Regional Beach Management Plan 2015:
Oldstairs Bay to Pegwell Bay

Report – ENVIMSE100035/R-01

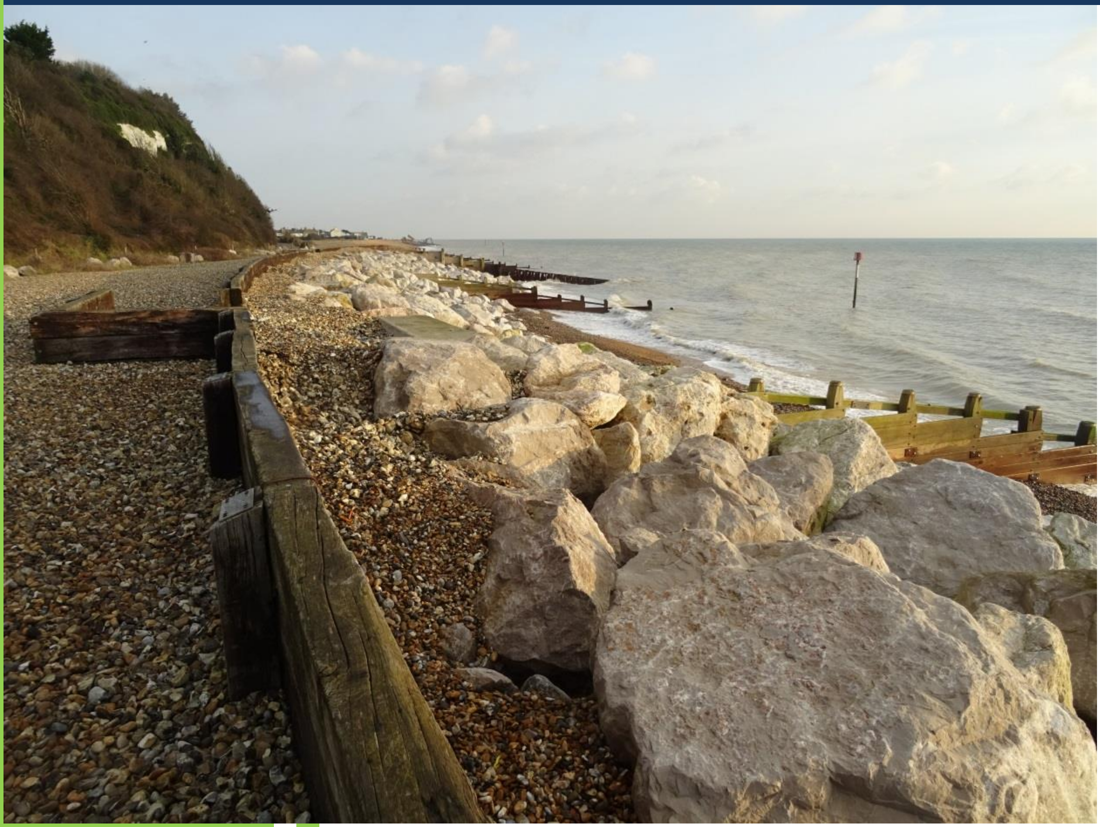
Final Report, February 2017

This series of regional Beach Management Plans for Southeast England are dedicated to the memory of Andy Bradbury.

The data that has been used to compile them is only available due to Andy's vision and drive for better coastal monitoring data to inform beach management.

East Kent ENGINEERING PARTNERSHIP

Regional Beach Management Plan 2015



Oldstairs Bay to Pegwell Bay

Main Report

Canterbury City Council

Engineering Services

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Canterbury

CT1 1YW

SOUTH EAST COASTAL GROUP

MANAGING THE SHORELINE

Environment Agency

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EXECUTIVE SUMMARY

This Beach Management Plan (BMP) has been prepared by **Canterbury City Council** on behalf of **Dover District Council and the Environment Agency**. The BMP sets out the implementation approaches for intervention and monitoring to maintain the beach where it provides an integral part of the sea defences between Oldstairs Bay and the River Stour at Sandwich Bay. The aim of the BMP is to inform, guide and assist these responsible authorities and organisations in managing the beach, and to ensure that the beach management continues to manage the risk of coastal flooding and erosion.

> *Beach Management Plans provide an accountable and transparent methodology for managing beaches as coastal defence assets based on risk information that derives from scheme design, monitoring and scientific/research input with the aim of managing the frontage in a sustainable way that enhances vegetated shingle habitats.*

To this effect the BMP contains the evidence base that has led to the management options. To achieve this aim of accountability and transparency, all source data, documents and methods are appended to this report in the Appendices and in digital form in the enclosed DVD.

The BMP proposes the following activities:

- Regular monitoring and annual recycling works at Wellington Parade
- Annual recycling from the Sandwich Bay estate to north Deal to mitigate losses in north Deal and to prevent shingle ingress into the sand dune habitat to the north of Sandwich
- Continued monitoring of beach levels via the Regional Coastal Monitoring Programme

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1 INTRODUCTION

1-1 PRESENT SITUATION

1-1-1 SMP AND OTHER STRATEGY POLICY

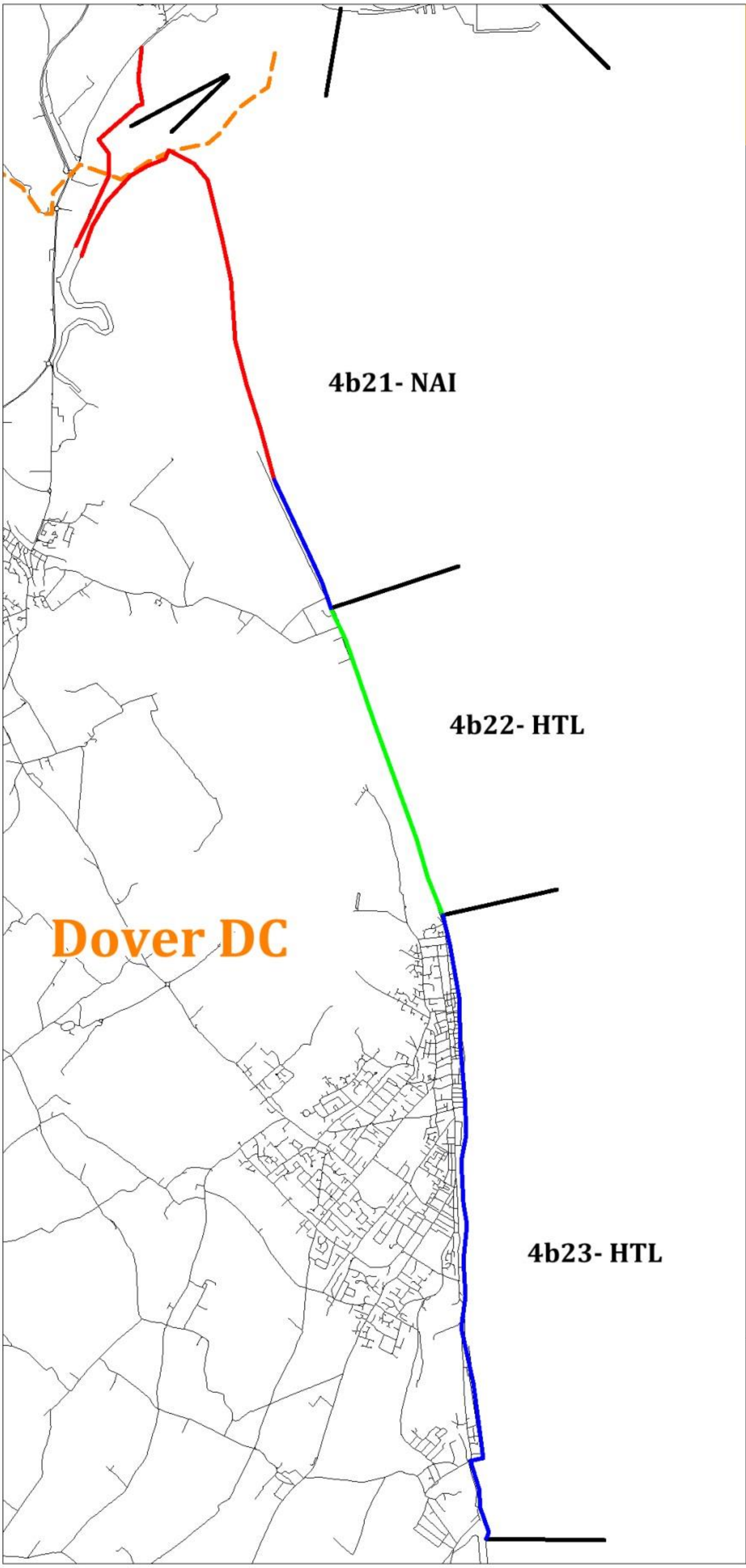
The coastline between Kingsdown and Pegwell Bay lies within the Isle of Grain to South Foreland Shoreline Management Plan (2010) and is inclusive of policy units 4b21 (South of the River Stour to Sandwich Bay Estate (North)) to 4b23 (Sandown Castle to Oldstairs Bay), Table 1-1. The frontage is managed under the responsibility of the organisations shown in Figures 1-1. Figures 1-2 and 1-3 show the Survey Units of the Regional Coastal Monitoring Programme (RCMP) of which this report is structured around.

TABLE 1-1 SMP POLICIES WITHIN BMP

Policy Unit	Description	Sediment Type	Short Term	Medium Term	Long Term
4b21	South of the River Stour to Sandwich Bay Estate North	Sand	NAI	NAI	NAI
4b22	Sandwich Bay Estate North to Sandown Castle	Shingle/Sand	HTL	HTL	HTL
4b23	Sandown Castle to Oldstairs Bay	Shingle	HTL	HTL	HTL

HTL – Hold the Line, NAI – No Active Intervention

FIGURE 1-1 LOCAL AUTHORITY AND SMP POLICY BOUNDARIES



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- Local Authority
- Privately Owned
- Environment Agency

