosion of the backing chalk cliffs will be reactivated. Re-activation of the cliffs will take place once defences fail, which may be outside the time frame of this SMP but for this investigation Year 70 has been assumed for failure. B'Dolier (2007) predicts erosion along this frontage, *assuming no defences* (i.e. 100 years of erosion by year 100) to be between <7 – 18m from the current shoreline by year 100. The pulse of sediment released from updrift of Ramsgate Harbour will be transported south and west towards Pegwell Bay and whilst sediment released from cliff reactivation will be composed predominantly of fine material it will contribute very little to the beach building budget. Therefore in the long term, little

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	No change predicted	Reactivation of the cliff face and cliff top erosion is likely to take place, due to degradation of the concrete sheathing. Despite this no change in the shoreline's position is predicted.	Using B'Dolier's (2007) figures and assuming defences will fail by Year 70 (i.e. 30 years of erosion), erosion along this frontage is predicted to be between <3 - <7.5m (mean <5.25m) from the current shoreline by year 100.

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
West Cliff (Western Harbour Arm to Cliffs End)	A seawall founded on a chalk platform (western undercliff defences), fronted by timber groynes immediately downdrift of Ramsgate Harbour. The Ramsgate Harbour access road tunnel portal is adjacent to the seawall.	The timber groynes and the seawall (<50 years) are expected to fail during this epoch.	No Defences

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	When compared to the chalk cliffs updrift, the chalk cliffs along this section of the coast appear to have slightly different bedding. They have also been anthropogenically modified (re-profiled). Defences front the eastern half of the cliffs along this section of the coast and in these areas it is envisaged that the cliffs will continue to experience only sub-aerial weathering during this epoch. The undefended cliffs between West Cliff and Pegwell Bay will continue to erode, whilst the wave cut chalk platform is likely to lower, although the rate is anticipated at being very low. By year 20, B'Dolier (2007) predicts erosion along undefended sections to be in the region of 2-5m between the western end of Western Undercliffe and Pegwell, where a large number of faults are exploited by storm wave activity, resulting in the formation of caves; 2-7m between Pegwell village and Cliffsend Tunnel, where rapid erosion of the numerous faults and joints have produced large caves; and, <1m between Cliffsend Tunnel and the Old Hoverport where erosion is very slow due to the vegetation growth on the Tertiary deposits.	The timber groynes are expected to fail at some point during this epoch. Upon their failure sediment previously retained (downdrift of Ramsgate Harbour) will be 'released' and transported alongshore. As the net drift is to the west it is envisaged that the sand will be moved towards Pegwell Bay. With the removal of foreshore cover a lack of sediment entering the system and a predicted rise in sea level (6mm/yr) the seawall will experience increased wave attack. As such, by year 35, all defences are assumed to have failed. Cliff erosion will be reactivated in these locations and the safe operation of the Ramsgate harbour access tunnel will be threatened. Erosion rates for the shoreline between Ramsgate Harbour and Cliffs End have been calculated by D'Olier (2007). *Assuming no defences are present,* erosion from the current shoreline at year 50 is predicted to be in the region of <4-10m between Ramsgate Harbour and the western end of Western Undercliffe; 4-10m between the western end of Western Undercliffe and Pegwell; 5-15m between Pegwell village and Cliffsend Tunnel; and, 1-3m between Cliffsend Tunnel and the Old Hoverport. Most erosion is therefore predicted to occur where the cliffs are characterised by numerous well defined faults and joints and where the shoreline is	With no defence structures in place the shoreline will start to respond naturally to the forcing factors. Thus a number of changes are predicted. Sediment 'released' from the foreshore, immediately downdrift of Ramsgate Harbour, due to groyne failure, could be countered by an input from the north of the harbour. However, it is currently unclear whether this input will be sufficient to counter sea level rise, nonetheless it is clear that the permanency of this cover will be temporary due to 1) the hydrodynamics – if they remain as they are today, coastal processes will transport the material west towards Pegwell Bay and 2) the amount of beach building material available is finite. Thus in the long term the loss of the beach and the appearance of a chalk platform immediately downdrift of Ramsgate Harbour is envisaged. *Assuming no defences are present*, D'Olier (2007) predicts cliff erosion from the current shoreline at year 100 to be in the region of <7-18m between Ramsgate Harbour and the western end of Western Undercliffe; 7-18m between the western end of Western Undercliffe and Pegwell; 12.5-35m between Pegwell village and Cliffsend Tunnel; and, 2-6m between Cliffsend Tunnel and the Old Hoverport.
	Groynes perched on the chalk platform, at the eastern end of this frontage, will continue to retain the small sandy beach, immediately updrift of Ramsgate Harbour. However, in the lee of these groynes the foreshore cover thins, in a westwards		

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Along the undefended sections, by year 20, erosion is predicted to be in the region of: • 2-5m (mean 3.5m) between the western end of Western Undercliffe and Pegwell; • 2-7m (mean 4.5m) between Pegwell village and Cliffsend Tunnel; and, • <1m between Cliffsend Tunnel and the Old Hoverport. No change predicted along the defended sections.	Along the undefended sections, erosion from the current shoreline, by year 50, is predicted to be in the region of: • 4-10m (mean 7m) between between the western end of Western Undercliffe and Pegwell; • 5-15m (mean 10m) between Pegwell village and Cliffsend Tunnel; and, • 1-3m (mean 2m) between Cliffsend Tunnel and the Old Hoverport. Along the remaining sections defences are assumed to fail in year 35 (i.e. 15 years of erosion by year 50). From D'Olier's (2007) figures it is predicted that erosion from the current shoreline, by year 50, will be in the region of: • <1.5-<3.75m (mean <2.63m) between Ramsgate Harbour and the western end of Western Undercliffe; • 1.5-3.75m (mean 2.63m) between the western end of Western Undercliffe and Pegwell; and, • 0.3-0.9m (mean 0.6m) between Cliffsend Tunnel and the Old Hoverport.	Along the undefended sections, erosion from the current shoreline, by year 100, is predicted to be in the region of: • 7-18m (mean 12.5m) between between the western end of Western Undercliffe and Pegwell; • 12.5-35m (mean 23.75m) between Pegwell village and Cliffsend Tunnel; and, • 2-6m (mean 4m) between Cliffsend Tunnel and the Old Hoverport. Along the remaining sections defences are assumed to fail in year 35 (i.e. 65 years of erosion by year 100). From D'Olier's (2007) figures it is predicted that erosion from the current shoreline, by year 100, will be in the region of: • <6.5-<16.25m (mean <11.4m) between Ramsgate Harbour and the western end of Western Undercliffe; • 6.5-16.25m (mean 11.4m) between the western end of Western Undercliffe and Pegwell; and,

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
			• 1.3-3.9m (mean 2.6m) between Cliffsend Tunnel and the Old Hoverport.

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Pegwell Bay (Cliffs End to Sandwich Bay Estate -	A revetted embankment protects the nature reserve; the remainder is fronted by the extensive sand dunes.	Revetment is expected to fail in the latter half of this epoch (<50 years).	No Defences

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
south)	Extensive tidal mudflats in the north of Pegwell Bay, give way to saltmarsh, tidal mudflats and the mouth of the River Stour in the centre of the Bay. South of the River Stour the wide sandy foreshore is backed by an extensive (relict) dune system. Further south a veneer of shingle covering the upper beach becomes more pronounced until eventually it becomes a relatively substantial shingle beach at Sandwich Bay Estate. It is predicted that the low-lying relict dune ridge system, will continue to experience 'ponding' in places, due to a lack of contemporary material supply. Further inland (i.e. landwards of the toll road) the relict sand dunes increase in height and are regarded as stable (which may be related to their age, being vegetated or being previously managed), either way it is envisaged that little change will take place to the relict dunes during this epoch. Sediment movement for this unit is complicated and in parts poorly understood. It is known that sediment converges at Pegwell Bay; predominantly fine sediment (sand and silt) which enters the system from the east (cliff recession), south (alongshore transport), the River Stour and from the offshore sand bank of Goodwin Sands. It is also known that the higher ground at Cliffs End restricts the northwards transgression of coarse material and that the ebb velocities of the	During this epoch significant changes in the dynamics at Pegwell Bay are predicted. In the northern section of this frontage erosion and flooding, in the vicinity of Cliffs End, is expected. Continual weakening of the revetted embankment, in front of Pegwell Bay Nature Reserve, will result in its demise. As the embankment fails, the backing hinterland will be subjected to flooding; furthermore there is the potential that the dynamics of the River Stour could change, if the river broke through the tight meander around Richborough. **<u>The impact of this on the coast would be a realignment of the river's mouth (to a location south of its current outlet).</u>** Sediment stored within the dunes, which "decorate" the shingle ridge between Shell Ness and Sandwich Flats, would be affected in two ways: 1) by the potential relocation of the Stour's mouth and 2) not having a sufficient volume of sediment to resist erosion. In conjunction to the aforementioned the dune-topped ridge will be at risk of breaching. The timing of the breach is uncertain, although it is anticipated that it could take place following the first major storm surge, especially if accompanied by swell wave activity. If this breach is not repaired (by natural processes) then a permanent hiatus will form. Once a significant breach occurs, the new opening is likely to be inundated on	During this epoch the area in the vicinity of Sandwich Bay Estate will be at risk from flooding. During this epoch further changes in the dynamics are predicted, as the system adjusts to changes from the previous epoch and responds to continued sea level rise (6mm/year). Thus, further flooding, both spatially and vertically, of the low-lying backing hinterland is predicted. It is likely that the relict channel and subsequent tributaries of the Wantsum Channel will be adopted, as a new estuary at both the north and east develops. Depending on the dynamics of the River Stour and the tidal currents there is the potential for either an ebb tidal delta or flood tidal channel to form. There is also the potential for change in wave attenuation (height, direction) and as such coastal processes (i.e. drift reversals, interrupting alongshore transport).

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Erosion of the shingle / sand topped ridge	Large scale flooding is predicted, with the exception of the area north of Sandwich Bay Estate (which would experience erosion). New shoreline alignment (Wantsum Channel) with estuarine processes developing	Large scale flooding is predicted New shoreline alignment (Wantsum Channel) and extended estuarine conditions.

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Sandwich Bay Estate (south) to Sandown Castle (remains of).	An un-revetted embankment constructed of colliery shale between Sandwich Bay Estate and Sandown Castle (remains of). Embankment at Sandwich Bay Estate is revetted with concrete armour units. The shingle beach provides essential protection to the embankment along this section.	The northern section of the revetment will fail during this epoch.	No Defences

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	This relatively short section of coast is characterised by a shingle beach ridge and a mixed sand and gravel foreshore. The low-lying backing hinterland is presently protected from flood inundation by a shale and earth embankment. However, in the south the embankment north of Sandown Castle (remains of) is extremely vulnerable and is predicted to fail within the first 10 years. Until failure, the beach fronting this section of the coast will continue to narrow, whilst the predominant drift direction will remain north. However, it is acknowledged that occasionally, under north-easterly conditions, sediment movement has the potential to reverse. Erosion of the beach and shingle ridge will increase the pressure on the backing defences; as such failure in the south is anticipated. Following failure, the ridge will breach fairly quickly and flood the low-lying backing hinterland. As the land backing the present ridge is low and the volume of material, which makes up the ridge, is small, it is unlikely that a beach would be maintained at this location. There is no higher ground to roll-back on, nor is there sufficient material for cannibilisation. In conjunction the situation is likely to be exacerbated by updrift structures continuing to holding beach. Therefore it is envisaged that come the close of this epoch a	After the initial breach, in the southern section of this frontage, it is anticipated that further flooding would occur on every spring tide and during any storm event. It is anticipated that flood depths of over 1m would occur across large areas of the backing hinterland. Initially it is anticipated that these waters would dissipate within days but with sea level rise predicted, inundation would become more regular and the groundwater increasingly saline. In the north it is predicted that the shingle ridge would become increasingly prone to wave attack and as such further segmentation would take place. During this epoch there is the potential for flooding from this frontage and the frontage downdrift (Pegwell Bay) to combine with inundation from the north Kent coast (along the Reculver to Minnis Bay frontage). Should this occur then the former tidal channel between north and east Kent would be re-activated. It is predicted that initially there is the potential for the former Roman shoreline position, at Richborough, to be reinstated and a large bay between Sandwich and the Isle of Thanet to resume. However there is also the potential for more dramatic change, which would leave the Isle of Thanet separated from the mainland. Large scale changes in shoreline dynamics are	During this epoch it is envisaged that the now naturally functioning coastline will be completely different to the coastline of today. It is predicted that by the close of this epoch a tidal channel will separate the Isle of Thanet from mainland Kent that alongshore coastal processes will be interrupted by the tidal channel, and that the plan position between Shell Ness and Deal could rotate up to 45 degrees anti-clockwise; allowing the North Sea to interact with the Straits of Dover. Inundation on this scale could result in the flooding of up to 9500 hectares of low lying land and 1500 hectares of erosion (Reculver to Minnis Bay Scheme, 1998).

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Thinning of the foreshore	Large scale flooding	Large scale flooding

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Sandown Castle (remains of) to Oldstairs Bay.	There is a seawall between Sandown Castle (remains of) and Deal Castle, with a short length of groynes at the northern end. Between Deal and Kingsdown there is a wide open shingle beach. At Kingsdown there is a seawall and timber groynes. Between Kingsdown and just north of Oldstairs Bay the beach is open and unmanaged with a short length of timber breastwork at the rear of the beach. At Oldstairs Bay there is a revetment and groynes.	The groynes along the north Deal frontage and at Kingsdown will have failed around Year 30. It is predicted that the remaining defences at Deal, Kingsdown and Oldstairs Bay will fail before the close of this epoch.	No defences

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Mixed gravel and sand beaches in the north give way to gravely beaches, with a small amount of sand on the lower foreshore, in the south (Kingsdown and Oldstairs Bay). Between Sandown Castle (remains of) and Walmer Castle the hinterland is generally low-lying, composed of storm gravel beach deposits, which rests on top of Head Brickearth (from the Pleistocene), which overlies Upper Cretaceous Chalk. Between Walmer Castle and Oldstairs Bay the hinterland rises. The storm gravel beach deposits rests on the Upper Cretaceous Chalk in the north but this gives way to a relict chalk cliff line at Kingsdown that finally joins the shore at Oldstairs Bay. Under a scenario of no active intervention, any beach management at Kingsdown would cease immediately, which is likely to result in accelerated beach narrowing at Kingsdown and as such an increase in the risk of overtopping. Along the remainder of frontage, the foreshore is also likely to erode, albeit at a lower rate, due to a continuation in the alongshore transport of material and the sheltering effect of the Goodwin Sands (offshore banks which reduce onshore wave attack). During this epoch it is envisaged that the integrity of the backing seawall at Kingsdown will not be at	All groynes along the north Deal and Kingsdown frontage will fail relatively early during this epoch. Their failure will result in a rapid re-adjustment of the shoreline, a consequence of it being held seawards of its natural alignment for a long time. At Deal flood inundation is predicted, this being a consequence of the low-lying nature of the backing hinterland and the potential of outflanking from downdrift frontages. However, at Kingsdown, it is predicted that the gravel beach could erode some 10m-20m over a 20 year period. Erosion of the beach will result in: 1) an increase in periodic overtopping, which will affect the backing assets and 2) the seawall coming under increased wave attack and will lead to its subsequent failure. Again a readjustment phase, following the collapse of this structure, is predicted before a position commensurate with the forcing factors is established; additional flooding of Deal is predicted. At Kingsdown it is unlikely that the backing hinterland will be at risk from flooding, due to the backing hinterland being in the region of +5m OD), although under extreme events and with no defences in place, the potential for flood inundation remains very much a possibility. In the south the beach at Oldstairs Bay has a history of volatility, in the last 50 years, for	With no defences in place, the coastline will be naturally functioning. Thus, material will continue to be transported northwards (if the hydrodynamics remain as they presently are), transporting material to frontages downdrift. It is predicted that along the majority of the frontage the gravel beach will continue to roll back. The rate of roll back has the potential to be greater during this epoch due to the influence of sea level rise (6mm/yr) and there is also the potential for an increased amount of material to be drawn down, under storm conditions and transported in the nearshore zone. The combination of the aforementioned leads to an increase in the potential for flooding, thus during this epoch it is envisaged that the northern section of Deal will be flooded on a permanent basis. The chalk platform at Kingsdown may become submerged as sea levels rise, and consequently erosion will increase. During this epoch the revetment fronting Oldstairs Bay will continue to have some influence in reducing wave attack and thus shoreline erosion. However, it is acknowledged that over time the revetment's standard of protection will continue to reduce