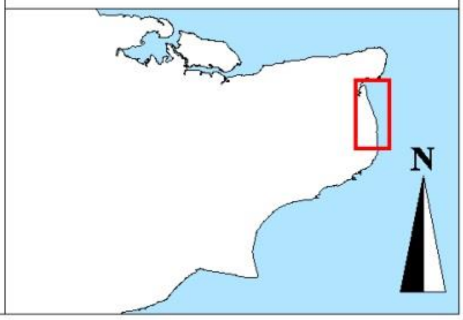

FIGURE 1-2 UNIT BOUNDARIES SANDWICH BAY

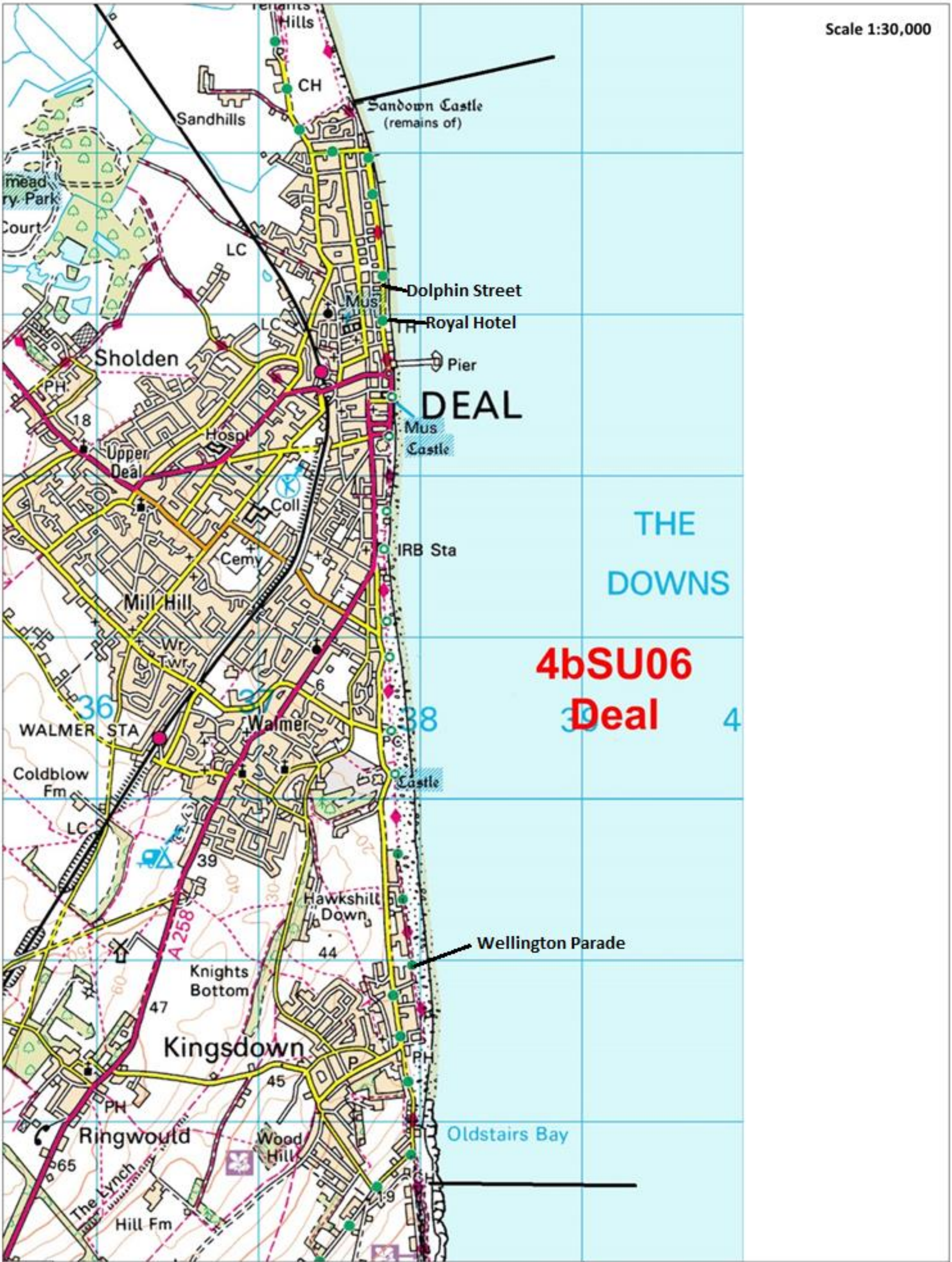

FIGURE 1-3 UNIT BOUNDARIES DEAL

1-1-2 PHYSICAL CHARACTERISTICS AND COASTAL DEFENCES

The study area is bounded to the north by the River Stour and Pegwell Bay inlet and to the south by the northern extent of the actively eroding cliffs of Dover which extend at the back of the beach as far north as Walmer. The dominant sediment transport runs south to north. Oldstairs Bay to Sandown Castle is characterised by coarse shingle which gradually mixes with finer material north of Deal Pier. Coarse sediment from the Deal Unit has been feeding into the Sandwich Unit causing a shingle sand composite beach between Sandown Castle and Princes Golf Course. North of Princes Golf Course the material becomes finer and vegetated sand dunes are dominant to the River Stour.

Refer to Appendix A - Site Photographs for place names and frontage overview.

OLDSTAIRS BAY

Oldstairs Bay is defended by a rock revetment with a crest height of +5.5mOD which was constructed in 2001 (Table 1-4). Recycling works have previously restored beach levels in Oldstairs Bay in 2008 and 2012. However since the chalk platform was exposed during storms in winter 2013, works have not been undertaken to replace this shingle as the rock revetment offers a sufficient Standard of Protection (SoP).

KINGSDOWN TO WALMER

Moving north, Kingsdown village is protected by a protruding seawall which is founded in the middle of the shingle beach with a crest height at +5.4mOD, with shingle in front and behind. In 2015 this wall was sheet piled to increased its stability and prevent undermining, the dilapidated groynes were removed and 16 timber groynes were constructed. Approximately 31,000m^3 of shingle was extracted from Walmer Castle, a known sediment store, and deposited within the new groyne bays in front of Kingsdown village.

From Wellington Parade at Kingsdown to 100m north of Deal Castle there are no hard defences. The majority of this shingle beach has a substantial crest width, over 100m in places, at a height of +5.8mOD which provide the town's mains protection (EA and DDC, 2007). Wellington Parade is a known scour zone as the beach transitions from heavily managed to unmanaged and requires regular maintenance to maintain a good standard of defence. In 2015 65,000m^3 of shingle was deposited in front of Wellington Parade, just north of the timber groyne field.

DEAL

The coastline between Deal Castle and The Royal Hotel, north of the Pier, has a course shingle beach and a seawall at +5.8mOD and in 2012 a rear wall was constructed between +6.3mOD and +6.6mOD. The shingle beach provides protection to properties in Deal and also protects the wall. North of The Royal Hotel towards Sandown Castle the seawall crest height ranges between +5.6mOD and +5.9mOD with a rear wall at +6.9mOD. Timber groynes control the shingle beach between the Dolphin Street and Sandown Castle.

SANDOWN CASTLE TO SANDWICH BAY ESTATE

Sandown Castle denotes the boundary between Sandwich and Deal and is encased in concrete and protected by rock armour. In 2012 a 190m rock revetment with a crest height of +6.8mOD was constructed directly north of Sandown Castle to provide north Deal with a 1:300 SoP and protects against the risk of breaching. The 190m revetment uses 6-10 tonne rock for the southern half whilst the northern half uses 3-6 tonne and is half the depth of the southern section (Halcrow, 2012). This was constructed as additional protection to the colliery shale embankment which is the main defence for much of the southern end of Sandwich. The residential area, Sandwich Bay estate, is located immediately behind a concrete based revetment and shingle beach (EA and DDC, 2007).

SANDWICH BAY

North of the Sandwich Bay estate there are no hard defences and the beach progresses from a shingle sand composite beach to a shallow sand beach backed by vegetated dunes of international conservation importance. There are no formal defences along this section of the coast as the dunes, attributed to the ‘Little Ice Age’ (1300-1850 A.D.), provide a suitable standard of flood protection (Halcrow, 2010). Shingle deposits overlay the sand beach along the northern half of this unit (EA and DDC, 2007). The area to the north of the Sandwich Bay estate is managed by Kent Wildlife Trust and Dover District Council (Figure 1-1).

The hinterland along the Sandwich coastline is low-lying and is the responsibility of the Environment Agency and Dover DC under the various Land Drainage acts and amended by the Flood and Water Management Act 2010.

1-1-3 GEOLOGY

TOPOGRAPHY

"Cretaceous Chalk dominates the geology of the area, forming significant cliff morphology to the south of the area. Structurally, the Chalk comprises part of an asymmetric syncline called the Richborough Trough, with the opposite limb emerging at Ramsgate. Active cliffs are the main landform features to the south leading up to Kingsdown. These are inactive due to the beach in front and reduce in height northward diminishing to sea level at Walmer Castle. At this point, the surface geology is composed of Pleistocene drift deposits forming low lying topography that is protected from marine flooding by the shingle beach. This remains the case through to and beyond Sandown Castle to the north of the study area" (Kirk McClure Morton, 2001).

The hinterland represents a continuation of the same geological structure (syncline) with the Chalk Downs occurring behind Kingsdown with low lying flood plain deposits present behind Deal.

FIGURE 1-4 GOODWIN SANDS, LOCATED 4-12KM OFFSHORE OF DEAL© CROWN COPYRIGHT AND DATABASE RIGHTS 2016 ORDNANCE SURVEY 100019614.

To the north east of Deal lies the Goodwin Sands (Figure 1-4). These are a series of natural shallow sandbanks that are created by tidal currents. They are often marked by breaking waves. Historical analysis of bathymetric charts suggests that these banks have been stable in morphological form for the past century and thus are likely to remain so for the lifetime of this

BMP. It is agreed that they afford some protection to Deal from wind and wave approach from Northeast and Southeast storm events. The Brake Sandbanks, Figure 1-4, that occur seaward of the Ramsgate Channel appear to play a role in wave attenuation along the Sandwich Bay Estate frontage to the north of this study area. Kirk McClure Morten (2001) undertook a historical assessment of this area and details are available from the Sandwich Bay Strategy Study. Their presence is unlikely to influence the shoreline evolution of the Deal to Kingsdown frontage and does not offer the level of protection to this coastline that it does further north. The Downs and the smaller Deal Bank offshore from the Deal Pier are smaller features that have a local impact on inshore wave diffraction at Deal (Atkins, 2001).

COASTAL EVOLUTION

"During the Holocene transgression sand and gravel deposited during the last glaciation on the floor of the English Channel and the Southern North Sea moved landward under the combined action of waves and sea level rise. The landward movement was accompanied by longshore movement in a north easterly direction just as it is now.

The 1st Edition Ordnance survey map shows a continuous fringing shingle beach at the toe of the cliffs from Folkestone all the way to Walmer. These beaches formed the transport corridor for the material that formed the Kingdown to Sandwich Spit but also captured the end of this transport with those beaches having disappeared in the 20th century. It is unknown when the cliffs north of Kingsdown were last actively eroded and south of Sandown Estate the spit is in places a narrow ridge the suffers from cannibalisation at the root of spit at Kingsdown and around deal due to the misalignment of the planshape to coastal processes and sediment supply. The drift deposits were formed during the last ice age by outflow in the current Stour estuary. At that time, sea level was estimated to be 120m lower than at present with a major river system occupying the modern English Channel. Retreat of the glaciers caused a rise in sea level, flooding the river systems and transporting most of the soft sediments onshore.

The provenance of materials composing the shingle beach is primarily derived from offshore bank stores and local geological outcrops (Cretaceous Chalk); consequently, flints and chert fragments predominate. Lithologically, the beaches do not greatly differ from shingle found at Folkestone Warren or Dungeness Foreland. The origin of the "spit" that the frontage comprises of is unknown. It is likely to represent the landward migration of a shingle that rolled onshore as a consequence of sea level rise during the Holocene period (5000 years ago).

The implications of this are now being felt today, as a combination of hard coastal engineering works and an exhaustion of natural sediment sources (created during glacial/postglacial periods) is having the effect of reducing the volumes of shingle being input into the coastal system, coupled with a net loss of shingle from the local sediment budget. In addition, the net movement of shingle deposits is significantly less through the "system" than for sand sized material. This has implications on the nature of beaches and their long term evolution" (Atkins, 2001).

Whilst the original provenance material was as stated above, the nature of the material is changing due to the beach recharge schemes which have introduced non-native material.