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Coastal squeeze between Sandown Castle (remains of) and Deal Castle – no change in the shoreline's position. Between Deal Castle and Walmer Castle no change in the shoreline position is predicted (flooding via percolation remains a risk). Between Walmer Castle and Kingsdown (north) slight erosion is predicted at the southern of the beach. Given the relatively low sediment transport rates in this area, the predicted average rate of erosion in this area is likely to be 0.5m/yr (Futurecoast, 2002). Erosion by year 20 = 10m. At Kingsdown no change in the shoreline is predicted however, there will be beach lowering. Between Kingsdown and Oldstairs Bay average erosion rates are predicted to be in the region of <0.1m/yr (Futurecoast, 2002). Erosion by year 20 = <2m. Periodic localised landslide events may also occur in this location, with a frequency of around <10m in 10 years (Futurecoast, 2002).	Between Sandown Castle (remains of) and Deal Castle flooding is predicted (which could merge with the downdrift unit). Between Deal Castle and Walmer Castle no change in the shoreline is predicted due to contemporary feed from the south. Between Walmer Castle and Kingsdown (north) the shoreline is predicted to erode on average by 0.5m/yr (Futurecoast, 2002). Erosion by year 50 = 25m from the current shoreline (i.e. 50 years of erosion). Erosion is predicted at Kingsdown (following wall failure at year 30): Average erosion rate is predicted to be in the region of 0.5-1.0m/yr (Futurecoast, 2002). Erosion by year 50 = 10-20m (mean 15m) (i.e. 20 years of erosion). Further erosion between Kingsdown (south) and Oldstairs Bay: average erosion rate is predicted to be in the region of <0.1m/yr (Futurecoast, 2002). Erosion by year 50 = <5m from the current shoreline (i.e. 50 years of erosion). Periodic localised landslide events may also occur in this	Between Sandown Castle (remains of) and Deal Castle further flooding is predicted. Between Deal Castle and Walmer Castle no change in the shoreline is predicted due to contemporary feed from the south and given that there is a significant volume of material updrift of this area. Between Walmer Castle and Kingsdown average erosion rate is predicted to accelerate to 0.5-1.0m / year (Futurecoast, 2002) as sea levels rise. Shoreline erosion by year 100 = 25-50m (mean 37.5m) from the current shoreline (i.e. 100 years of erosion). Further erosion is predicted at Kingsdown: average erosion rate is predicted to be in the region of 0.5-1.0m/yr (Futurecoast, 2002). This may accelerate further as sea levels rise. Erosion by year 100 = 35-70m (mean 52.5m) of erosion from the current shoreline (i.e. 70 years of erosion). Further erosion between Kingsdown (south) and Oldstairs Bay predicted: average erosion

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
		location, with a frequency of around <10m in 10 years (Futurecoast, 2002).	rate is predicted to be in the region of <0.1m/yr (Futurecoast, 2002). This may accelerate further as sea levels rise. Erosion by year 100 = <10m from the current shoreline (i.e. 100 years of erosion). Periodic localised landslide events may also occur in this location, with a frequency of around <10m in 10 years (Futurecoast, 2002).

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
South of Oldstairs Bay to South Foreland	Largely undefended although there is a relatively new rock revetment (25-50 years) a seawall protects the MoD firing range frontage, and seawall and groynes protects St Margaret's Bay.	The seawall along the MoD frontage will fail early during this epoch. The seawall and groynes along St Margaret's Bay will also fail during this epoch.	No Defences

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Chalk cliffs, punctuated by St Margaret's Bay dominate this section of the coast. It is predicted that along the undefended sections the chalk cliffs will continue to erode at a relatively low rate 0.1 to 0.5m/yr (Futurecoast, 2002). Landslide events may occur along the undefended cliffs, frequencies are predicted to be in the order of <10m in 10 years between Oldstairs Bay and St Margaret's Bay and in the order of <10m in 10-100 years south of St Margaret's Bay. However, where there are defences i.e. at the MoD Rifle Range and at St Margaret's Bay, erosion will continue to be restricted. The groynes at St Margaret's Bay will continue to hold the mixed sand and shingle beach in place. Thus no significant change is envisaged during this epoch. Sediment movement into the area is low to negligible due to the increasing rockbed level and hard defences updrift (i.e. Dover Harbour).	The seawall at Oldstairs Bay is likely to fail at the beginning of this epoch, as are the groynes at St Margaret's Bay. With their failure erosion will be reactivated and the beach at St Margaret's Bay will reduce. As the beach reduces the seawall at St Margaret's Bay come under greater attack and eventually fail. Upon failure, erosion of the shoreline along this section of the coast is predicted. During this epoch reactivation of cliff toe erosion is deemed unlikely as the cliffs are set back. The remainder of the frontage will continue to erode on a regular basis; 0.1 to 0.5m/yr and landsliding is predicted to continue as the previous epoch (Futurecoast, 2002). During a landslide event normally metres of land are lost however the material is predominantly fines and therefore not appropriate for beach building.	With no defence structures in place the shoreline will respond naturally to the forcing factors. It is envisaged that the chalk cliffs will continue to erode, between 0.1 to 0.5m / year (Futurecoast, 2002), although with a predicted rise in sea level (Defra (6mm/annum)[3] this annual rate may increase. There is the potential for landslide events to become more frequent in response to accelerated sea level rise. It is likely that beach / material previously held at St Margaret's Bay will remain in the natural embayment of St Margaret's Bay and will not move along the coast to Kingsdown. Similarly the promontory that currently fronts the MoD area will reduce significantly in width as a position more commensurate with the forcing factors is established. Exposure of a wave cut chalk platform at St Margaret's Bay and along the MoD frontage is anticipated with the loss of the beach at St Margaret's and the failure of the defences/promontory at the MoD frontage. During this epoch there is the potential that there may be cliff top property losses at St Margaret's-at-Cliffe.

[3] Defra (2001)

No Active Intervention Scenario Assessment Table – East Coast: North Foreland to South Foreland			
Location	**Predicted Change**		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	Average erosion rate along undefended sections is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). Erosion by year 20 = 2-10m (mean 6m). Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10 years (Futurecoast, 2002). Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10-100 years (Futurecoast, 2002). No change predicted along the defended sections.	Along the undefended cliff sections, average erosion rate is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). Erosion by year 50 = 5-25m (mean 15m) from the current shoreline (i.e. 50 years of erosion). Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10 years (Futurecoast, 2002.) Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10-100 years (Futurecoast, 2002). Assuming that defences will have failed by Year 35 at St Margaret's Bay, and average erosion rate in the region of 0.1-0.5m/yr (Futurecoast, 2002), erosion by year 50 = 1.5-7.5m (mean 4.5m) from the current shoreline (i.e. 15 years of erosion).	Along the undefended cliff sections, average erosion rate is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). This may accelerate further as sea levels rise. Erosion by year 100 = 10-50m from the current shoreline (i.e. 100 years of erosion). Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10-100 years (Futurecoast, 2002.) Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10 years (Futurecoast, 2002). Average erosion rate at St Margaret's Bay is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). This may accelerate further as sea levels rise. Erosion by year 100 = 6.5-32.5m (mean 19.5m) from the current shoreline (i.e. 65 years of erosion).

C.5 NAI Data Interpretation

C.5.1 Introduction

A number of data sets were used in the predictions of future shoreline response and evolution under the scenario of no active intervention, these included:

- Futurecoast historical shoreline change data (reported in the assessment of shoreline dynamics report (Section C1)).
- Other historical change data sets: e.g. at some locations cliff position data sets are available (reported in the assessment of shoreline dynamics report (Section C1)).
- Futurecoast predictions of future shoreline change under an ‘unconstrained’ scenario: this assumed that all defence structures were removed and other coastal defence management interventions ceased therefore is not directly comparable to a ‘no active intervention’ scenario.
- Environment Agency beach profile data: this data is only relevant for specific locations and restricted to specific time frames i.e. twenty years.
- Prediction of future shoreline response under a ‘Do Nothing’ scenario from first SMP.
- Thanet erosion rates from the Isle of Thanet Erosion Rate Study (D’Olier, 2007) commissioned by Thanet District Council.
- Other predictions of future shoreline response under no active intervention (or ‘do nothing’) scenario, e.g. from strategy studies completed since the first SMP.

C5.2 Data Assessments (NAI)

Frontage	*0-20yrs*	*20-50yrs*	*50-100yrs*
Allhallows-on-Sea to Grain	**Defended**: No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended slopes at Grain**: Average erosion rate 0.5-1m/yr: 10m-20m (mean 15m) by yr 20.	**Flooding**: Large scale flooding is predicted for the majority of this frontage. **Undefended slopes at Grain**: Average erosion rate 0.5-1m/yr: 25-50m (mean 37.5m) from the current shoreline by year 50 (i.e. 50 years of erosion). **Previously defended slopes**: Average erosion rate 0.5-1m/yr: 15-30m (mean 22.5m) from the current shoreline by year 50 (i.e. 30 years of erosion).	**Flooding:** A large proportion of the Isle of Grain will be experiencing estuarine conditions. **Undefended slopes at Grain:** Average erosion rate 0.5-1m/yr: 50-100m (mean 75m) from the current shoreline by year 100 (i.e. 100 years of erosion). **Previously defended slopes**: Average erosion rate 0.5-1m/yr: 40-80m (mean 60m) from the shoreline by year 100 (i.e. 80 years of erosion).
Sheerness to Scrapsgate	No change in shoreline position due to the continued presence of defences. Coastal squeeze anticipated.	**Flooding:** Flooding predicted for the whole frontage.	**Flooding:** Flooding predicted for the whole frontage.
Scrapsgate to Warden Point	No change in shoreline position due to the continued presence of defences. Coastal squeeze anticipated at Minster and Minster Slopes. **Undefended cliffs**: Average erosion rate 0.5-1m/yr: 10-20m (mean 15m) by year 20. Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years.	**Previously defended:** Once defences fail, average erosion rate 0.5-1m/yr: 15-30m (mean 22.5m) from the current shoreline by year 50 (i.e. 30 years of erosion). **Undefended cliffs:** Average erosion rate 0.5-1m/yr: 25-50m (mean 37.5m) from the current shoreline by year 50 (i.e. 50 years of erosion). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years.	**Previously defended:** Cliff erosion at Minster and Minster Slopes, average erosion rate 0.5-1m/yr: 40 -80m (mean 60m) from the current shoreline by year 100 (i.e. 80 years of erosion). In addition, the position of the top of the landslide by year 100, allowing for an average landslide width of 107m could be in the region of between 147-187m (mean 167m) from the current shoreline. **Undefended cliffs:** Average erosion rate 0.5-1m/yr: 50-100m (mean 75m) from the current shoreline by year 100 (i.e. 100 years of erosion).

			In addition, the position of the top of the landslide by year 100, allowing for an average landslide width of 107m could be in the region of between 157-207m (mean 182m) from the current shoreline. Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years.
Warden Point to Shell Ness	No change in shoreline position due to the continued presence of defences. Coastal squeeze anticipated. Rollback of the shingle ridge at 'The Bay'.	Rollback of the shingle ridge at 'the Bay'. **Flooding:** Predicted at parts of Warden, 'The Bay' and between Leysdown-on-Sea (south) and Shellness. **Previously defended:** Average erosion rate 0.5-1m/yr: 15-30m (mean 22.5m) from the current shoreline at Leysdown-on-Sea and Warden by year 50 (i.e. 30 years of erosion). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years.	**Flooding:** Permanent inlet created at 'The Bay' and the area south of Leysdown-on-Sea will be experiencing estuarine conditions. **Previously defended:** Average erosion rate 0.5-1m/yr: 40-80m (mean 60m) from the current shoreline by the close of this epoch (i.e. 80 years of erosion). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years.
Faversham Creek to Seasalter (Blue Anchor Pub)	No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Flooding:** Flooding predicted for the whole frontage.	**Flooding:** Flooding predicted for the whole frontage.
Seasalter (Blue Anchor Pub) to Whitstable	No change in shoreline position due to the continued presence of defences. Coastal squeeze anticipated.	Assumed seawalls will fail in Year 30.	**Flooding:** Permanent saline inundation is predicted in the east **Previously defended:** Average erosion rate 0.5-

Harbour		**Flooding:** Flooding is predicted in the east. **Previously defended:** Average erosion rate 0.5-1m/yr: 10-20m (mean 15m) from the current shoreline by year 50 (i.e. 20 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.	1m/yr: 35-70m (mean 52.5m) from the current shoreline by year 100 (i.e. 70 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.
Whitstable Harbour to Long Rock	No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	Assumes toe protection works will fail by Year 30. **Flooding:** Flooding is predicted at Swalecliffe. **Previously defended:** Average erosion rate 0.5-1m/yr: 10-20m (mean 15m) from the current shoreline by year 50 (i.e. 20 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.	**Flooding:** Further flooding around Swalecliffe. **Previously defended:** Average erosion rate 0.5-1m/yr: 35-70m (mean 52.5m) from the current shoreline by year 100 (i.e. 70 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.
Long Rock to Herne Bay Breakwater	No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Previously defended:** Average erosion rate 0.5-1m/yr: 10-20m (mean 15m) from the current shoreline by year 50 (i.e. 20 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years. **Herne Bay Harbour to Herne Bay Pier area**: no change in the shoreline position here.	**Previously defended:** Average erosion rate 0.5-1m/yr: 35-70m (mean 52.5m) from the current shoreline by year 100 (i.e. 70 years of erosion). **Herne Bay Harbour and Herne Bay Pier**: Defence failure predicted for Year 70. Thereafter Average erosion rate 0.5-1m/yr: 15-30m from the current shoreline by year 100 (i.e. 30 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10

			years.
Herne Bay Breakwater to Reculver	No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended Reculver CP:** Average erosion rate 0.1-0.5.m/yr: 2-10m (mean 6m) by year 20.	**Defended:** Assumed defences will fail in Year 35 (Herne, Beltinge and Bishopstone). Thereafter, average erosion rate 0.5-1m/yr: 7.5-15m from the current shoreline by year 50 (i.e. 15 years of erosion). Periodic localised landslide events may also occur in this area, with a frequency of around 10-50m in 10 years. **Undefended Reculver CP**: Average erosion rate 0.1-0.5.m/yr: 5-25m (mean 15m) from the current shoreline by year 50 (i.e. 50 years of erosion).	**Defended:** Average erosion rate 0.5-1m/yr: 32.5-65m (mean 48.75m) from the current shoreline by year 100 (i.e. 65 years of erosion). Periodic localised landslide events may also occur in this area, with a frequency of around 10-50m in 10 years. **Undefended Reculver CP**: Average erosion rate 0.1-0.5.m/yr: 10-50m (mean 30m) from the current shoreline by year 100 (i.e. 100 years of erosion).
Reculver to Minnis Bay(west)	No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	Inundation of the relict Wantsum Channel is predicted.	Inundation of the relict Wantsum Channel is predicted.
Margate (Minnis Bay to Fulsam Rock)	**Defended sections**: No change in shoreline position due to the continued presence of defences along the majority of shoreline. Coastal squeeze anticipated. **Undefended sections** (20yrs of erosion by year 20): Epple Bay to Westgate Golf Course 1 – 2m of erosion (mean 1.5m) by yr 20 (D'Olier, 2007).	**Defended sections**: Assumed toe protection works will fail in Year 35 (15 years of erosion by year 50): Using D'Olier (2007) figures: Minnis Bay to Epple Bay 2-9m by year 50, assuming 50 years of erosion = 0.05-0.18m/yr. Therefore 15 years of erosion = 0.75 – 2.7m of erosion from the current shoreline (mean 1.7m) by yr 50. Westgate Golf Course to the Western end of Westbrook Bay 1.5-7.5m by year 50, assuming 50 years of erosion = 0.05-0.15m/yr. Therefore 15 years of erosion = 0.75 – 2.25m of erosion from the	**Defended sections**: assumes all defences have failed (65yrs of erosion by year 100): Using D'Olier (2007) figures: Minnis Bay to Epple Bay 5-17m by year 100, assuming 100 years of erosion = 0.05-0.18m/yr. Therefore 65 years of erosion = (2.5m+0.75m) 3.25 – (9+2.7) 11.7m of erosion from the current shoreline (mean 7.5m) by yr 100. Westgate Golf Course to the Western end of Westbrook Bay 5-15m by year 100, assuming 100

		current shoreline (mean 1.5m) by yr 50. Western end of Westbrook Bay to Fulsam Rock 2-9m by year 50, assuming 50 years of erosion = 0.05-0.18m/yr. Therefore 15 years of erosion = 0.75 – 2.7m of erosion from the current shoreline (mean 1.7m) by yr 50. **Undefended section** (50 yrs of erosion by year 50): Epple Bay to Westgate Golf Course, erosion from the current shoreline of between 1.5 – 7.5m (mean 4.5m) by yr 50 (D'Olier, 2007).	years of erosion = 0.05-0.15m/yr. Therefore 65 years of erosion = (2.5+0.75) 3.25 – (7.5+2.25) 9.75m of erosion from the current shoreline (mean 6.5m) by yr 100. Western end of Westbrook Bay to Fulsam Rock 5-17m by year 100, assuming 100 years of erosion = 0.05-0.18m/yr. Therefore 65 years of erosion = (2.5+0.75) 3.25 – (9+2.7) 11.7m of erosion from the current shoreline (mean 7.5m) by yr 100. **Undefended section** (100yrs of erosion by year 100): Epple Bay to Westgate Golf Course 5 – 15m of erosion from the current shoreline (mean 10m) by yr 100 (D'Olier, 2007).
Cliftonville (Fulsam Rock to White Ness)	**Defended sections**: No change in shoreline position. Coastal squeeze anticipated. **Undefended sections** (20yrs of erosion by year 20) (D'Olier, 2007): Palm Bay and Botany Bay 1 – 2mof erosion (mean 1.5m) by yr 20. Botany Bay to White Ness 2 – 6m of erosion (mean 4m) by yr 20.	**Defended sections**: Assumed toe protection works will fail in Year 35 (15 years of erosion by year 50): Using D'Olier (2007) figures: Fulsam Rock to Foreness Point 1.5-7.5m by year 50, assuming 50 years of erosion = 0.05-0.15m/yr. Therefore 15 years of erosion = 0.75 -2.25m of erosion from the current shoreline (mean 1.5m) by yr 50. Foreness Point 3.5-12m by year 50, assuming 50 years of erosion = 0.1-0.25m/yr. Therefore 15 years	**Defended sections:** assumes all defences have failed (65yrs of erosion by year 100): Using D'Olier (2007) figures: Fulsam Rock to Foreness Point 5-15m by year 100, assuming 100 years of erosion = 0.05-0.15m/yr. Therefore 65 years of erosion = (2.5+0.75) 3.25 – (7.5+2.25) 9.75m of erosion from the current shoreline (mean 6.5m) by yr 100. Foreness Point 10-30m by year 100, assuming 100 years of erosion = 0.1-0.3m/yr. Therefore 65

		of erosion = 1.5 – 3.75m of erosion from the current shoreline (mean 2.6m) by yr 50. **Undefended sections** (50 yrs of erosion by yr 50) (D'Olier, 2007): Palm Bay 1.5 –7.5m of erosion from the current shoreline (mean 4.5m) by yr 50. Botany Bay 1.5 – 4m of erosion from the current shoreline (mean 2.75m) by yr 50. Botany Bay to White Ness 4 - 15m of erosion from the current shoreline (mean 9.5m) by yr 50.	years of erosion = (5+1.5) 6.5 – (15+3.75) 18.75m of erosion from the current shoreline (mean 12.6m) by yr 100. **Undefended sections** (100yrs of erosion by year 100) (D'Olier, 2007): Palm Bay 5 – 15m of erosion from the current shoreline (mean 10m) by yr 100. Botany Bay 3 – 7m of erosion from the current shoreline (mean 5m) by yr 100. Botany Bay to White Ness 12 - 40m of erosion from the current shoreline (mean 26 m) by yr 100.
White Ness to Ramsgate Harbour	**Defended sections**: no erosion **Undefended sections** (20yrs of erosion by yr 20) (D'Olier, 2007): White Ness to Captain Digby Inn 2 – 6m of erosion (mean 4m) by yr 20. Joss Bay 1 – 2.5m of erosion (mean 1.75m) by yr 20. Crumbling defences to North Stone Bay 1.5 – 3.5m of erosion (mean 2.5m) by yr 20. Dumpton Gap to Northern end of Winterstoke Undercliffe 3 – 7m of erosion (mean 5m) by yr	**Defended sections**: Defences assumed to fail in Year 35 (15 years of erosion by year 50). Using D'Olier (2007) figures: Castle Hotel; Northern end of Stone Bay to Bleak House; Louisa Bay to Dumpton Gap and Winterstoke Undercliffe to Northern Marine Esplanade 2-4.5m by year 50, assuming 50 years of erosion = 0.05-0.13m/yr. Therefore 15 years of erosion = 0.75 – 1.95m of erosion from the current shoreline (mean 1.35m) by yr 50. The northern end of Broadstairs Harbour to Louisa Bay and the northern end of Marine Esplanade to western end of Western Undercliffe <4-10m by year	**Defended sections:** assumes all defences have failed (65yrs of erosion by year 100): Using D'Olier (2007) figures: Castle Hotel; Northern end of Stone Bay to Bleak House; Louisa Bay to Dumpton Gap and Winterstoke Undercliffe to Northern Marine Esplanade 3.5-12m by year 100, assuming 100 years of erosion = 0.05-0.13m/yr. Therefore 65 years of erosion = (2.5+0.75) 3.25 – (6.5+1.95) 8.45m of erosion from the current shoreline (mean 5.85m) by yr 100. The northern end of Broadstairs Harbour to Louisa Bay and the northern end of Marine

	20.	50, assuming 50 years of erosion = <0.1-0.25m/yr. Therefore 15 years of erosion = <1.5 - 3.75m of erosion from the current shoreline (mean <2.63m) by yr 50. **Undefended sections** (50 yrs of erosion by yr 50) (D'Olier, 2007): White Ness to Captain Digby Inn 4 – 15m of erosion (mean 9.5m) from the current shoreline by yr 50. Joss Bay 2 – 4.5m of erosion (mean 3.25m) from the current shoreline by yr 50. Crumbling defences to North Stone Bay 3 – 7m of erosion (mean 5m) from the current shoreline by yr 50. Dumpton Gap to Northern end of Winterstoke Undercliffe 5 - 20m of erosion (mean 12.5m) from the current shoreline by yr 50.	Esplanade to western end of Western Undercliffe <7-18m by year 100, assuming 100 years of erosion = <0.1-0.25m/yr. Therefore 65 years of erosion = (5+1.5) <6.5 – (12.5-3.75) 16.25m of erosion from the current shoreline (mean <11.4m) by yr 100. **Undefended section** (100yrs of erosion by year 100) (D'Olier, 2007): White Ness to Captain Digby Inn 12 – 40m of erosion (mean 26m) from the current shoreline by yr 100. Joss Bay 3.5 – 12m of erosion (mean 7.75m) from the current shoreline by yr 100. Crumbling defences to North Stone Bay 5 – 12.5m of erosion (mean 8.75m) from the current shoreline by yr 100. Dumpton Gap to Northern end of Winterstoke Undercliffe 15 - 50m of erosion (mean 32.5m) from the current shoreline by yr 100.
Ramsgate Harbour	No change	No change	**Assumed defence failure at Yr 70:** Therefore 30 years of erosion assumed at yr 100. Using D'Olier (2007) figures: Ramsgate Harbour <7-18m by year 100, assuming 100 years of erosion = <0.1-0.25m/yr.

			Therefore 30 years of erosion = <3 - 7.5m of erosion from the current shoreline (mean <5.25m) by yr 100.
West Cliff (Ramsgate western harbour arm) to Cliffs End	**Defended sections**: No erosion **Undefended sections** (20yrs of erosion by yr 20) (D'Olier, 2007): The western end of Western Undercliffe to Pegwell 2 -5m of erosion (mean 3.5m) by yr 20. Pegwell village to Cliffsend Tunnel 2 – 7m of erosion (mean 4.5m) by yr 20. Cliffsend Tunnel to the Old Hoverport <1m of erosion by yr 20.	**Defended sections**: Defences assumed to fail in Year 35 (15 years of erosion by year 50). Using D'Olier (2007) figures: Ramsgate Harbour to the western end of Western Undercliffe <4-10m by year 50, assuming 50 years of erosion = <0.1-0.25m/yr. Therefore 15 years of erosion = <1.5 - <3.75m of erosion from the current shoreline (mean <2.6m) by yr 50. The western end of Western Undercliffe to Pegwell 4-10m by year 50, assuming 50 years of erosion = 0.1-0.25m/yr. Therefore 15 years of erosion = 1.5 – 3.75m of erosion from the current shoreline (mean 2.6m) by yr 50. Cliffsend Tunnel to the Old Hoverport 1-3m by year 50, assuming 50 years of erosion = 0.02-0.06m/yr. Therefore 15 years of erosion = 0.3 – 0.9m of erosion from the current shoreline (0.6m) by yr 50. **Undefended sections** (50 yrs of erosion by yr 50) (D'Olier, 2007): The western end of Western Undercliffe to Pegwell 4 -10m of erosion from the current shoreline (mean	**Defended sections:** assumes all defences have failed (65yrs of erosion by year 100): Unsing D'Olier (2007) figures: Ramsgate Harbour to the western end of Western Undercliffe <7-18m by year 100, assuming 100 years of erosion = <0.1-0.25m/yr. Therefore 65 years of erosion = (5+1.5) <6.5 – (12.5+3.75) 16.25m of erosion from the current shoreline (mean <11.4m) by yr 100. The western end of Western Undercliffe to Pegwell 7-18m by year 100, assuming 100 years of erosion = 0.1-0.25m/yr. Therefore 65 years of erosion = (5+1.5) 6.5 – (12.5-3.75) 16.25m of erosion from the current shoreline (mean 11.4m) by yr 100. Cliffsend Tunnel to the Old Hoverport 2-6m by year 100, assuming 100 years of erosion = 0.02-0.06m/yr. Therefore 65 years of erosion = (1+0.3) 1.3 – (3+0.9) 3.9m of erosion from the current shoreline (2.6m) by yr 100. **Undefended section** (100yrs of erosion by year 100) (D'Olier, 2007):

		7m) by yr 50. Pegwell village to Cliffsend Tunnel 5 – 15m of erosion from the current shoreline (mean 10m) by yr 50. Cliffsend Tunnel to the Old Hoverport 1 - 3m of erosion from the current shoreline (mean 2m) by yr 50.	The western end of Western Undercliffe to Pegwell 7 -18m of erosion from the current shoreline (mean 12.5m) by yr 100. Pegwell village to Cliffsend Tunnel 12.5 – 35m of erosion from the current shoreline (mean 23.75m) by yr 100. Cliffsend Tunnel to the Old Hoverport 2 - 6m of erosion from the current shoreline (mean 4m) by yr 100.
Pegwell Bay (Cliffs End to Sandwich Bay Estate	Erosion of the shingle ridge (0.25-1.0m / year)	Large scale flooding predicted	Large scale flooding predicted
Sandwich Bay Estate to Sandown Castle	Erosion of the shingle ridge (0.25-1.0m / year)	Large scale flooding predicted	Large scale flooding predicted
Sandown Castle to Oldstairs Bay	No change in the shoreline's position. Sandown Castle (remains of) and Deal Castle: coastal squeeze predicted. Between Deal Castle and Walmer Castle no change in the shoreline position is predicted (flooding via percolation remains a risk). Between Walmer Castle and Kingsdown (north) slight erosion is predicted at the	Between Sandown Castle (remains of) and Deal Castle flooding is predicted. Between Deal Castle and Walmer Castle no change in the shoreline is predicted. Between Walmer Castle and Kingsdown (north) the shoreline could erode 0.5m/year (15m in epoch 2). Total erosion 25m from the current shoreline by year	Between Sandown Castle (remains of) and Deal Castle further flooding is predicted. Between Deal Castle and Walmer Castle no change in the shoreline is predicted due to contemporary feed from the south. Between Walmer Castle and Kingsdown erosion is predicted to accelerate to 0.5-1.0m/yr: 25-50m (mean 37.5m) from the current shoreline by year

	southern of the beach. Given the relatively low sediment transport rates in this area, the rate of erosion in this area is likely to be approximately 0.5m/yr (total: 10m by year 20) At Kingsdown no change in the shoreline is predicted however, there will be beach lowering. **Undefended:** Between Kingsdown (south) and Oldstairs Bay average erosion rate <0.1m/yr: <2m by year 20. Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.	50 (i.e. 50 years of erosion). Erosion is predicted at Kingsdown (following defence failure at year 30) in the order of 0.5-1m/yr: 10-20m by year 50 (i.e. 20 years of erosion). **Undefended:** Between Kingsdown (south) and Oldstairs Bay: average erosion rate <0.1m/yr: <5m from the current shoreline (i.e. 50 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.	100 (i.e. 100 years of erosion). Further erosion is predicted at Kingsdown. Average erosion rate 0.5-1.0m/yr: 35-70m from the current shoreline by year 100 (i.e. 70 years of erosion). **Undefended:** Between Kingsdown (south) and Oldstairs Bay. Average erosion rate <0.1m/yr: <10m from the current shoreline by year 100 (i.e. 100 years of erosion). Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.
Oldstairs Bay to South Foreland	**Undefended**: Average erosion rate 0.1-0.5m/yr: 2-10m (mean 6m) by year 20. Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10 years. Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10-100 years. **Defended St Margaret's Bay**: no change.	**Undefended**: Average erosion rate 0.1-0.5m/yr: 5-25m (mean 15m) from the current shoreline by year 50 (i.e. 50 years of erosion). Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10 years. Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10-100 years. **Defended sections**: Defences fail in Year 35. Average erosion rate 0.1-0.5m/yr: 1.5-7.5m (mean 4.5m) from the current shoreline by year 50 (i.e. 15 years of erosion).	**Undefended**: Average erosion rate 0.1-0.5m/yr: 10-50m (mean 30m) from the current shoreline by year 100 (i.e. 100 years of erosion). Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10 years. Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10-100 years. **Defended sections**: Average erosion rate 0.1-0.5m/yr: 6.5-32.5 (mean 19.5m) from the current shoreline by year 100 (i.e. 65 years of erosion).