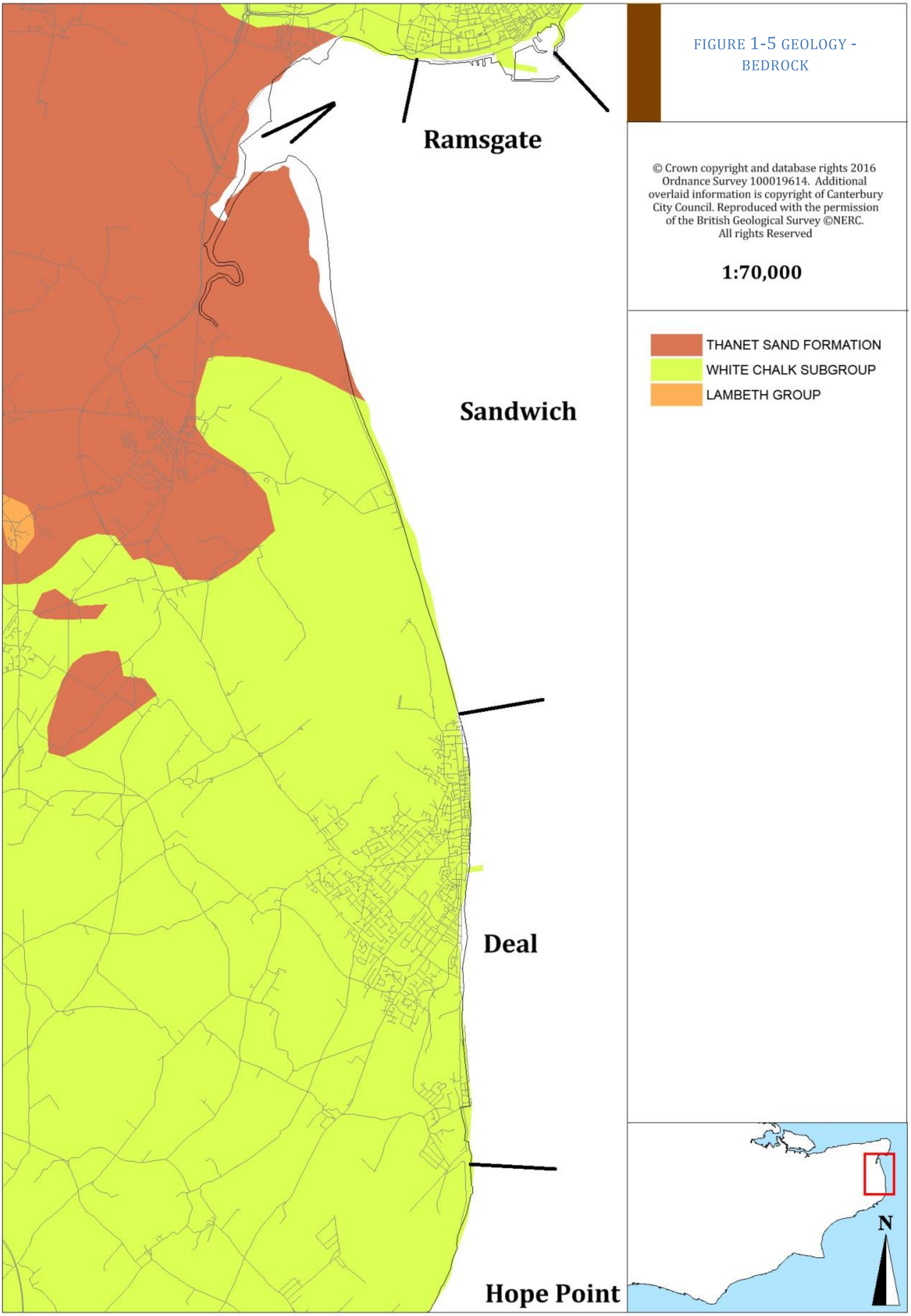

FIGURE 1-5 GEOLOGY - BEDROCK

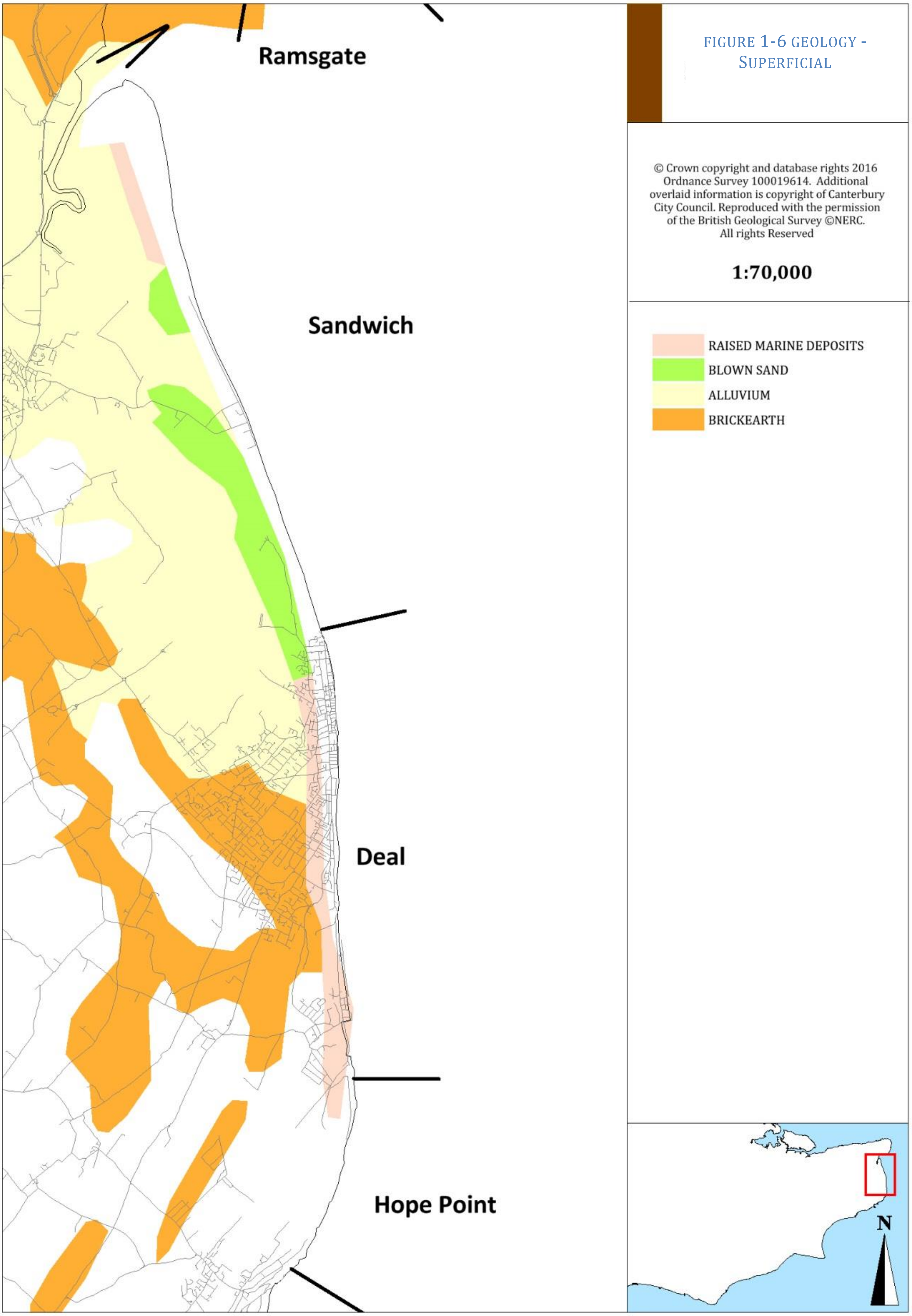

FIGURE 1-6 GEOLOGY - SUPERFICIAL

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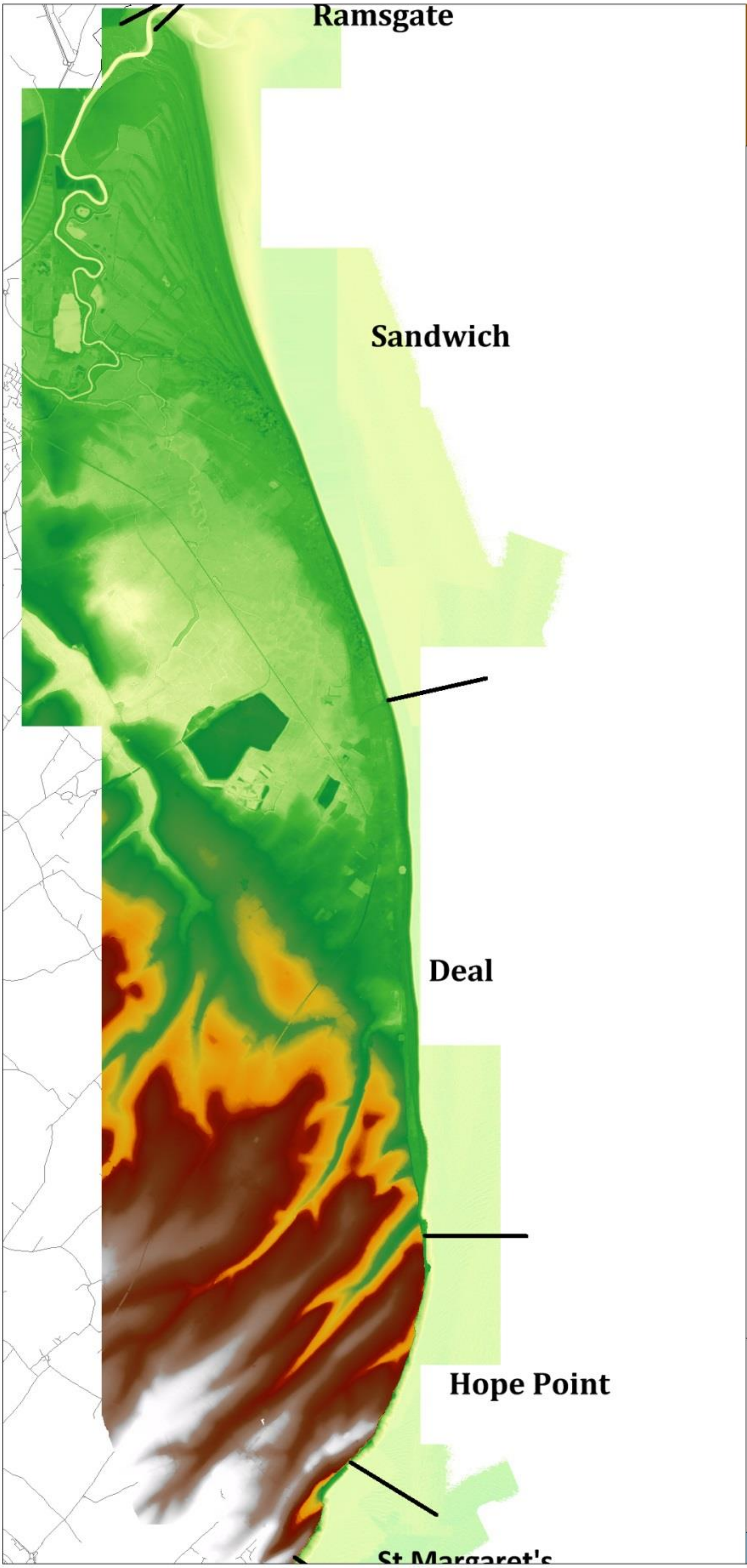
RAISED MARINE DEPOSITS
BLOWN SAND
ALLUVIUM
BRICKEARTH

FIGURE 1-7 LIDAR MAP



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Elevation (mOD)

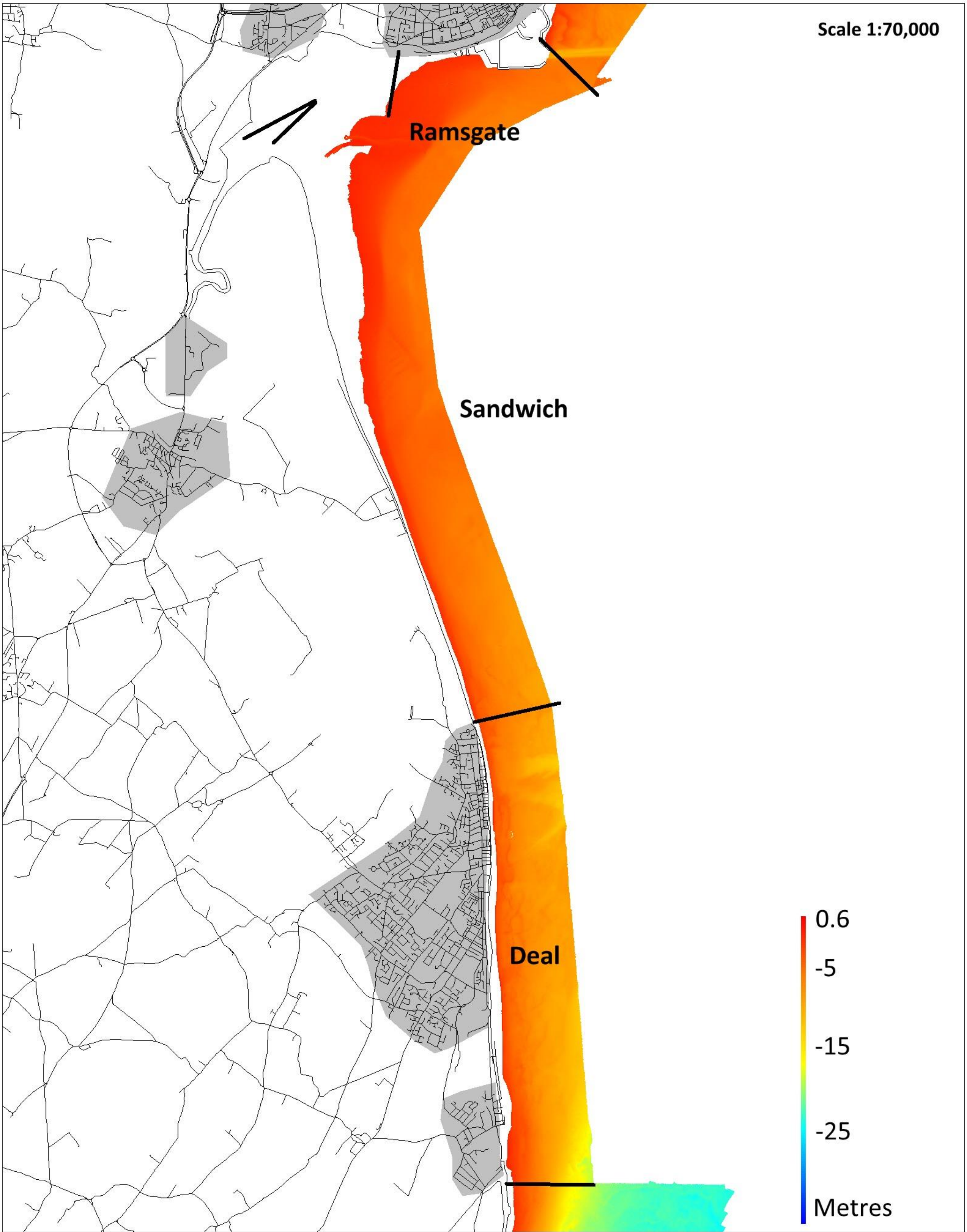

FIGURE 1-8 MULTIBEAM BATHYMETRY 2010

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1-2 HISTORY OF THE FRONTAGE

1-2-1 FLOODING INCIDENTS

Table 1-2 lists the flooding and storm events and Table 1-3 lists the erosion events between Oldstairs Bay and Sandwich Bay. As these reports are typically in the mainstream press they frequently lack detail on the total number of properties affected and extent of damage, however this is sufficient to provide a threshold to aid validation of overtopping calculations.