		Loss of rifle range	

C.6 Baseline Case 2 – With Present Management (WPM)

C6.1 Introduction

This report provides analysis of shoreline response conducted for the scenario of "With Present Management". This has considered that all existing defence practices are continued, accepting that in some cases this will require considerable improvement to present defences to maintain their integrity and effectiveness and has taken account of the fact that some presently redundant structures do not form part of this existing defence management.[4]

The analysis has been developed using the understanding of coastal behaviour from Futurecoast (2002) and the baseline understanding report produced,[5] existing coastal change data[6] and information on the nature and condition of existing coastal defences. In addition to this report, maps illustrating this are included at the end of this Appendix.

C6.2 Summary

The following text provides a summary of the analysis of shoreline response with details specific to each location and epoch contained within the Scenario Assessment Table.

Chalk Cliffs The chalk shore platform will continue to erode, albeit at relatively low rates. The Chalk sea cliffs, however, generally will not experience major change in plan-form, due to the presence of defences along much of their length. Over time, the little remaining foreshore sediment will progressively be squeezed between rising sea levels and a static (defended) or only slowly eroding (undefended) backshore (Futurecoast, 2002).

Clay Cliffs Where defended, the likelihood of cliff landsliding will be reduced (but not completely eliminated), reducing the volume of sediment released to the outer Thames (Futurecoast, 2002).

Low-lying Flood defences will hold the plan-form position of the shoreline, but the foreshore will narrow due to coastal squeeze. There will be a net loss of surface area of the inter-tidal flats, despite their continued vertical accretion. This will result in less attenuation of the wave and tidal energy and increasing vulnerability of the defences to damage (Futurecoast, 2002).

Shingle The presence of existing defences effectively fixes the present plan-form position of the shoreline and prevents the landwards migration of the shingle beach with rising sea levels. This will lead to foreshore narrowing and could

[4] Refer to Section C2 (Defence Assessment)
[5] Refer to Section C1
[6] Refer to Section

lead to progressive denudation of existing shingle stored on the beach (Futurecoast, 2002).

C6.3 With Present Management Scenario Assessment Table (North Coast)

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Allhallows-on-Sea to Grain	Clay embankment / seawalls with concrete block front slopes protect the majority of the frontage (<20 years). At Grain there are timber groynes, along a section of coast which is known to erode (<20yrs). Raised ground/cliffs protect Grain.	Upgrade all the defence structures	Further maintenance of the defences is predicted

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	This is a low lying section of the open coast that is backed predominantly by low lying reclaimed marshland (that has agricultural and environmental importance). The villages of Allhallows and Grain both however, sit on localised areas of high ground (gravel cliffs). The Yantlet Creek intercepts the open coast in the north whilst in the east the River Medway separates Grain from Sheerness. It is predicted that with the continued presence of defences (mainly embankments) along the majority of the shoreline, the shoreline will continue to respond in a similar manner to the present day. Therefore little change is predicted during this epoch. The mouth of the Medway will continue to be constrained by the presence of defences and highland. A small section of undefended gravel slope, north of Grain village, will continue to erode at an approximate rate of 0.5-1m/yr (Futurecoast, 2002). The oil fired power station at Grain will continue to be protected by the revetments and seawalls during this epoch and as such no change in shoreline alignment or risk of flooding is predicted. Continued sedimentation on the tidal flats, resulting in their further vertical rise is proposed.	All the defences will need to be upgraded during this epoch to prevent the backing hinterland from flooding on a large scale. Continuing to 'hold' the plan form of the shoreline will result in narrowing of the foreshore; thus squeezing the inter-tidal area and a reduction in cliff erosion. It is speculated that the small amount of westward transport of material, along this frontage, will continue during this epoch. Erosion of undefended slopes north of Grain will continue.	Further upgrading of the flood defences could be required during this epoch to counter the rising sea levels. Defence type might change during this epoch from a clay embankment to a more substantial structure i.e. a concrete seawall. Similarly the defences fronting Grain will require maintenance/upgrading (dependent on the defence type implemented in the previous epoch). Upgrading the defences will continue to hold the plan-form position of the shoreline and as such the risk of flooding will be significantly reduced. The inter-tidal are will however, continue be squeezed, resulting in a net loss of the inter-tidal flats. Holding the line here will also continue to 'constrain' the mouth of the River Medway; restricting the width of its mouth. Erosion of undefended slopes north of Grain will continue.

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	No change in shoreline but coastal squeeze along the defended section. **Undefended**: average erosion of undefended slopes is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 20 = 10-20m (15m mean).	No change in shoreline but coastal squeeze along the defended section. The defended slopes at Grain would need substantial management to prevent erosion. **Undefended**: Average erosion rate of the undefended slopes is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 25-50m (mean 37.5m) from the current shoreline (i.e. 50 yrs of erosion).	No change in shoreline but coastal squeeze along the defended section. **Undefended**: Average erosion rate of the undefended slopes is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 100 = 50-100m (mean 75m) from the current shoreline (i.e. 100 yrs of erosion).

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Sheppey West **(Sheerness to Scrapsgate)**	A seawall and groyned shingle beach protects Garrison Point to Barton's Point Between Barton's Point and the western edge of Minster is a (recharged) shingle barrier beach. There are no retaining structures along its length.	Upgrade / maintain the defences and increase the frequency/quantity of beach recharge at Scrapsgate.	Further upgrading of the defences and a potential change in management practises along the Scrapsgate (from soft to hard engineering).

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	The port at Sheerness and the east bank of the River Medway dominates this section of the coast. The presence of the port and its associated construction has affected the boundary of the coastal processes between the open coast and the estuary. Nonetheless some material will continue to by-pass these structures; leading to continued accretion, of silt, mud and sand, at Garrison Point (at the western end of this frontage). Conversely between Sheerness and Scrapsgate it is envisaged that the beach will continue to narrow (unless beaches are recharged), putting increased pressure on the backing defences. The predominant drift direction, along this section of the coast, will remain west. In continuing to defend this frontage, flood potential/risk, to the backing hinterland is eliminated / dramatically reduced.	During this epoch the majority of the defences, between Garrison Point and Barton's Point, will need to be upgraded whilst it is likely that the shingle beach, at Scrapsgate, will narrow further (unless recharged). Upgrading and maintaining the frontage will prevent inundation of the low lying hinterland. There is a potential that the eastern part of this frontage could migrate slightly landwards, due to the change in management practises (from hard to soft). If this were to be the case then inter-tidal squeeze would be restricted to the frontage between Garrison's Point and Barton Point. It is envisaged that material will still be transported westwards however; it is not clear whether Garrison Point will continue to accrete or start to erode, during this epoch, in response to the predicted rise in sea level (6mm/year).	During this epoch the majority of the flood defences will continue to hold the plan-form position of the shoreline, with the exception of the frontage between Barton's Point and Scrpasgate, which could migrate landwards if soft engineering continues. However, if hard engineering is implemented then the plan position along the entire frontage will be fixed. As a consequence of the shoreline being held and the predicted rise in sea level, further narrowing of the foreshore is envisaged. The combination of the aforementioned will induce increased wave attack on the defences and loss of the foreshore, which will lead to a net loss in the surface area of inter-tidal flats.
Shoreline Movement	No change in the plan form of the shoreline, coastal squeeze of the foreshore/inter-tidal area.	No change in the plan form of the shoreline, further squeeze of the foreshore/inter-tidal area.	No change in the plan form of the shoreline, increased squeeze of the foreshore/inter-tidal area.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Sheppey Central **(Scrapsgate to Warden Point)**	Minster is protected by a sea wall and rock revetment (<20 years). Minster Slopes is protected by a sea wall and a groyned beach (<20 years).	Upgrade all the defences	Maintain / upgrade the defences

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	This frontage is dominated by London Clay sea cliffs, which vary in height (8m to 52m). In the west the cliffs are heavily defended and as such the town of Minster will remain defended throughout this epoch. Along the remainder of the frontage the cliffs are unprotected and will continue to erode, predominately in the form of landslide events. Fine material released from cliff erosion is transported in suspension into the outer Thames estuary. The volume of coarser material (sand and shingle) released from the eroding cliffs will remain insufficient to build a protective foreshore cover. This material is transported westwards towards Garrison Point. As such the foreshore will remain as a narrow shingle beach sitting on top of a shore platform cut into the London Clay basement. During this epoch the fronting shore platform will also continue to degrade. There is no risk of flooding, during this epoch, due to the presence of the backing cliffs.	During this epoch the majority of the defences, will need to be upgraded. Upgrading the defences will prevent / reduce erosion at Minster and Minster slopes. Preventing / reducing erosion will reduce the input of fines into the sediment system. Although this material is too fine to build beaches it could have importance to the estuaries in the west. Nonetheless, sediment from erosion and landslide events from undefended cliffs in the east is predicted to continue throughout this epoch. Debris material, from landslide events, will be removed by tidal action relatively quickly. Therefore no/little protective cover will remain at the cliff toe, which will induce further instability. Fine sediment will continue to be transported in suspension into the outer Thames estuary, Coarse sediment will continue to be transported westwards, towards Garrison Point, In ‘continuing to ‘hold’ the plan form position of the shoreline at Minster and Minster Slopes the inter-tidal area will be squeezed and headlands will begin to form at Warden and Minster.	Response during this epoch will be a continuation of the previous epoch, albeit at an accelerated rate. With the predicted rise in sea level, it is likely that the defences will need to be maintained / upgraded during this epoch. Continuing to maintain / upgrade the defences will result in cliff erosion / land-sliding being reduced in these areas, thus the volume of sediment released to the outer Thames will continue to be reduced. There will be increased cliff erosion and an increased probability of landslides, along undefended sections. Fine sediment will continue to be released to the system (and transported alongshore – in a westwards direction). In ‘continuing to ‘hold’ the plan form position of the shoreline at Minster and Minster Slopes the inter-tidal area will continue to be squeezed as sea levels rise and headlands will become more prominent at Warden and Minster.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	**Defended section**: No change in the plan form of the shoreline, coastal squeeze of the foreshore/inter-tidal area. **Undefended sections**: Average erosion rate of undefended cliffs is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 20 = 10-20m (mean 15m). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years (Futurecoast, 2002).	**Defended sections**: No change in the plan form of the shoreline, further squeeze of the foreshore/inter-tidal area. **Undefended sections**: Average erosion rate of the undefended London Clay Cliffs is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). Erosion by year 50 = 25-50m (mean 37.5m) from the current shoreline (i.e. 50 yrs of erosion). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years (Futurecoast, 2002).	**Defended sections**: No change in the plan form of the shoreline, increased squeeze of the foreshore/inter-tidal area. **Undefended sections**: Average erosion rate of the undefended London Clay Cliffs is predicted to be in the region of 0.5-1m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 50-100m (mean 75m) from the current shoreline (i.e. 100 yrs of erosion). In addition, the position of the top of the landslide by year 100, allowing for an average landslide width of 107m could be in the region of between 157-207m (mean 182m) from the current shoreline. Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years (Futurecoast, 2002).

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Sheppey East **(Warden Point to Shell Ness)**	The town of Warden is fronted by a groyned beach and concrete revetment, with a sea wall to the southern end. In 'The Bay' area, protection is afforded by a barrier beach. A concrete sea wall and groyned beach protect Leysdown-on-Sea. At Shellness the frontage is protected by embankments, wooden groynes and the fronting shell beach. All defences have a residual life (<20 years).	Upgrade all the defences / management practises	Upgrade all the defences / management practises

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	The western part of this frontage is dominated by London Clay sea cliffs, which vary in height (8m to 52m). The majority of the frontage is heavily defended and as cliff erosion in the west is limited, the entire plan form of the shoreline is fixed, the towns of Warden and Leysdown-on-Sea are defended and there is little risk of the low-lying land, between Warden and Leysdown, being flooded. Thus, a continuation of this is trend is predicted, until the groynes fail, which will take place by the close of this epoch. Pockets of sandy beaches punctuate the foreshore. The groynes at Warden Village between Leysdown-on-Sea and the nose of Shell Ness will continue to maintain a sandy beach, although some degree of narrowing is anticipated during this epoch. It is believed that material fed to this frontage, comes predominantly from offshore shell banks (the rate has yet to be established). The other source of sediment is via alongshore transport, despite the continued presence of defence's. Material is moved alongshore, in a south-eastwards direction between Warden Point and the nose of Shell Ness and in a south-westwards direction in the lee of Shell Ness. Thus the sand/shell spit will continue to accrete, extending in south-west direction, into the outer reaches of the River Swale. By the close of this epoch it is predicted that all	During this epoch defences will need to be upgraded to maintain a similar standard of protection. With a predicted rise in sea level (6mm./year) management of the coast ,at 'The Bay' and Shellness, may need to change from a soft engineering option to a harder engineering approach, during this epoch, to reduce the risk of flooding to the low-lying hinterland. Where there are hard defences the plan position of the shoreline will be fixed and where there is softer engineering then the plan position of the shoreline will migrate landwards. If a variety of management options continues then it is envisaged that this section of the coast will start to behave in a fragmented manner. It will potentially impact on the coastal processes; namely the alongshore movement of sediment (north to south). With a potential reduction in sediment supply and the predicted rise in sea level, it is likely that the character of Shell Ness will change dramatically.	In the north cliff erosion and cliff land-sliding will continue to be restricted by the hard defences thus the plan form of the shoreline will remain fixed and the volume of sediment released to the outer Thames will reduce Between a rising sea level (6mm/year) and the sustained presence of backshore structures/heavy beach management, further foreshore lowering and squeeze of the tidal flats is envisaged. Sediment supply and sediment movement alongshore will reduce during this epoch due to a number of reasons: • Cliff erosion being prevented • The foreshore narrowing • A potentially fragmented coastline

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Shoreline Movement	No change in the plan form position of the shoreline, coastal squeeze of the foreshore/inter-tidal area. Potential roll back of the beach at 'The Bay'.	No change in the plan form of the shoreline, further squeeze of the foreshore/inter-tidal area.	No change in the plan form of the shoreline, increased squeeze of the foreshore/inter-tidal area.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Graveney Marshes (Faversham Creek to Seasalter PH)	Faversham Creek to Faversham Road is a re-curved seawall, block-work apron and dilapidated wooden groynes. Backing Faversham Road (in the east) is a clay (1953/54) embankment behind the (<20years).	Maintain / upgrade all the defences	Further upgrading of the defences