TABLE 1-2 COASTAL FLOODING AND STORM INCIDENTS

DATE	LOCATION	DESCRIPTION	REPAIR WORK	SOURCE
NOV 1897	EAST KENT	SEAWALL DAMAGED AND TOWNS INUNDATED BY A STORM SURGE		HTTP://WWW.MARGATELOCALHISTORY.CO.UK/PICTURES/PICTURES-STORMS.HTML
JAN 1953	SANDWICH AND DEAL	STORM SURGE INUNDATED LAND AND SETTLEMENTS >2M IN PLACES)	MULTIPLE COASTAL DEFENCE SCHEMES INCLUDING A 400M WALL IN DEAL TO REDUCE WAVE POWER	HTTPS://WWW.SURGEWATCH.ORG/EVENTS/10/
JAN 1978	DEAL	DEFENCES DAMAGED AND TOWN INUNDATED		HTTP://SASESEARCH.BRIGHTON.AC.UK/VIEW/?FROM=SEARCH&FROMID=&FILM=863
JAN 2010	DEAL	SECTION OF SEAWALL WASHED AWAY	EMERGENCY WORK TO REPAIR SEA WALL	HTTP://NEWS.BBC.CO.UK/1/HI/ENGLAND/KENT/8466549.STM

1-2-2 EROSION INCIDENTS

TABLE 1-3 EROSIVE EVENTS BETWEEN SANDWICH AND DEAL.

DATE	LOCATION	DESCRIPTION	REPAIR WORK	SOURCE
1949 PRESENT	OLDSTAIRS BAY	EROSION OF SHORELINE BY APPROXIMATELY 100M	CONTROL AND MAINTENANCE STRUCTURES IMPLEMENTED INCLUDING GROYNES, A SEAWALL AND BEACH RENOURISHMENT	HTTP://WWW.DOVER.GOV.UK/ENVIRONMENT/COAST--RIVERS/COAST-PROTECTION/COASTAL-EROSION.ASPX
JAN 1990	KINGSDOWN	LOSS OF UP TO 20,000M^3 OF BEACH MATERIAL		KINGSDOWN PAR (2015)
OCT 1996	KINGSDOWN	1M DROP IN HEIGHT OF BEACH AT SEAWALL	EMERGENCY WORK TO INCREASE PROTECTION AGAINST WAVE SCOUR	KINGSDOWN PAR (2015)
2003	KINGSDOWN	APPROX. 50M OF SEA WALL DAMAGED, SEA WALL UNDERMINED.	WALL REPAIRED, BEACH RECHARGE	KINGSDOWN PAR (2015)
DEC 2006	DEAL AND KINGSDOWN	LOSS OF ~11,000M^3 OF BEACH MATERIAL		KINGSDOWN PAR (2015)
2013/ 2014	OLDSTAIRS BAY, KINGSDOWN, WELLINGTON PARADE	12,000M3 BEACH MATERIAL LOST. COLLAPSED SEA WALL, BEACH LEVEL DROPPED BY 2.4M AT KINGSDOWN	BEACH, PROMENADE AND GROYNE WORKS	CCC REGIONAL MONITORING RECORDS

1-2-3 HISTORY OF COASTAL MANAGEMENT

DEAL TO SANDOWN CASTLE

This section has historically been the most actively managed in the study area. Construction of the defences at Deal started over 100 years ago. In the 1800's there were no promenades or sea walls but only the shingle bank on which brick houses, store houses etc. were built together with a number of wooden jetties. The town was the place of work for hundreds of boatmen who kept up the beach and dealt with denudations after storms. The defence history since 1872 is listed in Table 1-4.

SANDOWN CASTLE TO SANDWICH BAY

In 1984, a sea defence scheme was undertaken to strengthen and stabilise the existing shingle bank and beach. A Colliery Shale seawall was constructed to provide a partial replacement for the limited shingle supply, to control seepage within the beach and to provide a firm seawall crest and crest road foundation.

The scheme design consisted of rip rap being installed on the seaward edge upon the existing sand and shingle. This provided protection for shingle and sand to be retained upon the beach. Colliery shale was placed upon the backshore to provide a foundation for the toe drainage that ran through the profile (Hamilton, 1984).

The embankment runs approximately 7km from Sandown Castle to the River Stour estuary and provides low-lying land behind, which includes three links golf courses, arable and agricultural land and settlements such as Sandwich and Worth.

A rock revetment was constructed during the winter of 2012/13 in the far south of Sandwich Bay. The revetment was implemented to protect the shale embankment at the northern area of Deal as there was the possibility of water overtopping or breaching the embankment and flooding areas of Deal. The 190m length of rock revetment was constructed to provide a standard of protection of a 1 in 300 or 0.33% chance of a flood event occurring through breach in any one year.

	Sandwich Bay	Deal
1875		1872: Flood Bank created at Harold Road
		1889: Seawall and groynes constructed at Northern Deal
1900		1938-1957: Groynes constructed in northern Deal
		1958-1978: Further groynes added at Northern Deal
1950		1960: Seawall constructed at Deal. 22,000m^3 material imported to Deal
		1965-1979: 15 groynes constructed at Kingsdown
		1965: Lightweight concrete panel seawall at Kingsdown
		1974: 9,000m^3 material imported to Deal beach
		1978: Kingsdown seawall extended and splashwall added
	1984: Colliery Shale seawall and embankment constructed between Sandown Castle and the River Stour estuary	1984: Deal seawall reconstructed and splash wall added
		1988-89: Sandown castle encased in concrete seawall
		1995: 200m seawall south of Deal pier refaced
		1995: Buried timber crib wall at Kingsdown
		1995: 58,000m^3 shingle imported to Kingsdown beach
		1995-1998: Beach at Kingsdown renourished
		1997: Scour protection to southern seawall at Kingsdown
		1998: 80,000m^3 shingle imported to Kingsdown beach
		2001: Rock revetment and groynes at Oldstairs Bay
2000		2003-4: Seawall improvements at Kingsdown and 47,000m^3 shingle imported to Kingsdown beach
		2008-12: Strategic review which included the placement of shingle recharge between Sandown Castle and South Street., 3,900m^3 deposited at Oldstairs Bay.
		2012 - 20,000m^3 recycled from Walmer Castle to Oldstairs Bay and a further 3,000m^3 deposited at Kingsdown
	Winter 2012/13: Rock revetment north of Sandown Castle	2013: Splash wall constructed Stanley Road to King Street
		2013: 126,000m^3 sediment deposited between the Pier and Sandown Castle
		2014: Emergency Repairs to the Kingsdown seawall following a collapse by undermining. Sheet piling added to the majority of the wall. 12,000m^3 recycled from Walmer to Wellington Parade scour area.
		2015/16: 16no. New timber groynes to replace those at Kingsdown, 31,000m^3 deposited in groyne field, 65,000m^3 deposited in Wellington Parade
		2016: Beach recycling between the Pier and Sandown Castle to redistribute material

TABLE 1-4 COASTAL DEFENCE TIMELINE, 1872-2016

1-2-4 ENVIRONMENTAL OPPORTUNITIES AND CONSTRAINTS

The issues relating to the local environment are fully described in the Environmental Assessment in Appendix B of this report. This section provides a brief overview of the key issues within the area, affecting coastal management, for protected sites, agriculture, infrastructure, tourism and recreation, culture and archaeology.

ENVIRONMENTAL RESTRICTIONS

The study area contains several sites which have been designated for their wildlife and geological value as protected sites with varying international, national and local significance. To retain the natural integrity of these sites certain activities are restricted and it may be necessary to contact Natural England before proceeding with any works. Figure 1-8 gives an overview of the areas with environmental designations. More detailed mapping is available within Appendix B.

Statutory designations

Sites protected by law within the study area:

- Sandwich Bay SAC
- Thanet Coast and Sandwich Bay SPA
- Thanet Coast and Sandwich Bay Ramsar
- Sandwich Bay to Hacklinge Marsh SSSI
- Sandwich and Pegwell Bay NNR
- Dover To Kingsdown Cliffs SAC
- Dover To Kingsdown Cliffs SSSI
- Deal To Dover MCZ
- Goodwin Sands rMCZ
- Kingsdown And Walmer Beach Local Wildlife Site (LWS)
- Prince's Beachlands LNR

Natural England should be contacted for planning proposals that are likely to have a significant effect on a SSSI, MCZ, SAC, SPA or Ramsar site. For SAC or SPA sites a habitat regulations assessment may need to be carried out. Additionally, Natural England should also be consulted for planning proposals that require an Environmental Impact Assessment (Appendix B, Section 3).

The following activities within Table 1-5, which may affect coastal works, are prohibited within SSSI sites. For SSSI sites a letter of comfort must be obtained from Natural England via the Discretionary Advice Service to undertake certain activities. Depending on the type of works, this process can take several months so should be pursued within the early stages of the project.

TABLE 1-5 POTENTIAL RESTRICTIONS TO COASTAL WORKS

COASTAL WORKS IDENTIFIED BY NATURAL ENGLAND AS OPERATIONS WHICH MAY DAMAGE THE FEATURES OF INTEREST.
ERECTION AND REPAIR OF SEA DEFENCES OR COAST PROTECTION WORKS, INCLUDING CLIFF OR LANDSLIP DRAINAGE OR STABILISATION MEASURES
EXTRACTION OF MINERALS INCLUDING PEAT, SHINGLE, HARD ROCK, SAND AND GRAVEL, TOPSOIL, SUBSOIL, CHALK, SHELLS AND SPOIL.
DESTRUCTION, CONSTRUCTION, REMOVAL, REROUTING, OR RE GRADING OF ROADS, TRACKS, WALLS, FENCES, HARDSTANDS, BANKS, DITCHES OR OTHER EARTHWORKS, INCLUDING SOIL AND SOFT ROCK EXPOSURES OR THE LAYING, MAINTENANCE OR REMOVAL OF PIPELINES AND CABLES, ABOVE OR BELOW GROUND.
STORAGE OF MATERIALS.
ERECTION OF PERMANENT OR TEMPORARY STRUCTURES OR THE UNDERTAKING OF ENGINEERING WORKS, INCLUDING DRILLING.
MODIFICATION OF NATURAL OR MAN-MADE FEATURES
REMOVAL OF GEOLOGICAL SPECIMENS, INCLUDING ROCK SAMPLES, MINERALS AND FOSSILS.
USE OF VEHICLES OR CRAFT.
RECREATIONAL OR OTHER ACTIVITIES LIKELY TO DAMAGE OR DISTURB THE FEATURES OF SPECIAL INTEREST.