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	Extensive tidal flats backed by large areas of former salt marsh that have been enclosed and reclaimed from the sea for agricultural use dominate this section of the coast. During this epoch it is envisaged that the low lying frontage and backing hinterland of Graveney Marshes will continue to be controlled by the shoreline defences and shoreline infrastructure. Thus no flood inundation is predicted during this epoch. The foreshore comprises shell fragments, in the west (washed onshore from the extensive shellfish beds in the mouth of the River Swale estuary) and a small volume of shingle (flints, black pebbles and claystone on the upper beach) in the east. Despite a westwards transport of material this diversion of sediment types and sizes will be maintained throughout this epoch. Groynes along the frontage will continue to restrict the east to west transport of sediment. Similarly Faversham Creek, at the western end of this frontage, will continue to act as a barrier to sediment and as such the sandy beach, with high shell content, will continue to accumulate on the east bank of the creek. Once at this location the strong ebb flows, of the River Swale, will continue to push the sediment north to Pollard Spit; on the south side of the River Swale.	During this epoch the majority of the defences will need to be upgraded. Upgrading and maintaining the frontage will prevent inundation of the low lying hinterland. If flood embankments continue to be the main form of defence, along this frontage, then a landwards migration of plan-form position of the shoreline is predicted, until these defences are reached. When this occurs it is likely that defence type will need to change to something more substantial, to reduce the risk of the backing hinterland flooding. In continuing to hold the line along this frontage the mouth of the River Swale will continue to be influenced, in particular the width, which will be significantly smaller than the predicted natural form.	Flood defences will continue to hold the plan-form position of the shoreline, but the foreshore will narrow as a consequence (due to coastal squeeze). It is also predicted that there will be a net loss of surface area of the inter-tidal flats and that there will be little material moving alongshore. In continuing to hold the shoreline here, further restrictions will be imposed upon the River Medway.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	Landwards migration of the shoreline towards the flood defences.	Landwards migration of the shoreline towards the flood defences. Thereafter no change in shoreline and coastal squeeze.	No change in the plan form of the shoreline, increased squeeze of the foreshore/inter-tidal area.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Whitstable Bay West **(Seasalter PH to Whitstable Harbour)**	Re-curved sea walls topped with a concrete promenade front the majority of this coast. Groynes and recharge sustain the fronting shingle beaches. At the quays and around the harbour are various perimeter sea walls built in the 1980's. Seawalls, groynes and beach recharge protect Seasalter slopes.	Upgrade all the defences and increase the frequency/amount of beach recharge.	Upgrade all the defences and increase the frequency/amount of beach recharge.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	The updrift and shoreline structures will continue to influence the morphodynamics along this section of the coast. New timber groynes and beach recharge works were completed along most of the frontage in September 2006. However, with no further beach recharge scheduled the foreshore will narrow during this epoch. Due to the updrift defences, the throughput of sediment (sand and silt) from the east is restricted. Thus the mudflats immediately downdrift of Whitstable Harbour will continue to deplete. Some material does however, bypass the defences and this is predicted to continue throughout this epoch. It is envisaged that the slight promontory around Lower Island will be maintained.	The terminal groyne affect of the harbour arms will continue to affect sediment inputs from the east (Whitstable Bay East). Thus, the contemporary sediment supply will continue to be affected and insufficient to counter the predicted rise in sea level (6mm/yr). As such an increase in the frequency / quantity of beach recharge is likely, to help maintain a suitable standard of protection. In continuing to hold the plan form position of the shoreline, the mudflats are predicted to thin further. It is also predicted that with the predicted rise in sea level, some material will continue to bypass the groynes, despite them being upgraded.	During this epoch a continuation of the previous is predicted. The flood and erosion defences will hold the plan-form position of the shoreline and the foreshore will continue to narrow due to coastal squeeze. As such a net loss of surface area of the inter-tidal flats is predicted. It is envisaged that this will be particularly severe along the eastern part of this frontage due to the updrift effect of the harbour arms.
Shoreline Movement	Slight narrowing of the foreshore is predicted.	Thinning of the foreshore (despite beach recharge).	Thinning of the foreshore, particularly in the east, despite beach recharge. Coastal squeeze of the inter-tidal area is predicted.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Whitstable Bay East (Whitstable Harbour to Long Rock)	A seawall protects Harbour Beach and the Tankerton frontage. Beach re-grading and recharge also occurs along the majority of this coast. At Long Rock the natural spit is backed by a clay bund.	Upgrade all the defences and increase the frequency/amount of beach recharge.	Upgrade all the defences and increase the frequency/amount of beach recharge.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	The majority of the foreshore along this section of the coast is fronted by a predominantly shingle beach, although in some places it is mixed with sand. The beach overlies a London Clay platform. Behind the shingle beach / shingle and sand beach is a seawall, which at Tankerton is backed by grassed slopes, up to 20m in height whilst at Whitstable Harbour Beach and at Swalecliffe Brook/Long Rock is backed by low-lying land. It is predicted that during this epoch there will be a continuation of the present day beach management practises. The newly constructed groynes will hold the majority of the recharged material and could also potentially trap some of the sediment moving alongshore (east to west). As such the backing defences / hinterland are not deemed being at risk (from erosion / flooding) during this epoch. The eastern harbour arm at Whitstable will continue to act like a terminal groyne, restricting sediment moving eastwards to downdrift frontages. The old pipeline at Whitstable Street will continue to restrict, albeit on a very small scale, the movement of predominantly fine material alongshore.	During this epoch a continuation of the previous one is envisaged. The groynes along the foreshore will continue to try and 'trap' recharged beach material and material moving alongshore. Similarly the linear defences will continue to protect the backing hinterland from eroding and flooding. Recharging the beach will continue to provide the London Clay platform with some protection although 'fixing' the plan form position of the shoreline will have a detrimental impact on the platform, which will result in waves propagating closer to the shore, in response to coastal squeeze. Alongshore transport will continue to be affected (by the groynes and by the harbour arm at Whitstable) thus affecting the supply to frontages downdrift. During this epoch it is envisaged that he frequency / quantity of beach recharge may need to increase to keep pace with the predicted rise in sea level.	It is envisaged that there will be very little sediment entering the system from the east, due to defence structures updrift and a lack of contemporary beach feed material. Thus if sea level continues to rise then the amount of beach recharge will need to increase. During this epoch the groynes will need to be upgraded to continue to trap the relatively small volume of drifting sand and shingle and hold the recharged material in place. Foreshore cover will provide a little protection to the underlying London Clay shore platform, but it will not prevent platform lowering. Linear defences and cliff management will continue to fix the plan-form position of the shoreline, which will squeeze the foreshore between a rising sea level and a static backshore defence. Additionally, it will preclude sediment input (particularly of sand and shingle) from the cliffs to the foreshore, exposing the shore platform and foreshore to further lowering and erosion.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	Coastal squeeze	Coastal squeeze	Coastal squeeze

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Herne Bay **(Long Rock to Herne Bay Harbour)**	A seawall, groynes and rock gabions (mid 1980's) protect the Long Rock to Herne Bay frontage (<20 years). Between Herne Bay Pier and Herne Bay Harbour is a sea wall, a harbour arm and a recently recharged beach (<100yrs).	Upgrade the defences between Long Rock and Herne Bay frontage. Maintain the harbour arm defences / within the harbour.	Upgrade all the defences along the frontage.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	Again this frontage is dominated by London Clay sea cliffs whilst the foreshore comprises a predominantly shingle beach, although there is some sand and mud, which overlies a London Clay shore platform. The continued presence of defences throughout the majority of this epoch will see a continuation of the present shoreline processes. 1) The dominant drift direction will remain westwards. 2) The terminal groyne at Hampton Pier will continue to have a major controlling influence; sustaining a wider beach updrift of the structure and a narrower one in its lee (due to the structure continuing to interrupt sediment movement alongshore). 3) The harbour arm at Herne Bay will continue to provide some degree of protection to the town's frontage. As such the sand beach, in its lee, will remain reasonably wide. However, as one moves west along the frontage the sand beach thins irrespective of the groyne field and the westward transferral of sediment, therefore further thinning of the foreshore is envisaged. 4) erosion of the backing London Clay cliffs will be prevented by the sustained presence of defences.	During this epoch a continuation of the previous one is envisaged. The linear defence structures and cliff management practises will continue to fix the plan form position of the foreshore. This will squeeze the foreshore between a rising sea level and a static backshore defence. Additionally, it will preclude sediment input (particularly of sand and shingle) from the cliffs to the foreshore, exposing the shore platform and foreshore to further lowering and erosion. Groynes along the Long Rock to Herne Bay frontage will continue to 'trap' the beach and recharged beach material. They will also restrict the alongshore transport (east to west) of sediment, as will the harbour arm at Herne Bay.	For this epoch a continuation of the one previous is predicted. Little sediment will enter the system from the east, due to defence structures updrift and a lack of contemporary beach building material. The volume / frequency of beach recharge, between Herne Bay Pier and Herne Bay Harbour is likely to increase. There is also the possibility that recharge material will be needed for the remainder of the frontage, especially if sea levels rise at the predicted rate (6mm/yr). Groynes will need to be upgraded during this epoch to 1) continue to trap the relatively small volume of drifting sand and shingle, 2) hold the recharged material in place and 3) keep pace with sea level rise. If there is foreshore cover then it will provide some protection to the underlying London Clay shore platform, but it will not prevent platform lowering Cliff management will continue to fix the plan-form position of the shoreline which will squeeze the foreshore between a rising sea level and a static backshore defence. Additionally, it will preclude sediment input (particularly of sand and shingle) from the cliffs to the foreshore, exposing the shore platform and foreshore to lowering.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	Coastal squeeze	Coastal squeeze	Coastal squeeze

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Herne Bay Harbour to Reculver	Herne Bay Harbour to Bishopstone Glen: a seawall/ promenade and groynes. The backing cliffs are graded, grassed and drained. There is a short section of rock armour at Eastcliff (<20 years). Bishopstone Glen to Reculver: seawall fronted by rock armour. There is a block ragstone apron at Reculver Towans, which lies on top of recharged beach material. An undefended section of cliffs at Reculver Country Park.	The defences will need to be upgraded	The defences will need to be upgraded

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	Again this frontage is dominated by London Clay sea cliffs whilst the foreshore comprises a predominantly shingle beach, although there is some sand and mud, which overlies a London Clay shore platform. The continued presence of defences throughout the majority of this epoch will see a continuation of the present shoreline processes. 1) The dominant drift direction will remain westwards. 2) The terminal groyne at Hampton Pier will continue to have a major controlling influence; sustaining a wider beach updrift of the structure and a narrower one in its lee (due to the structure continuing to interrupt sediment movement alongshore). 3) The harbour arm at Herne Bay will continue to provide some degree of protection to the town's frontage. As such the sand / shingle beach, in its lee, will remain reasonably wide. However, as one moves west along the frontage the sand beach thins irrespective of the groyne field and the westward transferral of sediment, therefore further thinning of the foreshore is envisaged. Undefended cliffs at Reculver Country Park will continue to erode at an approximate rate of 0.1-	During this epoch it is predicted the defences /management practises will need to be upgraded / increased to maintain a similar standard of protection to the present day. Upgrading the defences will continue to fix the plan position of the shoreline which is likely to result in further squeeze of the foreshore. This will increase the amount of pressure on the defences and accelerate the erosion of the London Clay platform. The revetment between Bishopstone Glen and Reculver will allow some cliff erosion. However, the amount deemed acceptable will have to be agreed. If erosion along this stretch is acceptable then material eroded from the cliffs (sand and gravel) will provide some protective cover to the foreshore. However, with the predominant alongshore transport being westwards, it is envisaged that this material will be transported towards Herne Bay Harbour. If erosion along this stretch of the coast is not deemed acceptable then defence type will need to change, to something more restrictive, and as a consequence little/no feed is predicted. Undefended cliffs at Reculver Country Park will continue to experience erosion at a similar rate to the previous epoch.	It is envisaged that recharge material will need to be added to the frontage to provide some form of protection to the defences and the underlying London Clay platform. Upgrading the groynes will help in 'holding' this material, as feed from updrift sources is predicted to be non-existent. Cliff management practises implemented in the previous epoch will also need maintenance and / or upgrading (depending on defence type previously implemented). Upgrading / maintaining the defences here will preclude sediment input (particularly of sand and shingle) from the cliffs to the foreshore, thus exposing the shore platform and foreshore to further lowering. In general the plan-form position of the shoreline will be fixed. Thus between a rising sea level and a static backshore defence the foreshore/inter-tidal area will be squeezed. Undefended cliffs at Reculver Country Park will continue to experience erosion at a similar rate to the previous epoch. In addition, there is the potential for landslide events to occur (landslide frequency of <10m in 10-100 years, Futurecoast (2002)).

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	Coastal squeeze Undefended cliff erosion rate (Reculver CP) is predicted to be, on average, in the region of 0.1-0.5m/yr (Futurecoast, 2002). Erosion by year 20 = 2-10m (6m mean).	Coastal squeeze At Reculver CP: average erosion rate is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). Erosion by year 50 = 5-25m (mean 15m) from the current shoreline (i.e. 50 years of erosion).	Coastal squeeze At Reculver CP: average erosion rate is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). However this rate may increase as sea levels rise and with increased storminess. Erosion by year 100 = 10-50m (mean: 30m) from the current shoreline (i.e. 100 years of erosion).

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Reculver to Minnis Bay	Sea wall topped with a concrete access way, 14 rock groynes, and the large shingle beach is maintained with beach replenishment (<20 years) at both the west and eastern sections. Reculver Towers: block ragstone apron and a rock armour revetment (<50 years).	Upgrade all defences and maintain the beach with recharge.	Upgrade / maintain the ragstone apron, and increase the frequency / volume of beach recharge.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	A narrow strip of drift deposits (alluvium and head brickearth) from the Quaternary (125,000 to 10,000 yrs BP) dominant the foreshore. The beach in the west is composed of shingle and sand, which gives way to mainly shingle and a sparse covering of sand on the lower foreshore in the east. This front's a low-lying alluvium hinterland, which once was part of the Wantsum Channel, Due to the continued presence of defences little change in coastal processes and geomorphological response is envisaged during this epoch. For example the stone apron will continue to protect Reculver Towers rock revetment from erosion, as well as act as a barrier to the alongshore (east to west) transport of material. Without the input of replenished material, the vulnerability of the central section would increase, thus further narrowing of the foreshore is envisaged. This in turn will put increased pressure on the backing earth embankments, which protects the marsh hinterland from extensive flooding.	During this epoch it is predicted that all defences will need to be upgraded to maintain a similar standard of protection to the present day. Upgrading the defences fixes the plan position of the shoreline. Thus between a rising sea level and a static backshore defence the foreshore/inter-tidal area will be squeezed. The continued presence of defences is likely to result in accelerated lowering of the London Clay platform. To counter this recharge material would need to be added to the foreshore, to provide a protective cover. The contemporary sediment supply will be insignificant; this will be a consequence of updrift geology and defences.	In response to the predicted rise in sea level it is foreseen that defence structures will need to be upgraded and the beach will need further recharge. The sustained presence of the defences will continue to fix the plan-form position of the shoreline, which in turn prevents a landwards migration, of the plan-form, to a position more commensurate with the forcing factors. As such coastal squeeze is likely to increase during this epoch – resulting in a very narrow inter-tidal area and potentially little / no beach. If the latter is to be the case then the construction of additional groynes plus additional recharge could become a necessity. By the close of this epoch it is envisaged that there will be little / no alongshore transport.
	Sediment transport patterns along this section are somewhat complicated, due to the presence of offshore banks. Thus, despite the dominant movement of material along this frontage being to the west, material can move		

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	Beach erosion and coastal squeeze	Coastal squeeze	Coastal squeeze

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Margate	Harbour arms, seawall, groynes	Upgrade the defences	Maintain / upgrade the defences

(Minnis Bay to Fulsam Rock)	The majority of this frontage is heavily populated with the towns of Birchington, Westgate-on-sea and Margate and as such, heavily defended. The Upper Cretaceous chalk cliffs (10-25m in height), are protected by seawalls, which rest on the chalk platform (which can in places reach widths up to 250m). The harbour arms at Margate provide shelter to the beaches in its lee, whilst the groynes along the frontage will continue to retain the mobile layer of sand and shingle. Thus the present management practises prevents the shoreline from retreating – and this will continue throughout this epoch. It is envisaged that the offshore will continue to provide some (fine) material to the frontage and that the groynes and harbour arms will continue to restrict alongshore transport. The undefended section of shoreline between Epple Bay and Westgate Golf Course will experience low rates of erosion in the region of 1-2m by year 20 (D'Olier, 2007).	With sea level predicted to rise (6mm/year) and the plan form of the shoreline remaining fixed, it is likely that the foreshore will narrow (sandy beaches will reduce) and defences will become more prone to attack. As such, all defences will need to be upgraded and the foreshore could potentially benefit from recharge, which will help maintain its recreational value. Some feed of material from the east is predicted; however the harbour arms will restrict its movement westwards. Similarly inside the harbour arms, the groynes will continue to restrict sediment movement alongshore, thus contributing to restricted downdrift feed. Along the undefended section, between Epple Bay and Westgate Golf Course, erosion in the region of 1.5 – 7.5m from the current shoreline is predicted by year 50 (D'Olier, 2007).	During this epoch a continuation of the previous is envisaged. In essence: the Chalk sea cliffs will not experience a major change in plan-form, due to the presence of defences along much of their length. The Chalk shore platform will continue to erode, albeit at relatively low rates, the foreshore sediment will progressively be squeezed between rising sea levels and a static (defended) slowly eroding (undefended) backshore. Sediment alongshore will continue to be restricted. Along the undefended section, between Epple Bay and Westgate Golf Course, erosion of between 5 – 15m from the current shoreline is predicted by year 100 (D'Olier, 2007). Consequently, the cliff top road will be at risk in places during this epoch.
Shoreline Movement	Coastal squeeze Along the undefended section, cliff erosion is predicted to be between 1 – 2m (mean 1.5m) by year 20.	Coastal squeeze and a small amount of platform lowering. Along the undefended section, between Epple Bay and Westgate Golf Course, erosion of between 1.5 – 7.5m (mean 4.5m) from the current shoreline is	Coastal squeeze and a small amount of platform lowering. Along the undefended section, between Epple Bay and Westgate Golf Course, erosion of between 5 – 15m (mean 10m) from the current

		predicted by year 50.	shoreline is predicted by year 100.