These restrictions do not apply for:

- emergency work, for example work to protect livestock during a flood or storm (Natural England must be notified as soon as possible afterwards)
- work with permission from the local council, attained through the planning application process
- work that has statutory permission for from a public body such as the Environment Agency or Forestry Commission (if they have consulted Natural England)

Additionally, all coastal works which extend below Mean High Water must receive a marine license which is provided by the Marine Management Organisation (MMO). If the project requires an Environmental Impact Assessment (EIA) the MMO must be consulted at the scoping stage; there are some exemptions, including beach recycling works, listed in Appendix H.

Non Statutory Designations

Sites with no legal protection in the study area:

- South Bank of the Swale LNR

- Bishopstone Cliffs LNR

It is important to consider those sites of local significance, i.e. LWS and LNR, by consulting with the land manager, e.g. Dover District Council or Kent Wildlife Trust.

ENVIRONMENTAL OPPORTUNITIES

Two Biodiversity Opportunity Areas (BOA) exist within the study area (Figure 1-9); attention should be focused in these areas in order to secure the maximum biodiversity benefits. The BOAs also show where the greatest gains can be made from habitat enhancement, restoration and recreation. More detail is given in Appendix B.

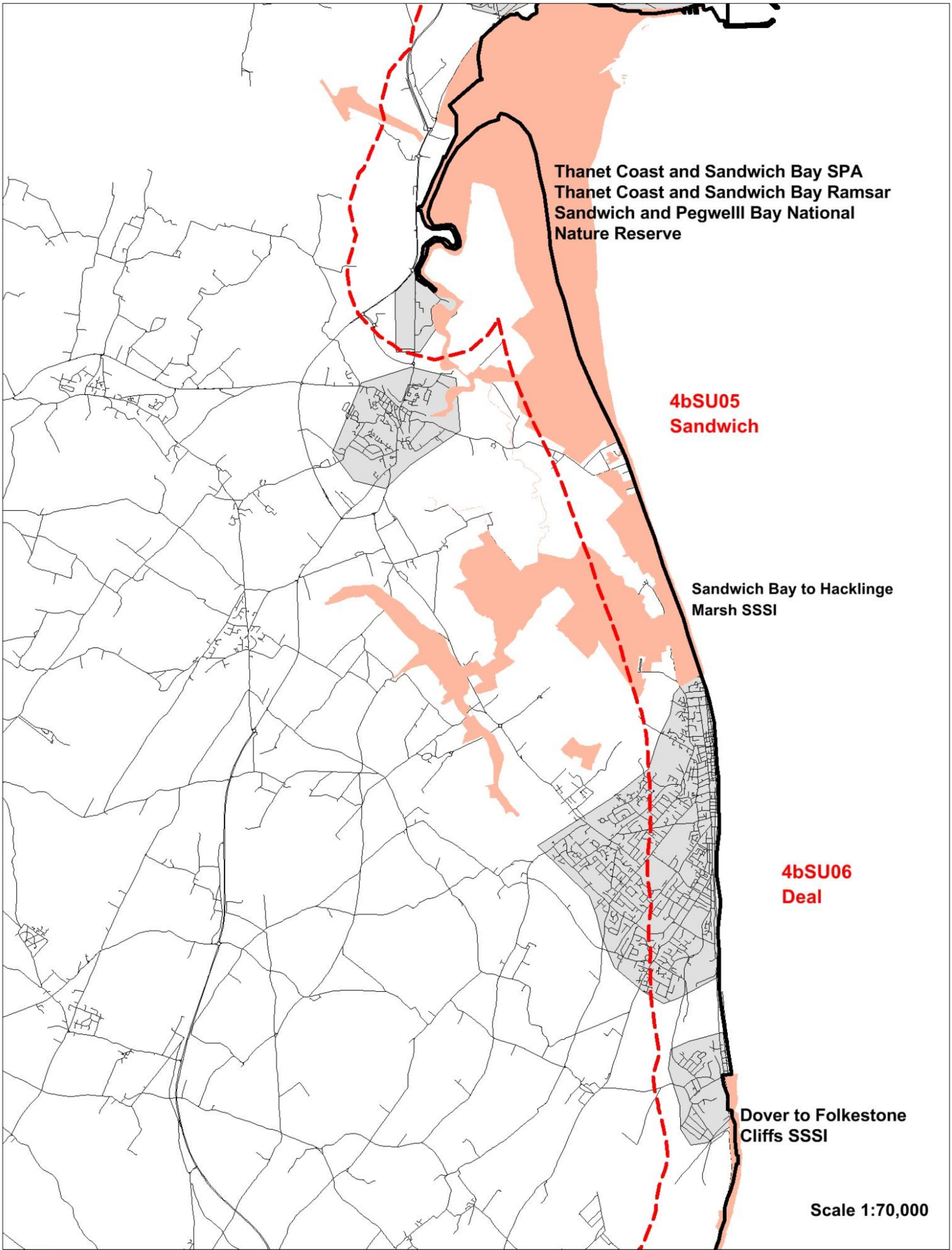

FIGURE 1-9 ENVIRONMENTAL RESTRICTIONS OVERVIEW MAP

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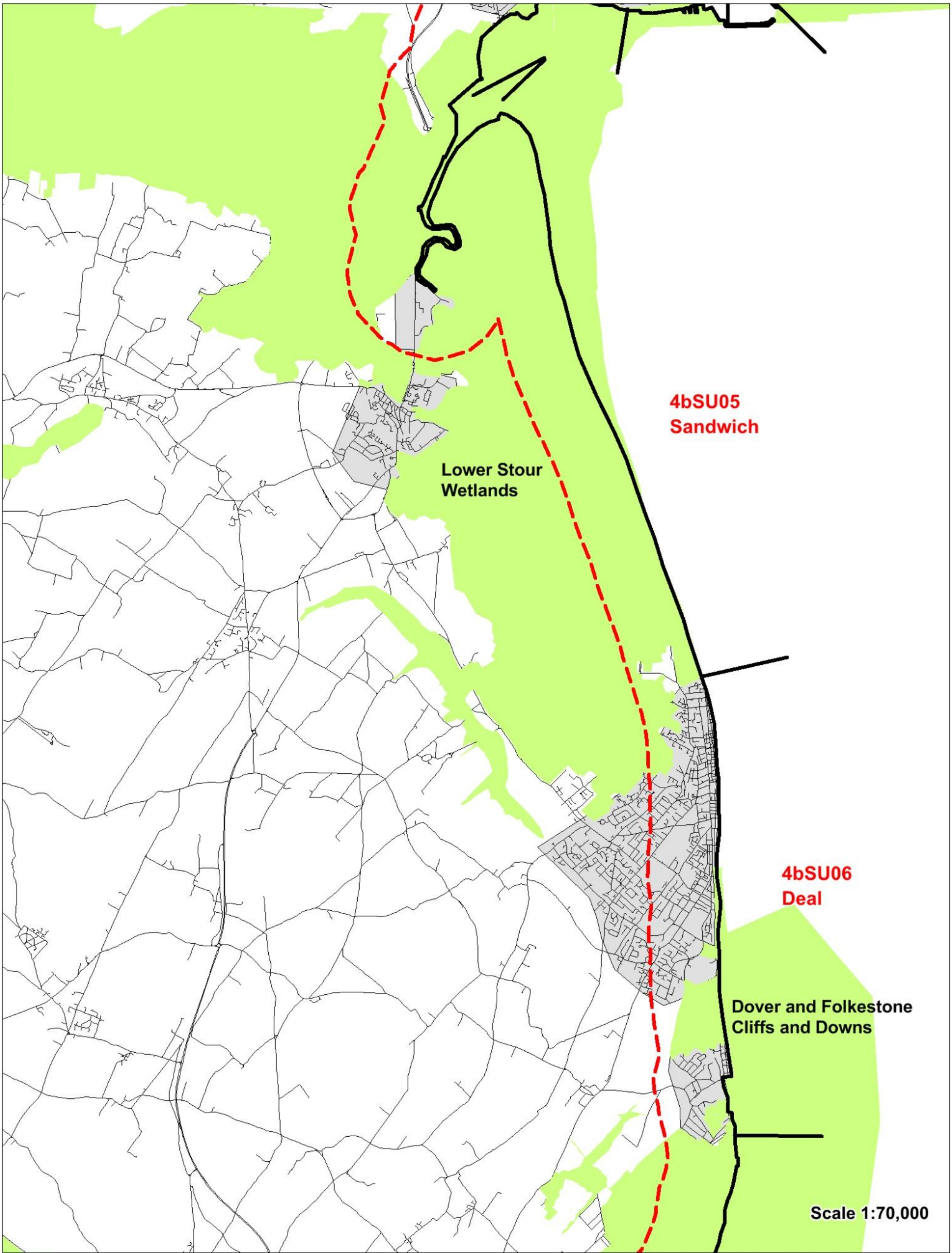

FIGURE 1-10 ENVIRONMENTAL OPPORTUNITIES OVERVIEW MAP

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1-2-5 AGRICULTURE

The majority of the coastline in the study area is non-agricultural (such as Sandwich Bay sand dunes) or urban (e.g. Deal, Walmer, and Kingsdown). The majority of the agricultural land which exists within a 1km buffer of the coastline is Grade 3 (good to moderate) with a small amount of Grade 2 (very good quality) to the south of the Stour.

1-2-6 INFRASTRUCTURE

There is a single main road running through the study area which is the A258 Figure 1-5). This road connects Deal with Dover to the South. Both North and South of Deal the road turns inland, with only a minor coast road servicing Sandwich Bay to the north and Oldstairs to the south.

The coastal railway between Dover and Margate runs through the study area however at its closest it is still 500m from the coast, just South of Deal pier.

1-2-7 ARCHAEOLOGY & CULTURAL HERITAGE

When sites of high archaeological and cultural value have been identified, they are assessed and recommendations are put forward. In England, three statutes provide protection for archaeological sites and their settings:

- *Ancient Monuments and Archaeological Areas Act (AMAA) 1979*;
- *Town and Country Planning (Listed Buildings and Conservation Areas) Act 1990*;
- *Protection of Wrecks Act 1973.*

The study area contains two ancient monuments and 73 listed buildings, with a further 274 listed buildings and a listed shipwreck within a 1km buffer of the study area.

2 CURRENT RISK

An essential part of this BMP is to consider the purpose of each beach to determine the standard of protection required. The purpose of the beach is graded against four categories; protection from still water flooding, protection against overtopping, erosion and structures. The coastline has been assessed against the four hazards as summarised below. Appendix C provides detailed mapping of impacts under the following four classifications.

2-1 FLOODING

Coastal flooding can be highly destructive, damaging buildings and affecting the fertility of land. For the beach to exist for the protection from flooding the beach is reducing damage to property through flying shingle, overtopping and over wash, ponding, partial breach and full breach are considered as the main impacts of flooding. The disruption following coastal flooding can be extensive to the public, transport and agriculture. The salinity of the water can also cause issues, leading to farmland becoming infertile and upsetting natural freshwater habitats. Sandwich Bay to Walmer is at risk of coastal flooding (Appendix C). The theoretical worst case flood depth based on the 1 in 200 year still water level (+4.55mOD) with no defences is shown in Figure 2-1.

2-2 OVERTOPPING

In addition to the impact on flooding, overtopping is classed as a danger to pedestrians on the beach, promenade and road and vehicles on the road; the larger the beach the lower the overtopping. The coastline of Oldstairs Bay, Kingsdown and Deal are all at risk of overtopping due to the close nature of properties, promenades and roads to the defences (Appendix C).

2-3 EROSION

Damage to slopes and cliffs, property on top of the slopes and cliffs and damage to property through loss of beach are all reduced by the presence of a shingle beach. Wellington Parade and Oldstairs Bay are the key erosion risk areas within the frontage (Appendix C).

2-4 DAMAGE TO STRUCTURES

The beach is reducing damage to structures includes undermining of the seawall which will lead to seawall failure and material washout from behind the wall, damage to the seawall face and crown, promenade, splash and retaining walls, revetments and lastly, damage to drainage outfalls, harbour arms and rock revetments, rock groynes and timber groynes. An extensive series of defences protect the Deal and Kingsdown frontages to the South; north of Sandwich Bay estate is free of defence structures (Appendix C).