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Cliftonville **(Fulsam Rock to White**	Seawalls protect steep chalk cliffs along rest of coastline; however the cliffs at Palm Bay, Botany Bay and between Botany Bay and White Ness are undefended.	Upgrade defences	Upgrade defences

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Ness)	This coastline is characterised by steep chalk cliffs whilst the foreshore consists of a chalk platform, which varies in width up to 250m and is, in places, covered by a thin and highly mobile layer of sand and shingle. Seawalls along the majority of the frontage, with the exception of Palm Bay, Botany Bay, and Botany Bay to White Ness, will continue to provide the cliffs with toe protection. This restricts the production of geological exposures as well as a small supply of sediment (flint). Although the offshore, Margate Sands, acts as the main source. Along the undefended sections the fronting beaches will continue to provide some protection to the cliffs. Thus any erosion that does occur will do so slowly. By year 20, at Palm Bay and Botany Bay erosion is predicted to be in the region of 1-2m, and 2-6m between Botany Bay and White Ness (D'Olier, 2007). The dominant westward movement of material along this frontage will continue throughout this epoch, thus creating a drift divide at North Foreland (and as such no feed to the East Kent coast).	During this epoch the existing defences will need to be upgraded to maintain a similar standard of protection to the present day. Thus the defended cliffs will continue to erode, via sub-aerial weathering, at a rate similar to the present day - resulting in a small amount of cliff top retreat. The predicted rise in sea level / wave attack will impact on the defences and on the cliffs. In the medium term, along undefended sections, erosion from the current shoreline is predicted to be in the region of between 1.5 – 7.5m at Palm Bay, 1.5 – 4m at Botany Bay and in the region of 4-15m between Botany Bay and White Ness by year 50 (D'Olier, 2007). Cliff recession will continue to yield mainly fine sediment and a very small amount of flinty shingle to the foreshore. Any flint rubble released will accumulate initially at the toe of the cliff until it becomes broken down and transported alongshore (in a westwards direction) and offshore. Where the plan form of the shoreline is fixed by defences or where cliff erosion rates are low (i.e. the entire section of this coast) coastal squeeze will take place.	During this epoch a continuation of the previous is envisaged. In essence: the Chalk sea cliffs will not experience a major change in plan-form, due to the presence of defences along much of their length. The Chalk shore platform will continue to erode, albeit at relatively low rates, the foreshore sediment will progressively be squeezed between rising sea levels and a static (defended) / slowly eroding (undefended) backshore. Sediment alongshore will continue to be restricted. Along undefended sections, D'Olier (2007) predicts cliff erosion at year 100 in the region of 5 -15m from the current shoreline at Palm Bay, 3 – 7m at Botany Bay and in the region of 12 – 40m between Botany Bay and White Ness, which is one of the most actively eroded sections of the Thanet coastline due to the numerous joints in the cliffs and exposure to storm waves.
		It is predicted that some sand will continue to be supplied from the offshore.	

<table>
<tr><th rowspan="2">Location</th><th colspan="3">Predicted Change</th></tr>
<tr><th>Years 0-20 (2025)</th><th>Years 20-50 (2055)</th><th>Years 50-100 (2105)</th></tr>
<tr><td>Shoreline Movement</td><td>Along the undefended sections at Palm Bay and Botany Bay, erosion is predicted to be between 1 – 2m (mean 1.5m) and 2-6m (mean 4m) between Botany Bay and White Ness by year 20.

No change along the defended sections.</td><td>Along the undefended sections, by year 50, erosion from the current shoreline is predicted to be between:

• 1.5 –7.5m (mean 4.5m) at Palm Bay;
• 1.5-4m (mean 2.75m) at Botany Bay; and,
• 4-15m (mean 9.5m) of erosion between Botany Bay and White Ness.

No change in shoreline position along the defended sections – coastal squeeze.</td><td>Along the undefended sections, by year 100, erosion from the current shoreline is predicted to be in the region of:

• 5 – 15m (mean 10m) at Palm Bay;
• 3 – 7m (mean 5m) at Botany Bay; and,
• 12 – 40m (mean 26m) between Botany Bay and White Ness.

No change in shoreline position along the defended sections – coastal squeeze.</td></tr>
</table>

C6.5 With Present Management Scenario Assessment Table (East Coast)

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
White Ness to Ramsgate Harbour (East Cliff)	A seawall/promontory at Kingsgate, a small harbour at Broadstairs and a seawall founded on the chalk platform at Stone Bay. The defences will need to be upgraded during Years 20 to 50 to continue to afford a suitable standard of protection.	Upgrade the defences	Upgrade the defences

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Chalk sea cliffs, which rise to a height of 15-30m (Futurecoast, 2002) and are fronted by a chalk shore platform and separated by a number of small bays. The cliffs will continue to erode, along the undefended sections. By year 20, D'Olier (2007) predicts erosion to be in the region of 2 – 6m between White Ness and Captain Digby Inn, 1-2.5m at Joss Bay, 1.5 – 3.5m between the crumbling defences and north Stone Bay and 3 – 7m between Dumpton Gap and the northern end of Winterstoke Undercliffe, the fastest eroding section on the Thanet coast due to well defined joints/faults in the chalk. The variations in erosion rates are related to differences in bedding and/or changes in shoreline alignment between Foreness Point and Ramsgate; alignment changes from north-west to south-east to north-south respectively. As such the cliffs would be subject to variations in wave approach and thus changes in incident wave energy, with the former being subject to the more aggressive northerly wave climate. Along the defended frontages i.e. Kingsgate, Broadstairs and Stone Bay only limited erosion of the cliffs caused by natural weathering would take place during this epoch. Chalk platforms front the cliffs between North Foreland and Ramsgate. During this epoch it is	During this period a continuation of the earlier epoch is anticipated. Along the undefended sections erosion is predicted to be in the region of 4-15m from the current shoreline between White Ness and Captain Digby Inn; 2-4.5m at Joss Bay; 3-7m between the crumbling defences and north Stone Bay and 5-20m between Dumpton Gap and the northern end of Winterstoke Undercliffe by year 50 (D'Olier, 2007). The highest erosion rates are therefore predicted for those sections of cliff where joints and faults are numerous and well defined (i.e. between Dumpton Gap and the northern end of Winterstoke Undercliffe and between White Ness and Captain Digby Inn). These rates may however, be greater if a landslide event occurs. Along the defended sections of the coast i.e. Kingsgate, Broadstairs and Stone Bay the defences will need to be upgraded to continue to provide the same standard of protection as present. It is acknowledged that the toe defences prevent predominantly fine sediment from entering the system, material regarded as too fine to build beaches. It is also acknowledged that the defences arrest geological interests.	During this epoch it is envisaged that Kingsgate Bay, Broadstairs and Stone Bay will become less sheltered. This is due to the adjacent cliffs being undefended and therefore eroding whilst cliff erosion is being prevented at Kingsgate, Broadstairs and Stone Bay. As a consequence it is envisaged that wave attack at these defended locations is likely to increase and thus additional pressure will be exerted on the defences. This increase in exposure will also be exacerbated by a predicted increase in accelerated sea level rise (6mm/year) and once again there will be increased pressure on the defences. During this epoch recession rates are predicted to be in the region of 12-40m from the current shoreline between White Ness and Captain Digby Inn; 3.5-12m at Joss Bay; 5-12.5m between the crumbling defences and north Stone Bay and 15-50m between Dumpton Gap and the northern end of Winterstoke Undercliffe by year 100 (D'Olier, 2007). The type of material eroded will be predominantly fine and therefore not suitable for beach-building. During this epoch there may be the potential for single landslide events. Again this will yield mainly fine, none beach building, material to the sediment budget (Futurecoast, 2002). Sediment transport direction and rates are likely

<table>
<tr><th rowspan="2">Location</th><th colspan="3">Predicted Change</th></tr>
<tr><th>Years 0-20 (2025)</th><th>Years 20-50 (2055)</th><th>Years 50-100 (2105)</th></tr>
<tr><td>Shoreline Movement</td><td>No change in shoreline position along the defended sections – coastal squeeze.

Along the undefended sections, by year 20, erosion is predicted to be around:

• 2-6m between White Ness and Captain Digby Inn;
• 1-2.5m between at Joss Bay;
• 1.5-3.5m between the crumbling defences and north Stone Bay; and,
• 3-7m between Dumpton Gap and the northern end of Winterstoke Undercliffe.</td><td>No change in shoreline position along the defended sections – coastal squeeze.

Along the undefended sections, by year 50, erosion from the current shoreline is predicted to be around:

• 4-15m between White Ness and Captain Digby Inn;
• 2-4.5m between at Joss Bay;
• 3-7m between the crumbling defences and north Stone Bay; and,
• 5-20m between Dumpton Gap and the northern end of Winterstoke Undercliffe.</td><td>No change in shoreline position along the defended sections – coastal squeeze.

Along the undefended sections, by year 100, erosion from the current shoreline is predicted to be around:

• 12-40m between White Ness and Captain Digby Inn;
• 3.5-12m between at Joss Bay;
• 5-12.5m between the crumbling defences and north Stone Bay; and,
• 15-50m between Dumpton Gap and the northern end of Winterstoke Undercliffe.</td></tr>
</table>

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Ramsgate Harbour	Substantial harbour arms, with a rock armoured breakwater (that protect the cliff toe). The chalk cliffs are sheathed with concrete to reduce sub-aerial weathering.		Upgrade the defence structures
	The present management practises at Ramsgate prevents erosion along this section of the coast and precludes alongshore sediment transport. The present management practises precludes the alongshore transport of sediment, due to the 'blocking-nature' of the harbour arms, as well as the presence of a foreshore along this frontage. The protection the defences afford, to the backing assets, will continue throughout this epoch.	The present management practises at Ramsgate will continue to prevent erosion. As such no change in shoreline position is expected during this epoch. Despite a predicted increase in sea level (6mm/year) the shoreline dynamics are predicted to remain similar to what they presently are i.e. north-east to south-west dominant hydrodynamics. Therefore the defence structures will continue to exacerbate alongshore transport and as such material will continue to be retained updrift of Ramsgate. With no foreshore cover and a predicted increase in sea level, the standard of protection the defences afford, could start to reduce thus to ensure the backing assets remain protected then defence management planning and approval will need to take place during the latter half of this epoch.	During this epoch the defences will need to be upgraded to maintain the same standard of protection. Although with an accelerated rise in sea level predicted (6mm/yr) the need for the present defences to be built bigger is inevitable. Alongshore transport will continue to be restricted along this frontage, with sediment continuing to be held updrift of the harbour arms. By the close of this epoch it is envisaged that the shoreline position of the harbour will stand 'proud' when compared to the adjacent, undefended sections of the coast. Should this be the case then it is possible that 1) the alongshore movement of material (albeit a small amount) will be exacerbated further and 2) there may be an outflanking issue beyond the lifetime of the SMP (+100 years).
Shoreline Movement	No change in shoreline predicted – but coastal squeeze of the inter-tidal area.	No change in shoreline predicted – but coastal squeeze of the inter-tidal area.	No change in shoreline predicted – but coastal squeeze of the inter-tidal area.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
West Cliff (Western Harbour Arm to Cliffs	A seawall founded on a chalk platform (western undercliff defences), fronted by timber groynes.	Upgrade the groynes and recharge the beach in the east.	Upgrade the defence structures, recharge the beach in the east.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
End)	The chalk cliffs along this section of the coast appear to have slightly different bedding, to that in the north and have been anthropogenically modified (re-profiled). Defences front the eastern half of the cliffs along this section of the coast and in these areas it is envisaged that the cliffs will continue to experience only sub-aerial weathering during this epoch. The undefended cliffs between West Cliff and Pegwell Bay will continue to erode. By year 20, erosion is predicted to be in the region of 2-5m between the western end of Western Undercliffe and Pegwell ; 2-7m between Pegwell village and Cliffsend Tunnel where rapid erosion of the numerous faults and joints have produced large caves; and, <1m between Cliffsend Tunnel and the Old Hoverport, where erosion is very slow due to the vegetation growth on the Tertiary deposits (D'Olier, 2007). Groynes perched on the chalk platform, at the eastern end of this frontage, will continue to retain the small sandy beach, immediately updrift of Ramsgate Harbour. However, in the lee of these groynes the foreshore cover thins, in a westwards direction, to the point of there being no beach fronting the Pegwell settlement chalk cliffs. It is therefore envisaged that the general form and processes operating today will be sustained throughout this epoch	During the early stages of this epoch the timber groynes will need to be upgraded, to continue to retain beaches and provide the same standard of protection. However, with a rise in sea level (6mm/year) predicted, more substantial groynes may be required. Between a rising sea level and the continued presence of defence structures/beach management, squeeze of the foreshore and / or platform lowering is predicted. Despite the continued presence of groynes it is envisaged that some material will still be transported westwards, towards Pegwell Bay. Thus to retain an amenity beach along the eastern part of this frontage, recharged material may need to be added. D'Olier (2007) predicts that the undefended cliffs, in the western half of this frontage, will erode at an approximate rate of 4-10m from the current shoreline between the western end of Western Undercliffe and Pegwell; 5-15m between Pegwell village and Cliffsend Tunnel and 1-3m between Cliffsend Tunnel and the Old Hoverport by year 50. The small amount of material this provides to the foreshore will not be suitable / substantial enough to build protective beaches. Most erosion is therefore predicted to occur where the cliffs are characterised by numerous well defined faults and joints and where the shoreline is most exposed to strong easterly to south-westerly storm waves, i.e. between Pegwell village and Cliffsend Tunnel. The small amount of	During this epoch a continuation of the previous epoch is anticipated. Thus, defences will need further upgrading / maintaining, the amenity beach in the east will come under increased pressure, due to coastal squeeze and alongshore sediment transport and therefore will required additional recharge. Along the undefended cliff sections erosion is predicted to be in the region of 7-18m from the current shoreline between the western end of Western Undercliffe and Pegwell; 12.5-35m between Pegwell village and Cliffsend Tunnel and 2-6m between Cliffsend Tunnel and the Old Hoverport (D'Olier, 2007) by year 100.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	No change predicted along the defended sections. Along the undefended sections, by year 20, erosion is predicted to be in the order of: • 2-5m between the western end of Western Undercliffe and Pegwell; • 2-7m between Pegwell village and Cliffsend Tunnel; and, • <1m between Cliffend Tunnel and the Old Hoverport.	No change predicted along the defended sections. Along the undefended sections, by year 50, erosion from the current shoreline is predicted to be in the order of: • 4-10m between the western end of Western Undercliffe and Pegwell; • 5-15m between Pegwell village and Cliffsend Tunnel; and, • 1-3m between Cliffend Tunnel and the Old Hoverport.	No change predicted along the defended sections. Along the undefended section, by year 100, erosion from the current shoreline is predicted to be in the order of: • 7-18m between the western end of Western Undercliffe and Pegwell; • 12.5-35m between Pegwell village and Cliffsend Tunnel; and, • 2-6m between Cliffend Tunnel and the Old Hoverport.