2-5 AMENITY

Amenity impacts include damage to the amenity which is not infrastructure, for example reduction in beach width. Each beach has been given a score out of 100 to determine the level of amenity at risk within a 1km buffer of the coastline. The Amenity criteria are listed in Table 2-1 and a summary of the results are in Table 2-2. The calculations are shown in Appendix C.

TABLE 2-1 CRITERIA FOR AMENITY SCALE

SCALE	POINTS	DESCRIPTION
1 – 2	0-20	THE BEACH IS NOT EASILY ACCESSED, NO CAR PARKING, NO FACILITIES, LITTLE USAGE.
3 – 4	21-40	THE BEACH IS ACCESSIBLE, NO CAR PARKING, MINIMAL FACILITIES, LITTLE USAGE.
5 – 6	41-60	THE BEACH HAS EASY ACCESS, CAR PARKING, SOME FACILITIES AND REGULAR USAGE – MAINLY DOG WALKERS.
7 – 8	61-80	THE BEACH HAS EASY ACCESS, AMPLE CAR PARKING, GOOD FACILITIES, WELL USED, GENERATES SOME INCOME TO THE AREA.
9 – 10	81-100	THE BEACH HAS EASY ACCESS, AMPLE CAR PARKING, AND GOOD FACILITIES, IS A MAIN ATTRACTION FOR TOURISTS, HEAVILY USED, LIFEGUARDED AND RELIED ON FOR INCOME THOUGH HOTELS.

TABLE 2-2 AMENITY SCORES

LOCATION	SUB CELL	SCORE /100
SANDWICH		10
DEAL NORTH	MAIN BEACH	70
DEAL SOUTH	KINGSDOWN AND OLDSTAIRS BAY	23

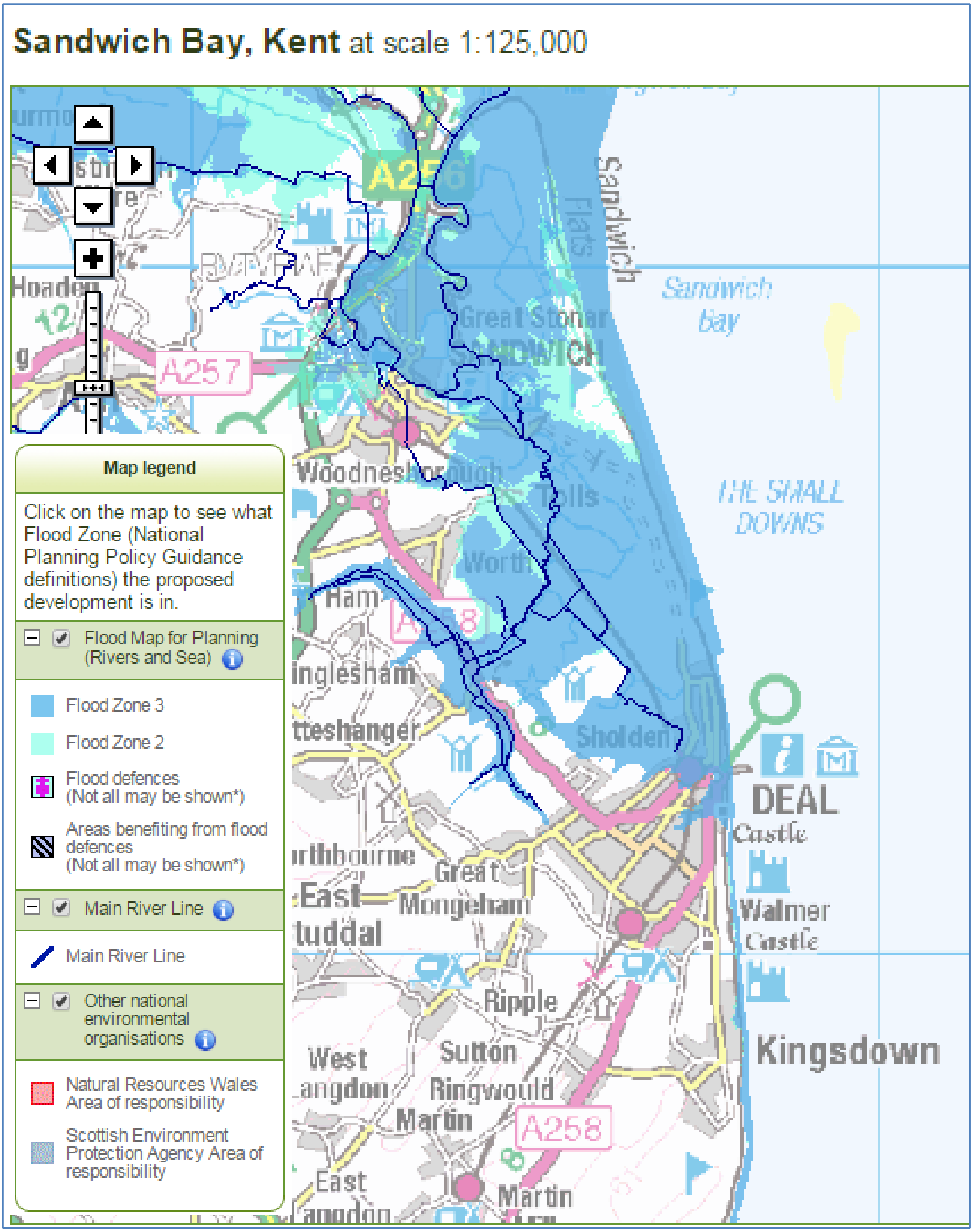

FIGURE 2-1 FLOOD MAP FOR PLANNING (WWW.ENVIRONMENT-AGENCY.GOV.UK).

Flood zones are not differentiated in relation to the source of flooding. flood defences and areas benefitting from flood defences are not visible at this scale.

3 PHYSICAL INPUTS

3-1 WATER LEVELS

3-1-1 TIDAL WATER LEVELS

Deal has a tidal range of 2.9m during mean neap tides and up to 5.4m during mean spring tides (Admiralty Tidal Tables).

3-1-2 EXTREME WATER LEVELS

Extreme water levels were taken from the results of *Coastal flood boundary conditions for UK mainland and islands* (Environment Agency, 2011). Water levels along the BMP frontage vary by only a few centimetres as shown in Table 3-1 (locations of the two extreme water level points are shown in Figure 3-1).

Table 3-1 Extreme Water Levels (+mOD) and Return Periods

Return Period (1 in x years)	Sandwich	Deal	Uncertainty values
1 in 1	3.7	3.71	0.2
1 in 5	3.94	3.95	0.2
1 in 10	4.06	4.07	0.2
1 in 25	4.2	4.2	0.2
1 in 50	4.32	4.32	0.2
1 in 100	4.45	4.44	0.3
1 in 200	4.57	4.55	0.3

Values taken from Coastal flood boundary conditions for UK mainland and islands (Environment Agency, 2011)

There is one primary water level data source within the study area. A wave radar recorder is situated on Deal Pier operating since 2005. Historical secondary tide data is limited. It should be noted that the outputs are heavily reliant on the modelling and interpolation between nodes (Dover and Margate). Tidal predictions vary between software packages, namely POLTIPS (Proudman Oceanography Laboratory) and Admiralty TOTALTIDE (UK Hydrographic Office), and this may translate into uncertainty with regards the extreme sea levels.

Comparison with the Dover Beach Response System (2001) study shows that the results are consistent for higher return periods (1 in 200 years). Given this is the baseline standard of protection used in this report, and there is not sufficient historical data to validate the results, they are considered the best available data at this time.

FIGURE 3-1 LOCATION OF EXTREME WATER LEVELS (EWL) AND EXAMPLE POINTS

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3-1-3 WAVES

The wave climate is dominated by waves from the South and the South East, resulting in a northerly drift of beach material along the whole frontage. Waves form the South will undergo significant refraction. Waves from the east are less frequent but it should be recognised that periods of waves from the northeast can result in a temporary reversal in the sediment drift direction.

Four sources of data have been used for this study, measured data from the Deal Pier wave radar, Goodwin Sands wave buoy, wind data and Met Office wave hindcast data that models 30 years of predicted wave conditions.

3-1-4 WAVE RECORDER

As part of the Regional Coastal Monitoring Project a network of wave buoys has been deployed around the coast since 2003.

FIGURE 3-2 LOCATION OF WAVE BUOYS ON THE SOUTH EAST COAST

Wave heights are recorded both at Goodwin Sands wave buoy, located at 51°15.01' N 001° 28.98' E and Deal Pier wave radar, at 51° 13.4275' N 001° 24.5555' E. At Goodwin Sands, wave parameters are recorded using a Datawell Directional WaveRider Mk III buoy. The buoy was first deployed on 06 June 2008. At Deal, wave and tide data are measured using a Rosemount WaveRadar Rex, which was installed on 26 August 2005. The Goodwin Sands wave buoy is located along the 10m CD contour.

A summary of collected data is presented in the following wave rose (Figure 3-3)

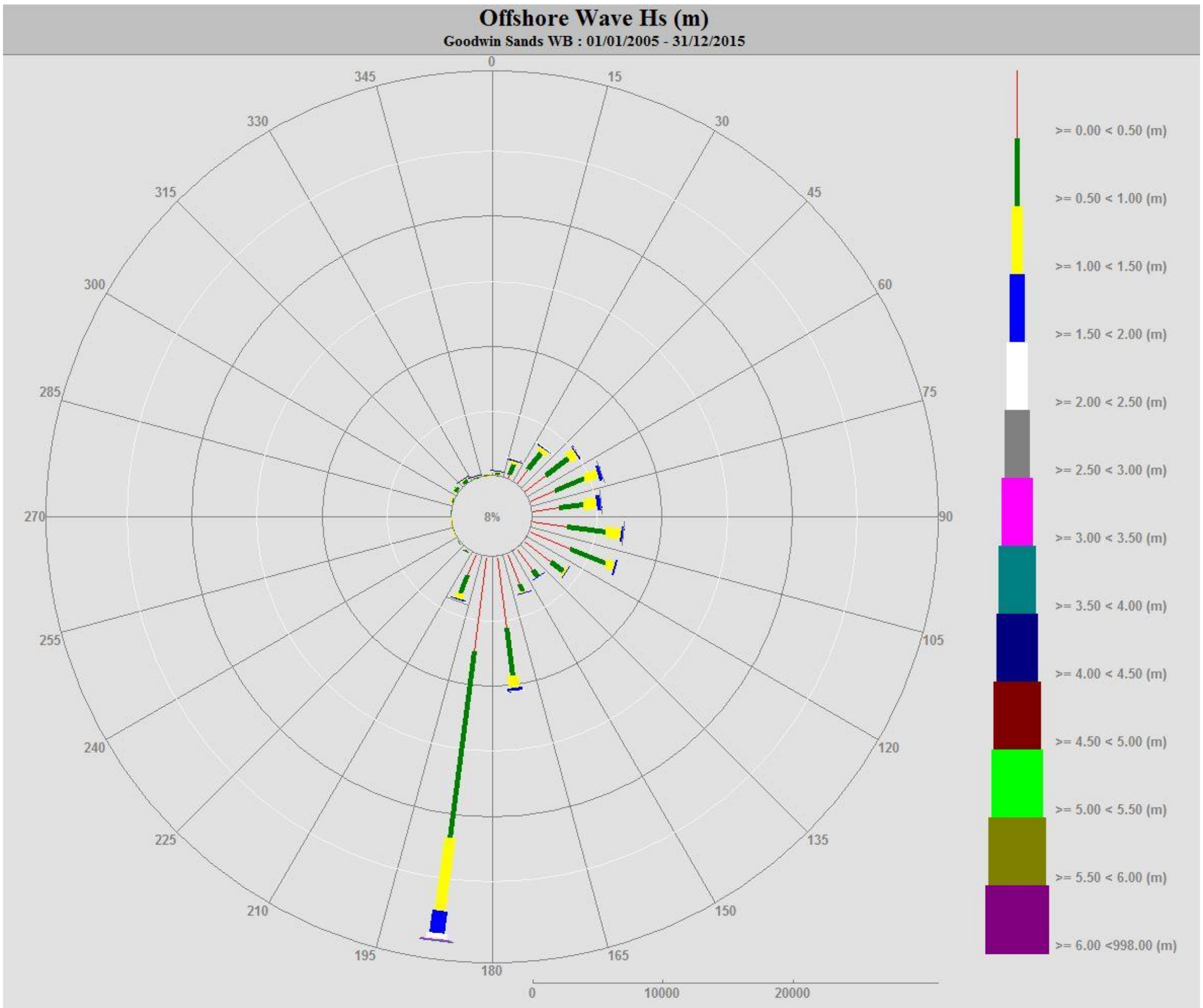

FIGURE 3-3 WAVE ROSE OFFSHORE WAVE HEIGHT (HS) GOODWIN SANDS 01/01/2005 TO 31/12/2015

3-1-5 MET OFFICE HINDCAST

Using thirty-three years of Met Office Hindcast data for 52 nearshore locations at ~5km intervals (Figure 3-4) the Joint Return Probability for Beach Management study (Mason, 2014), calculated extreme return periods for each of these points.

FIGURE 3-4 LOCATION OF MET OFFICE HINDCAST POINTS

Significant wave height return periods for Met Office points MO586, MO549 and MO517 are included for reference in Table 3-2. The drop in wave height from MO517 northwards is the result of the sheltering from westerly and south-westerly wave in the lee of the South Foreland cliffs. The methods employed to generate significant wave heights and their return periods do not take into consideration water depth and whether waves of that size could exist at that point given the effect of depth limitation. This is accounted for later in this report.

TABLE 3-2 SIGNIFICANT WAVE HEIGHT, HS (M) RETURN PERIODS FOR FOUR MET OFFICE HINDCAST POINTS; VALUES IN PARENTHESIS ARE THE WATER DEPTH AT THIS POINT.

RETURN PERIOD (1 IN X YEARS)	M0586 (9M)	M0549 (11M)	M0517 (11M)
1 IN 1	3.10	3.18	3.64
1 IN 5	3.61	3.70	4.18
1 IN 10	3.76	3.87	4.35
1 IN 20	3.90	4.01	4.50
1 IN 50	4.05	4.17	4.67
1 IN 100	4.15	4.28	4.79
1 IN 200	4.24	4.38	4.89

Contours of the annual 0.05% wave height exceedance are illustrated in Figure 3-5 and show the geographical variability within the study area suggesting very little variation in conditions between Pegwell Bay and Oldstairs Bay.

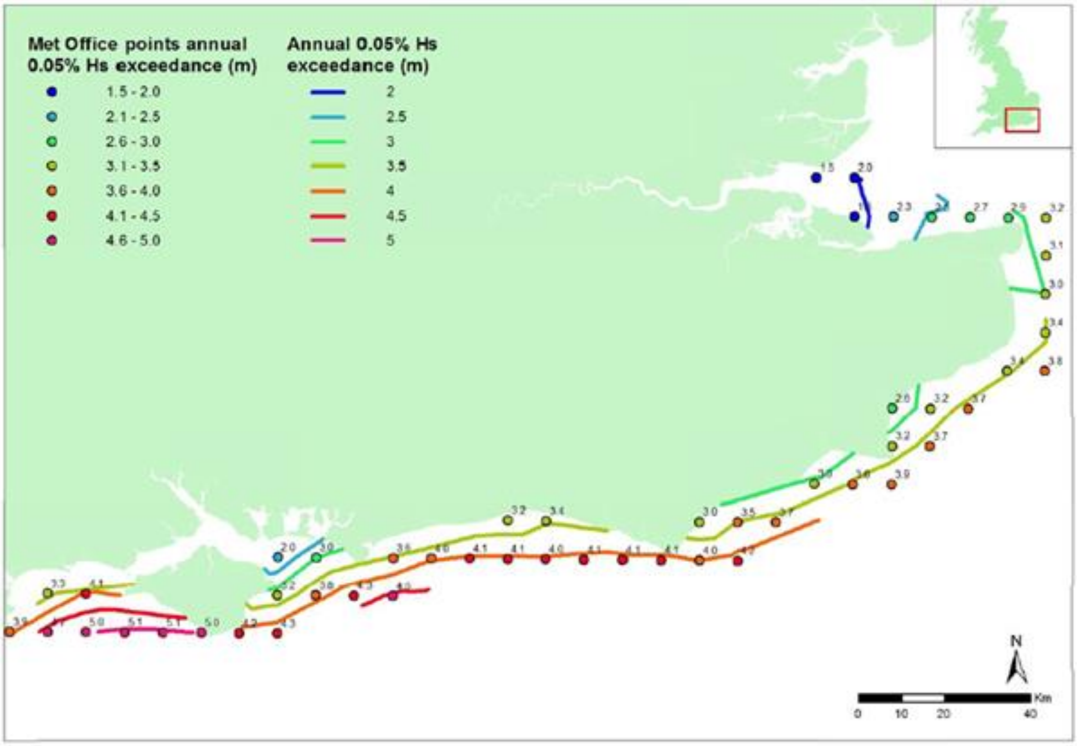

FIGURE 3-5 ANNUAL SIGNIFICANT WAVE HEIGHT (HS [M]) 0.05% EXCEEDANCE JOINT RETURN PROBABILITY FOR BEACH MANAGEMENT (MASON, 2014).

3-2 JOINT PROBABILITY ANALYSIS

Joint return periods were established using the 33 year Met Office Hindcast data and results from the EA water level boundary set as part of Mason (2014). These were calculated for 1, 2, 5, 10, 20, 50, 100 and 200 year return periods, using the HR Wallingford TR2 SR653 desk calculator, for each Met Office point.

Results for Met office points MO586, MO549 and MO517 are presented graphically below. Note that the potential depth limitation is broadly calculated and included on the charts, but this is calculated more accurately under specific conditions later in the report.

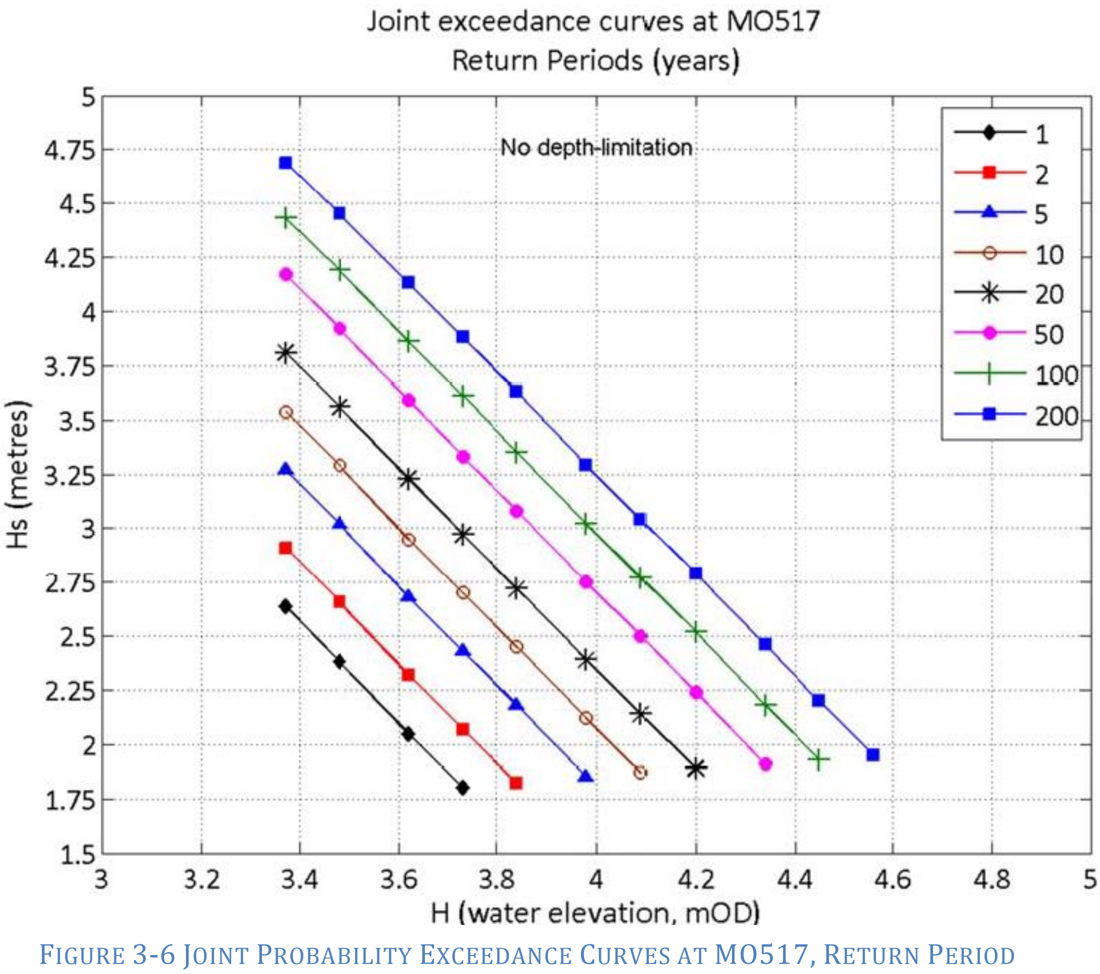

FIGURE 3-6 JOINT PROBABILITY EXCEEDANCE CURVES AT MO517, RETURN PERIOD (YEARS)

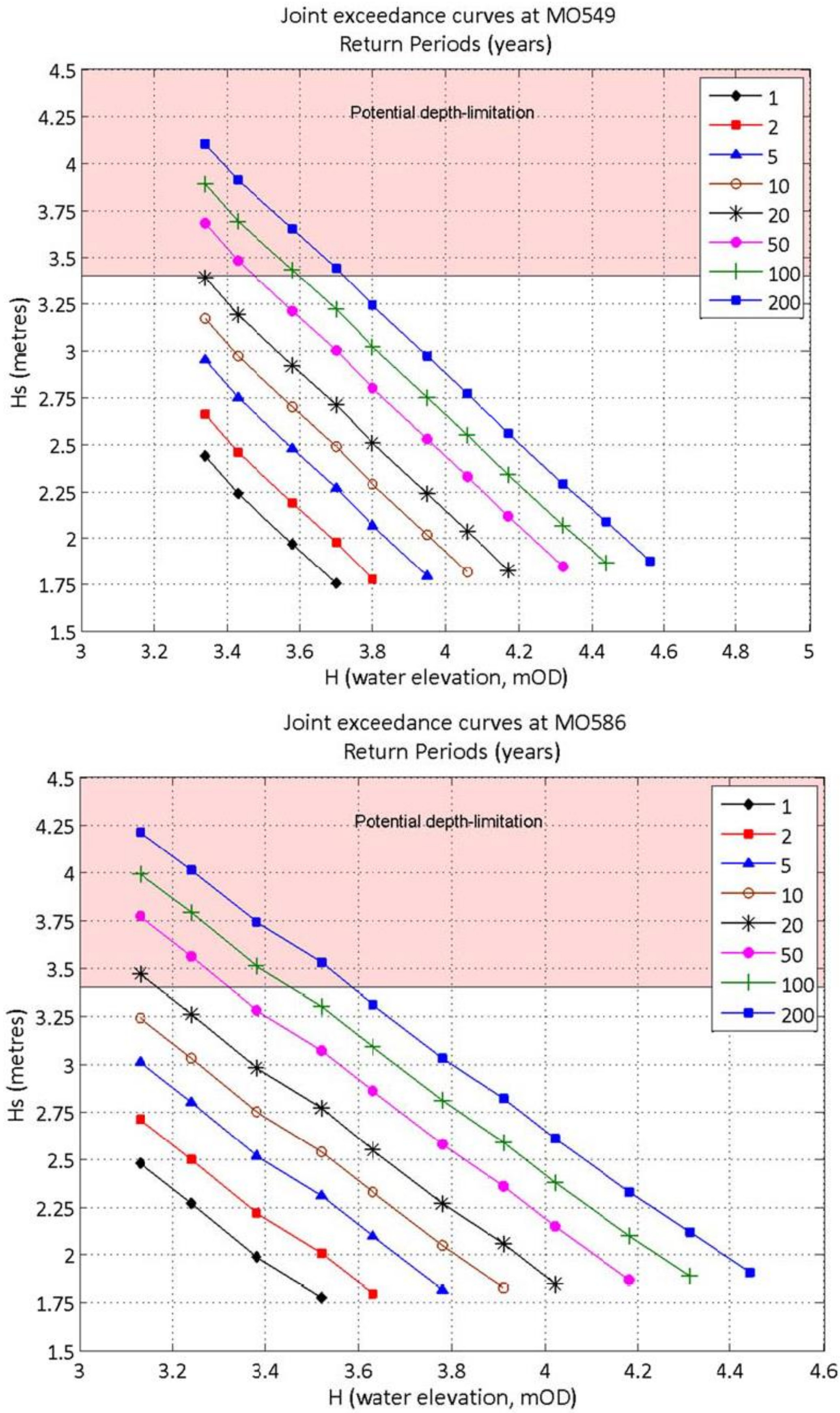

FIGURE 3-7 JOINT PROBABILITY EXCEEDANCE CURVES AT MO549 AND MO586, RETURN PERIOD (YEARS)

3-3 SEDIMENT CHARACTERISTICS

Most of the beaches within the study area are typical of those found throughout the Southeast of England, comprising mixed sand and shingle sediment. However, north of Sandwich Bay Estate the sand content increases above the up to ~30% of interstitial sand typical of shingle beaches and the beach takes on the character of a sandy beach.