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
Pegwell Bay (Cliffs End to Sandwich Bay Estate)	A revetted embankment protects the nature reserve; the remainder is fronted by the extensive sand dunes.	Upgrade all the defences and construct secondary flood embankments.	Upgrade and maintain the defences

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Extensive tidal mudflats in the north of Pegwell Bay, give way to saltmarsh, tidal mudflats and the mouth of the River Stour in the centre of the Bay. South of the River Stour the wide sandy foreshore is backed by an extensive (relict) dune system. Further south a veneer of shingle covering the upper beach becomes more pronounced until eventually it becomes a relatively substantial shingle beach at Sandwich Bay Estate. It is predicted that the low-lying relict dune ridge system, will continue to experience 'ponding' in places, due to a lack of contemporary material supply. Further inland (i.e. landwards of the toll road) the relict sand dunes increase in height and are regarded as stable (which may be related to their age, being vegetated or being previously managed), either way it is envisaged that little change will take place to the relict dunes during this epoch. Sediment movement for this unit is complicated and in parts poorly understood. It is known that sediment converges at Pegwell Bay; predominantly fine sediment (sand and silt) which enters the system from the east (cliff recession), south (alongshore transport), the River Stour and from the offshore sand bank of Goodwin Sands.	The revetment that protects the nature reserve and the backing hinterland from flooding will need to be upgraded substantially to provide a suitable standard of protection to this frontage. Further The predicted rise in sea level (6mm/yr) could necessitate the construction of primary and/or secondary defences along a greater proportion of this frontage – this will reduce the risk of flooding. Where defences are constructed / upgraded then thinning of the foreshore / inter-tidal area is predicted. It is predicted that very little material will enter the frontage from alongshore, this being a consequence of defences updrift being upgraded (and thus becoming more effective) and a general lack of contemporary sediment supply. It is foreseen that the predicted rise in sea level (6mm/yr) will induce an increase in hydrodynamic activity in Pegwell Bay, which presently enjoys a very sheltered location. A change in the degree of sheltering will affect the sediments ability to settle and thus accrete. Thus there is the potential for a reduction in the rate of accretion within the bay.	During this epoch a continuation of the previous one is predicted. With alongshore material being arrested by Ramsgate Harbour and defences along the Sandwich and Deal frontage, pressure on the bay will increase. As such it is not clear whether the accretion trend at Pegwell Bay, will continue. Furthermore the situation has the potential to be exacerbated by the predicted rise in sea level (6mm/year), thus by the close of this epoch it is postulated that Pegwell Bay may no longer be experiencing accretion. Should erosion within the bay take place then 1) the foreshore will narrow and 2) there is a high possibility that the fine material will be transported offshore. During this epoch defences already established and any additional defences constructed could require further maintenance / upgrading.
	It is also known that the higher ground at Cliffs End restricts the northwards transgression of coarse material and that the ebb velocities of the River Stour influence the progradation / accretion of fine material. In light of the aforementioned		

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	Accretion (within the bay) but erosion of the shingle / sand topped ridge.	No change in shoreline due to defence construction. Coastal squeeze of the inter-tidal area.	No change in shoreline due to defence construction. Coastal squeeze of the inter-tidal area.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Sandwich Bay Estate to Sandown Castle (remains of)	An un-revetted embankment constructed of colliery shale between Sandwich Bay Estate and Sandown Castle (remains of). Embankment at Sandwich Bay Estate is revetted with concrete armour units. The shingle beach provides essential protection to the embankment along this section.	Implement alternative management/defence strategies	Maintain / upgrade defences

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	This relatively short section of coast is characterised by a shingle beach ridge and a mixed sand and gravel foreshore. The low-lying backing hinterland is presently protected from flood inundation by a shale and earth embankment, which is particularly vulnerable in the south and will need to be upgraded relatively early during this epoch. The north the embankment is not as vulnerable but will need upgrading before the close of this epoch nonetheless. With defences being held, the beach fronting this section will narrow; despite the predominant drift direction being north, due to the presence of defences updrift. (It is acknowledged that occasionally, under north-easterly conditions, sediment movement has the potential to reverse.) Erosion of the beach and shingle ridge will increase pressure on the backing defences. Thus to 'hold the line' here the following beach management options ought to be implemented for the following epochs: beach recharge and constructing alternative (more substantial) defences.	As already alluded to alternative management strategies will be required to 'hold the line' during this epoch. The volume of ridge/beach material is too small to provide a suitable standard of protection and will therefore benefit from recharge. As there is no higher ground for the shingle ridge to roll-back on, its integrity, in the long term, will be at question. In response to this, constructing a hard / linear defence is the most feasible option, to reduce the risk of the backing hinterland from flooding. As time progresses and with the predicted increase in sea level rise (6mm/yr) the probability of the recharged beach/ridge 'thinning' is high. Thus regular monitoring of the beach is recommended as well as additional beach recharge.	With material continuing to be 'held' downdrift, by the defences (at Deal and Walmer) and sea level continuing to rise, the integrity of the beach / ridge, along this frontage, will come under increased attack. If hard defences were constructed in the previous epoch then the risk of flooding, to the backing hinterland, is reduced. However, thinning of the foreshore is not, resulting in squeeze of the inter-tidal area. It is assumed that the predominant drift direction will continue to be north and as such groynes may need to be constructed during this epoch to help 'trap' the beach material along this section of the coast. If defences are constructed then there will be an impact on downdrift frontages (Pegwell Bay).

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	Thinning of the foreshore predicted (prior to beach recharge)	No change in the shorelines position (due to defences being upgraded) but coastal squeeze of the inter-tidal area.	No change in the shorelines position (due to defences being upgraded) but coastal squeeze of the inter-tidal area.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Sandown Castle (remains of) to Oldstairs Bay	There is a seawall between Sandown Castle (remains of) and Deal Castle, with a short length of groynes at the northern end. Between Deal and Kingsdown there is a wide open shingle beach. At Kingsdown there is a seawall and timber groynes. Between Kingsdown and just north of Oldstairs Bay the beach is open and unmanaged with a short length of timber breastwork at the rear of the beach. At Oldstairs Bay there is a revetment and groynes.	Upgrade all the defence structures, increase beach recharge.	Upgrade all the defence structures, increase beach recharge.

Location	Predicted Change		
	Years 0-20 (2025)	**Years 20-50 (2055)**	**Years 50-100 (2105)**
	Mixed gravel and sand beaches in the north give way to gravely beaches, with a small amount of sand on the lower foreshore, in the south (Kingsdown and Oldstairs Bay). Between Sandown Castle (remains of) and Walmer Castle the hinterland is generally low-lying, composed of storm gravel beach deposits, which rests on top of Head brickearth (from the Pleistocene), which overlies Upper Cretaceous Chalk. Between Walmer Castle and Oldstairs Bay the hinterland rises. The storm gravel beach deposits rests on the Upper Cretaceous Chalk in the north but this gives way to a relict chalk cliff line at Kingsdown that finally joins the shore at Oldstairs Bay. Under a scenario of with present management beach recharge at Kingsdown (in the south) will continue. Previously 36,000m3 was imported (1998), 5 years later a further 90,000m3 was imported and thereafter annual beach recycling (10,00m3/year) has taken place. During this epoch it is foreseen that annual recharge will continue although it is acknowledged that the volume is likely to increase, to maintain a form similar to the present day beach profile. Along the remainder of frontage, the foreshore is also likely to erode a little, due to the alongshore transport of material (northwards) - although localised drift reversals could occur.	An increase in the volume of beach recharge at Kingsdown will be required during this epoch. Similarly the all the other defences dotted along this section of the coast will need to be upgraded. As such the fronting gravel beach (at Walmer and Deal) will narrow slightly, in response to 1) the predicted rise in sea level (6mm/yr) and 2) material continuing to be transported north. As consequence of the defence structures being upgraded and the plan form of the shoreline being fixed, it is predicted that there will be squeeze of the inter-tidal area. The foreshore fronting Oldstairs Bay is particularly vulnerable, due to a lack of foreshore cover and a history of volatility. It is envisaged that the beach here will need to be either substantially recharged or substantially defended.	In response to the predicted rise in sea level (6mm/yr) the following is envisaged: • Continued / accelerated squeeze of the foreshore – which is likely to result in the reduction of beach amenities / activities. • Continued / accelerated squeeze of the strandline vegetation. • The drawdown of beach material – this may become more frequent due to higher water levels propagating closer to the shore. • Overtopping events will start to become more frequent. Overwashing and ponding of water on the backing infrastructure/amenities, is to be expected. • Further maintenance / upgrading of the defence works will be required. • The impact on alongshore coastal processes is predicted to be substantial, due to defences restricting the movement of sediment northwards.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	Between Sandown Castle (remains of) and Walmer Castle no change in the shoreline position is predicted, although there will be squeeze of the foreshore and flooding via percolation remains a risk between Deal Castle and Walmer Castle. Between Walmer Castle and Kingsdown (north) slight erosion is predicted, whilst at Kingsdown no change in the shoreline is predicted although there may be some coastal squeeze. Between Kingsdown and Oldstairs Bay average erosion rates are predicted to be in the region of <0.1m/yr (Futurecoast, 2002). Erosion by year 20 = <2m. Periodic localised landslide events may also occur in this location, with a frequency of around <10m in 10 years (Futurecoast, 2002).	Between Sandown Castle (remains of) and Deal Castle new defences will reduce the flood risk potential. Between Deal Castle and Walmer Castle no change in the shoreline is predicted. Between Walmer Castle and Kingsdown (north) some erosion is predicted whilst at Kingsdown there will be no change in shoreline (due to the defences) but squeeze of the inter-tidal area. Further erosion between Kingsdown (south) and Oldstairs Bay: average erosion rate is predicted to be in the region of <0.1m/yr (Futurecoast, 2002). Erosion by year 50 = <5m from the current shoreline (i.e. 50 years of erosion). Periodic localised landslide events may also occur in this location, with a frequency of around <10m in 10 years (Futurecoast, 2002).	Coastal squeeze of the foreshore / inter-tidal area is predicted. Further erosion between Kingsdown (south) and Oldstairs Bay predicted: average erosion rate is predicted to be in the region of <0.1m/yr (Futurecoast, 2002). This may accelerate further as sea levels rise. Erosion by year 100 = <10m from the current shoreline (i.e. 100 years of erosion). Periodic localised landslide events may also occur in this location, with a frequency of around <10m in 10 years (Futurecoast, 2002).

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Oldstairs Bay to South Foreland	Largely undefended although there is a relatively new rock revetment (25-50 years). A seawall protects the MoD firing range frontage, and seawall and groynes protect St Margaret's Bay	Upgrade the defences	Upgrade the defences

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
	Chalk cliffs, punctuated by St Margaret's Bay dominate this section of the coast. It is predicted that along the undefended sections the chalk cliffs will continue to erode at a relatively low rate 0.1 to 0.5m/yr. However, where there are defences i.e. at the MoD Rifle Range and at St Margaret's Bay, erosion will continue to be restricted. The groynes at St Margaret's Bay will continue to hold the mixed sand and shingle beach in place. Thus no significant change is envisaged during this epoch. Sediment movement into the area is low to negligible due to the increasing rockbed level and hard defences updrift (i.e. Dover Harbour).	During this period a continuation of the earlier epoch is anticipated where there are no defences and increased pressure where there are. The general trend of 0.1-0.5m/yr erosion (Futurecoast, 2002) will prevail along the undefended sections of the coast. Along the defended sections of the coast i.e. the MoD firing range and St Margaret's Bay the defences will need to be upgraded in order to continue to provide a similar standard of protection. It is acknowledged that the toe defences prevent predominantly fine material, from the cliffs, entering the system. This material is not regarded at beach-building but it is also acknowledged that the defences arrest geological interests. Along this section of the coast there is the potential for landslide events to become more frequent in response to a predicted rise in sea level. During a landslide event normally metres of land are lost however as the material is predominantly fine it is regarded as unsuitable for building beaches.	During this epoch it is envisaged that the MoD firing range and St Margaret's Bay will become less sheltered. This is due to the adjacent cliffs being undefended and therefore eroding whilst cliff erosion is being arrested at the MoD firing range and St Margaret's Bay. As time progresses the MoD promontory will become more pronounced. As a consequence it is envisaged that wave attack at these defended locations will increase and thus additional pressure will be exerted on the defences. This increase in exposure will also be exacerbated by a predicted increase in accelerated sea level rise (6mm/year). Where the chalk cliffs aren't defended then they will continue to erode on a regular basis; which could vary from 0.1 to 0.5 m / year (Futurecoast, 2002). There is also the possibility of landsliding events taking place during this epoch, along these undefended sections.

Location	Predicted Change		
	Years 0-20 (2025)	Years 20-50 (2055)	Years 50-100 (2105)
Shoreline Movement	No change in shoreline position predicted along the defended sections – although some coastal squeeze is predicted. Average erosion rate along undefended sections is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). Erosion by year 20 = 2-10m (mean 6m). Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10 years (Futurecoast, 2002). Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10-100 years (Futurecoast, 2002).	No change in shoreline position predicted along the defended sections (coastal squeeze predicted). Along the undefended cliff sections, average erosion rate is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). Erosion by year 50 = 5-25m (mean 15m) from the current shoreline (i.e. 50 years of erosion). Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10 years (Futurecoast, 2002.) Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10-100 years (Futurecoast, 2002).	No change in shoreline position predicted along the defended sections. Along the undefended cliff sections, average erosion rate is predicted to be in the region of 0.1-0.5m/yr (Futurecoast, 2002). This may accelerate further as sea levels rise. Erosion by year 100 = 10-50m from the current shoreline (i.e. 100 years of erosion). Periodic localised landslide events may also occur north of St Margaret's Bay, with a frequency of around <10m in 10-100 years (Futurecoast, 2002.) Periodic localised landslide events may also occur south of St Margaret's Bay, with a frequency of around <1m in 10 years (Futurecoast, 2002).

C.7 WPM Data Interpretation

C.7.1 Introduction

A number of data sets were used in the predictions of future shoreline response and evolution under the scenario of with present management, these included:

- Futurecoast historical shoreline change data (reported in the assessment of shoreline dynamics report (Section C1)).

- Futurecoast predictions of future shoreline change under a ‘constrained’ scenario: this assumed that the current defence structures remained in place and other coastal defence management interventions continued.

- Prediction of future shoreline response under a ‘Hold the Line’ scenario from first SMP and strategy studies.

- Thanet erosion rates from the Isle of Thanet Erosion Rate Study (D’Olier, 2007) commissioned by Thanet District Council.

- Coastal defence data.

C7.2 Data Assessments (WPM)

Frontage	***0-20yrs***	***20-50yrs***	***50-100yrs***
Allhallows-on-Sea to Grain	**Defended:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended:** Average erosion rate 0.5-1.0m/yr. Total erosion: 10-20m predicted by year 20.	**Defended:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended:** Average erosion rate 0.5-1.0m/yr: 25-50m (mean 37.5m) from the current shoreline by year 50 (i.e. 50 years of erosion).	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended Section:** Average erosion rate 0.5-1.0m/yr: 50-100m (mean 75m) from the current shoreline by year 100 (i.e. 100 year of erosion).
Sheerness to Scrapsgate	**Defended:** No change in shoreline position due to the continue presence of defences. Coastal squeeze and narrowing of the shingle beach is anticipated.	**Defended:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.
Scrapsgate to Warden Point	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended Section:** Average erosion rate 0.5-1m/yr: 10-20m by year 20. Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended Section:** Average erosion rate 0.5-1m/yr: 25-50m (mean 37.5m) from the current shoreline by year 50 (i.e. 50 years of erosion). Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended Section:** Average erosion rate 0.5-1m/yr: 50-100m (mean 75m) from the current shoreline by year 100 (i.e. 100 years of erosion plus 10 landslide events). In addition, the position of the top of the landslide by year 100, assuming an average landslide width of 107m, could be in the region of between 157-207m (mean 182m) from the current shoreline by year 100. Periodic localised landslide events may also occur, with a frequency of around 10-50m in 10 years.

Frontage	*0-20yrs*	*20-50yrs*	*50-100yrs*
Warden Point to Shell Ness	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. Continued accretion predicted for Shell Ness. Potential roll back of the beach at The Bay.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. It is uncertain whether Shell Ness will continue to accrete.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. Shell Ness may experience erosion.
Faversham Creek to Seasalter (Blue Anchor Pub)	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.
Seasalter (Blue Anchor Pub) to Whitstable Harbour	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.
Whitstable Harbour to Long Rock	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze and denudation of the shingle beach and Long Rock anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze and denudation of the shingle beach and Long Rock anticipated.
Long Rock to Herne Bay Breakwater	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.

Frontage	*0-20yrs*	*20-50yrs*	*50-100yrs*
Herne Bay Breakwater to Reculver (east of Towers)	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended Section:** Erosion at Reculver Country Park. Average erosion rate 0.1-0.5m/yr: 2-10m (mean 6m) by year 20.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended Section:** Erosion at Reculver Country Park. Average erosion rate 0.1-0.5m/yr: 5-25m (mean 15m) from the current shoreline by year 50 (i.e. 50 years of erosion).	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended Section:** Erosion at Reculver Country Park. Average erosion rate 0.1-0.5m/yr: 10-50m (mean 30m) from the current shoreline by year 100 (i.e. 100 years of erosion).
Reculver to Plumpudding Island / Minnis Bay	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze and denudation of the shingle beach anticipated.	**Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze and denudation of the shingle beach anticipated.
Minnis Bay to Westgate-on-Sea	**Defended Sections:** Cliff toe erosion prevented. **Undefended section** (20yrs of erosion by year 20) (D'Olier, 2007): Epple Bay to Westgate Golf Course 1 – 2m of erosion (mean 1.5m) by year 20.	**Defended Sections:** Cliff toe erosion prevented **Undefended section** (50 yrs of erosion by year 50) (D'Olier, 2007): Epple Bay to Westgate Golf Course, erosion of between 1.5 – 7.5m from the current shoreline (mean 4.5m) by year 50.	**Defended Sections:** Cliff toe erosion prevented **Undefended section** (100yrs of erosion by year 100) (D'Olier, 2007): Epple Bay to Westgate Golf Course 5 – 15m of erosion from the current shoreline (mean 10m) by year 100.
Margate (Westgate-on-Sea to Fulsam Rock)	**Defended Sections:** Cliff toe erosion prevented	**Defended Sections:** Cliff toe erosion prevented	**Defended Sections:** Cliff toe erosion prevented

Frontage	*0-20yrs*	*20-50yrs*	*50-100yrs*
Cliftonville (Fulsam Rock to White Ness)	**Defended Sections:** Cliff toe erosion prevented **Undefended sections** (20yrs of erosion by year 20) (D'Olier, 2007): Palm Bay and Botany Bay 1 – 2m of erosion (mean 1.5m) by yr 20. Botany Bay to White Ness 2-6m of erosion (mean 4m) by yr 20.	**Defended sections:** Cliff toe erosion prevented **Undefended sections** (50 yrs of erosion by yr 50) (D'Olier, 2007): Palm Bay 1.5 –7.5m of erosion from the current shoreline (mean 4.5m) by yr 50. Botany Bay 1.5 – 4m of erosion from the current shoreline (mean 2.75m) by yr 50. Botany Bay to White Ness 4-15m of erosion from the current shoreline (mean 9.5m) by yr 50.	**Defended sections:** Cliff toe erosion prevented **Undefended section** (100yrs of erosion by year 100) (D'Olier, 2007): Palm Bay 5 – 15m of erosion from the current shoreline (mean 10m) by yr 100. Botany Bay 3 – 7m of erosion from the current shoreline (mean 5m) by yr 100. Botany Bay to White Ness 12-40m of erosion from the current shoreline (mean 26m) by yr 100.

Frontage	*0-20yrs*	*20-50yrs*	*50-100yrs*
White Ness to Ramsgate Harbour	**Defended sections:** Cliff toe erosion prevented **Undefended sections** (20yrs of erosion by yr 20) (D'Olier, 2007): White Ness to Captain Digby Inn 2 – 6m of erosion (mean 4m) by yr 20. Joss Bay 1 – 2.5m of erosion (mean 1.75m) by year 20. Crumbling defences to North Stone Bay 1.5 – 3.5m of erosion (mean 2.5m) by yr 20. Dumpton Gap to Northern end of Winterstoke Undercliffe 3 – 7m of erosion (mean 5m) by yr 20.	**Defended Sections:** Cliff toe erosion prevented **Undefended sections** (50 yrs of erosion by yr 50) (D'Olier, 2007): White Ness to Captain Digby Inn 4 – 15m of erosion (mean 9.5m) from the current shoreline by yr 50. Joss Bay 2 – 4.5m of erosion (mean 3.25m) from the current shoreline by yr 50. Crumbling defences to North Stone Bay 3 – 7m of erosion (mean 5m) from the current shoreline by yr 50. Dumpton Gap to Northern end of Winterstoke Undercliffe 5 - 20m of erosion (mean 12.5m) from the current shoreline by yr 50.	**Defended Sections:** Cliff toe erosion prevented **Undefended section** (100yrs of erosion by year 100) (D'Olier, 2007): White Ness to Captain Digby Inn 12 – 40m of erosion (mean 26m) from the current shoreline by yr 100. Joss Bay 3.5 – 12m of erosion (mean 7.75m) from the current shoreline by yr 100. Crumbling defences to North Stone Bay 5 – 12.5m of erosion (mean 8.75m) from the current shoreline by yr 100. Dumpton Gap to Northern end of Winterstoke Undercliffe 15 - 50m of erosion (mean 32.5m) from the current shoreline by yr 100.
Ramsgate Harbour	No change in the plan form position of the shoreline.	No change in the plan form position of the shoreline	No change in the plan form position of the shoreline.

Frontage	*0-20yrs*	*20-50yrs*	*50-100yrs*
West Cliff (Ramsgate western harbour arm) to Cliffs End	**Defended sections**: Cliff toe erosion prevented **Undefended sections** (20yrs of erosion by yr 20) (D'Olier, 2007): The western end of Western Undercliffe to Pegwell 2 -5m of erosion (mean 3.5m) by yr 20. Pegwell village to Cliffsend Tunnel 2 – 7m of erosion (mean 4.5m) by yr 20. Cliffsend Tunnel to Old Hoverport <1m of erosion by yr 20.	**Defended Sections**: Cliff toe erosion prevented **Undefended sections** (50 yrs of erosion by yr 50) (D'Olier, 2007): The western end of Western Undercliffe to Pegwell 4 -10m of erosion from the current shoreline (mean 7m) by yr 50. Pegwell village to Cliffsend Tunnel 5 – 15m of erosion from the current shoreline (mean 10m) by yr 50. Cliffsend Tunnel to Old Hoverport 1 - 3m of erosion from the current shoreline (mean 2m) by yr 50.	**Defended Sections**: Cliff toe erosion prevented **Undefended section** (100yrs of erosion by year 100) (D'Olier, 2007): The western end of Western Undercliffe to Pegwell 7 -18m of erosion from the current shoreline (mean 12.5m) by yr 100. Pegwell village to Cliffsend Tunnel 12.5 – 35m of erosion from the current shoreline (mean 23.75m) by yr 100. Cliffsend Tunnel to Old Hoverport 2 - 6m of erosion from the current shoreline (mean 4m) by yr 100.
Pegwell Bay (Cliffs End to Sandwich Bay Estate	**Undefended Sections:** Erosion of the sand/shingle ridge (0.25-1.0m / year) **Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Undefended Sections:** It is uncertain whether the dunes would continue to accrete during this epoch. **Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.	**Undefended Sections:** Erosion of the dunes / flats and potentially some flooding predicted **Defended Sections:** No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated.
Sandwich Bay Estate to Sandown Castle	No shoreline defences (but secondary defences): Erosion of the shingle ridge predicted (0.25-1.0m / year) i.e. a total of 10-20m by 2025.	No shoreline defences (but secondary defences): Erosion of the shingle ridge predicted (0.25-1.0m / year)	No shoreline defences (but secondary defences): Erosion of the shingle ridge predicted, potential for breaching.

Frontage	*0-20yrs*	*20-50yrs*	*50-100yrs*
Sandown Castle to Oldstairs Bay	**Defended Sections:** Between Sandown Castle (remains of) and Walmer Castle: No change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. Between Walmer Castle and Kingsdown (north) the plan form is held. At the southern end the shingle beach will experience some erosion: approximately 0.5m/yr or a total of 10m by 2025. At Kingsdown: no change in shoreline position due to the continue presence of defences. Coastal squeeze anticipated. **Undefended:** Between Kingsdown and Oldstairs Bay. Average erosion rate <0.1m/yr: <2m by year 20. Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.	**Defended Sections:** no change in shoreline position due to the continue presence of defences. Coastal squeeze and beach denudation is anticipated. **Undefended:** Between Kingsdown and Oldstairs Bay. Average erosion rate <0.1m/yr: <5m from the current shoreline by year 50. Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.	**Defended Sections:** no change in shoreline position due to the continue presence of defences. Coastal squeeze and beach denudation is anticipated. **Undefended:** Between Kingsdown and Oldstairs Bay. Average erosion rate <0.1m/yr: <10m by year 100. Periodic localised landslide events may also occur, with a frequency of around <10m in 10 years.
Oldstairs Bay to St. Margaret's	**Defended:** MoD rifle range will continue to fail (it is already in a state of disrepair as the range is no longer in use). **Undefended:** Average erosion rate 0.1-0.5m/yr: 2-10m (mean 6m) by year 20. Periodic localised landslide events may also occur in this location, with a frequency of <10m in 10 years.	**Defended:** MoD rifle range will continue to fail (it is already in a state of disrepair as the range is no longer in use). **Undefended:** Average erosion rate 0.1-0.5m/yr: 5-25m (mean 15m) from the current shoreline by year 50. Periodic localised landslide events may also occur in this location, with a frequency of <10m in 10 years.	**Defended:** MoD rifle range will continue to fail (it is already in a state of disrepair as the range is no longer in use). **Undefended:** Average erosion rate 0.1-0.5m/yr: 10-50m (mean 30) from the current shoreline by year 100. Periodic localised landslide events may also occur in this location, with a frequency of <10m in 10 years.

Frontage	***0-20yrs***	***20-50yrs***	***50-100yrs***
St Margaret's	**Defended sections:** no change in shoreline position due to the continue presence of defences. Coastal squeeze and beach denudation is anticipated.	**Defended Sections:** no change in shoreline position due to the continue presence of defences. Coastal squeeze and beach denudation is anticipated.	**Defended Sections:** no change in shoreline position due to the continue presence of defences. Coastal squeeze and beach denudation is anticipated.
South Foreland	**Undefended sections**: Average erosion rate 0.1-0.5m/yr**:** 2-10m (mean 6m) by year 20. Periodic localised landslide events may also occur in this location, with a frequency of <1m in 10-100 years.	**Undefended sections:** Average erosion rate 0.1-0.5m/yr**:** 5-25m (mean 15m) from the current shoreline by year 50. Periodic localised landslide events may also occur in this location, with a frequency of <1m in 10-100 years.	**Undefended sections**: Average erosion rate 0.1-0.5m/yr**:** 10-50m (mean 30) from the current shoreline by year 100. Periodic localised landslide events may also occur in this location, with a frequency of <1m in 10-100 years.

Annex C1 No Active Intervention and With Present Management Maps

Erosion Mapping Methodology

EROSION LINES

Erosion rates used in the following NAI and WPM maps have been sourced primarily from Futurecoast (Defra, 2002) and a new study commissioned by Thanet District Council on Thanet erosion rates (D'Olier, 2007).

In the following maps, erosion has been illustrated over the 100 year period using three 'mean' erosion lines (one for each epoch) i.e. mean erosion from the current shoreline at years 20, 50 and 100 (see Figure 1).

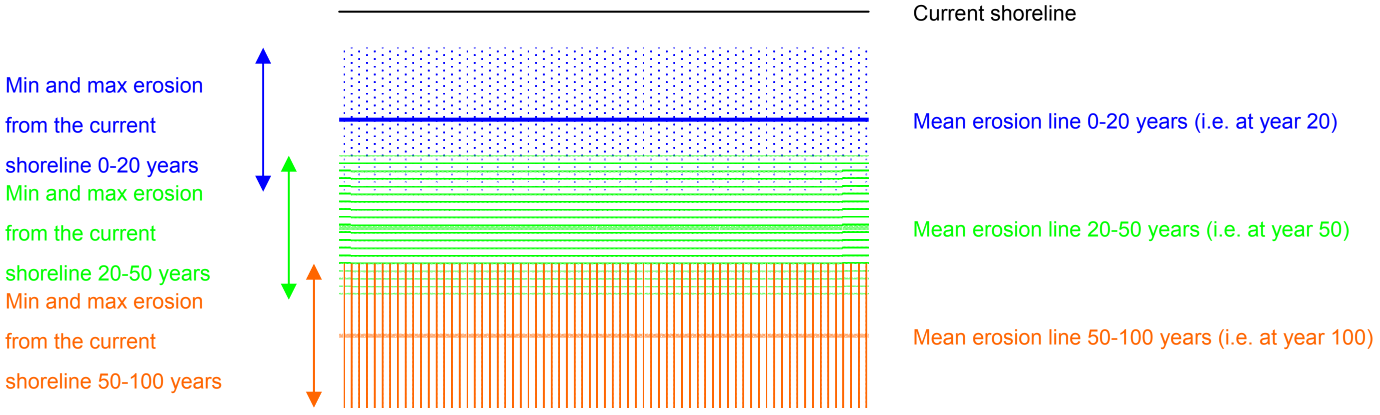

Figure 1: Illustration of mean erosion lines used in NAI and WPM mapping.

Tables C5.2 and C7.2 in the main Appendix C include calculations for each erosion area.

Erosion along the north of the Isle of Sheppey (between Minster Slopes to Warden Bay) is dominated by landslides, therefore, it was more representative to also show the position of the top of the landslide on the maps. An average landslide width was calculated using a selection of landslide widths from contemporary aerial photographs along the frontage. The average landslide width was calculated to be 107m. It was decided to only show the top of the landslide for epoch 3 (50-100 years) to avoid confusion and reduce the number of lines shown on the maps. This average landslide width was added to the minimum, maximum and consequently mean erosion values for epoch 3 (50-100 years) to represent the approximate position of the top of the landslide at year 100 (see Table C5.2).

Erosion lines and rates shown in the following maps, are the mean, minimum and maximum shoreline positions calculated from the current shoreline position at the close of each epoch (i.e. at year 20, year 50 and year 100).