TABLE 3-3 SEDIMENT CHARACTERISTICS FOR SANDWICH BAY AND DEAL

LOCATION	BEACH SEDIMENT	FORESHORE SEDIMENT
SANDWICH	SHINGLE	SAND
DEAL	SHINGLE	SAND

Dornbusch (2005) completed a study on the properties of the beach material across several sites along the south and south east coastline. Five sites along the Sandwich bay to Oldstairs bay frontage were included in the study; the northern end of Kingsdown, just south of Deal pier, just north of Sandown castle, Sandwich bay Estate and close to the Stour. The results are shown in Figures 3-8 to 3-10 which have been adapted from the Beach Material Properties report (2005).

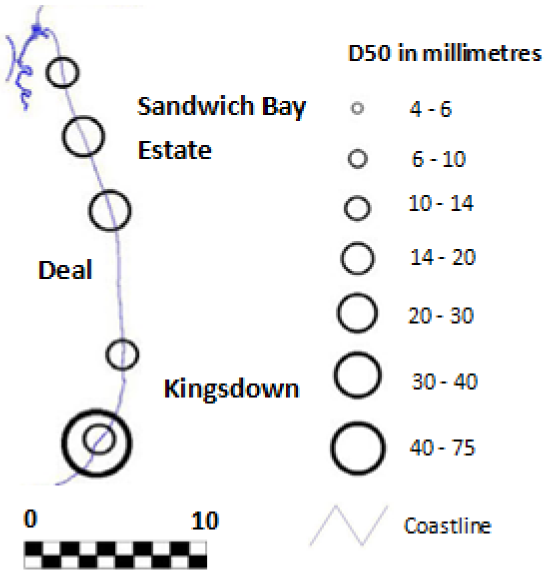

FIGURE 3-8 MAP SHOWING THE D50 GRAIN SIZE OF MATERIAL >2MM FOR EACH SAMPLE TAKEN FROM THE TOP OF THE BEACH

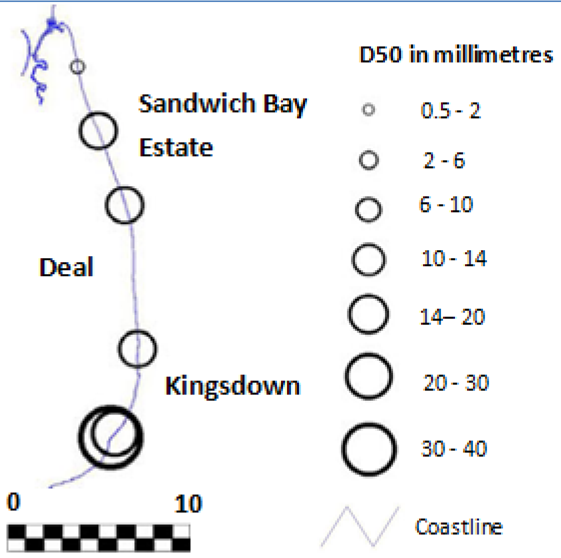

FIGURE 3-9 MAP SHOWING THE D50 GRAIN SIZE AVERAGED OVER EACH SAMPLE IN A PROFILE

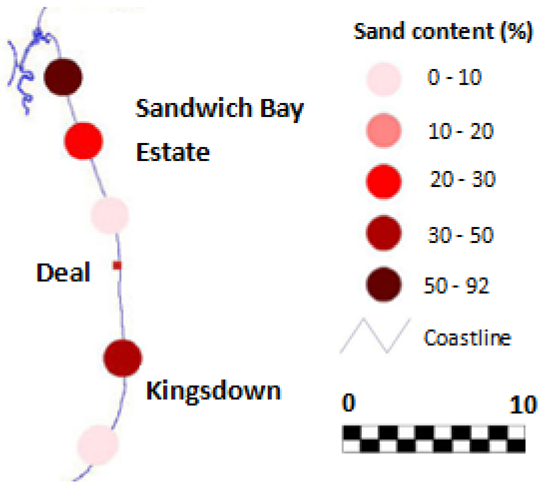

FIGURE 3-10 MAP SHOWING THE AVERAGE SAND CONTENT OF EACH PROFILE

3-4 BEACH GEOMETRY

The coastline between Oldstairs Bay and Sandwich Bay faces east, increasingly inclining to the north east towards Pegwell Bay. Figure 3-11 identifies the orientation of the coastline in relation to due north.

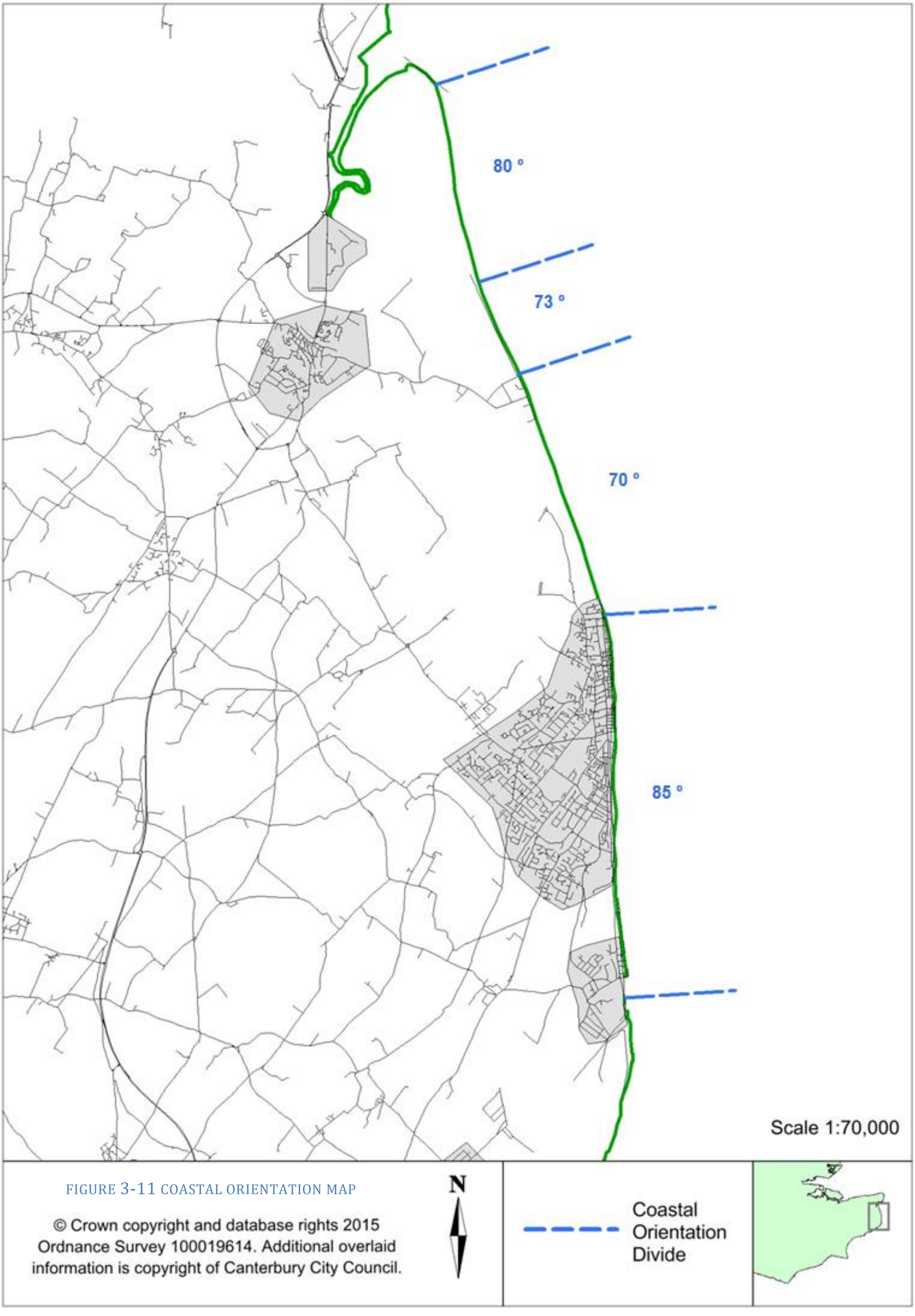

FIGURE 3-11 COASTAL ORIENTATION MAP

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4 HISTORICAL MONITORING

4-1 CONTROL NETWORK

A control network was set up by Shepway District Council for the Regional Coastal Monitoring Programme (RCMP) in 2003, covering the coastline between Sandwich and Deal. It includes several E1 (surveyed for longer than 8 hours), E2 (surveyed for 6-8 hours) and E3 pins (surveyed for 8 minutes) which are all suitable for levelling and GPS surveys (Figure 4-1). GPS equipment has an accuracy of +/- 30mm in the vertical and +/- 30mm in the horizontal.

4-2 TOPOGRAPHIC SURVEYS

Coastal monitoring is undertaken annually through the Regional Coastal Monitoring Programme; its primary aim is to provide a repeatable and cost effective method of monitoring the English coastline. Following many years of ad hoc monitoring of coastal processes within the southeast, through local authorities and the Environment Agency, an extensive integrated survey programme was developed to cover approximately 1,000km of open coastline and estuaries between the Isle of Grain and Portland Bill. Data are collected by Local Authority in-house teams and are freely available via the Channel Coastal Observatory, which is based in Southampton.

4-2-1 GPS

The elevations of the beaches between Sandwich and Deal are surveyed with GPS equipment. GPS RTK methods are used to collect 2-D (profile method) or quasi 3-D (continuous method) representations of the beach. A beach profile is a cross section which starts are sea wall, or back of beach, and runs perpendicular to the coastline and ends at MHWS, a rock platform or if mud foreshore then 50m off the toe.

Linked to the Control Network, the GPS equipment has the ability to "stake-out" to the position of existing profile lines ensuring the same cross sections are surveyed every year. GPS equipment is mounted onto a detail pole at 1.8m and a new topographic point is taken at every significant change in elevation to produce a 2D replica of the beach face. Profiles are categorised as designated or intermediate lines. Designated profiles are representative of long stretches of coast, positioned along different orientations, different defence types or in areas of concern and can provide an overview of the beach. Intermediate profiles are spaced at 40-50m intervals between the designated profiles and provide a detailed coverage of the beach (Appendix D).

The continuous method produces blanket coverage of the beach. GPS equipment is mounted onto either a rucksack or a quadbike and the surveyor walks (or drives) shore parallel lines along all changes of slope with points recorded every two seconds, or every 2m. This data is then post-processed in a GIS package to produce the quasi 3-D model of the beach.

SPRING & AUTUMN SURVEYS

The designated profiles have been surveyed during the spring and autumn since 2003. Analysis is available for all profiles and is used to monitor beach response to wave conditions or replenishment schemes.

SUMMER SURVEYS

A full survey is conducted to provide a quasi 3D model of the beaches once every five years, unless the survey unit is a Beach Management Plan Site which would be surveyed annually. This comprises a full set of designated and intermediate profiles and a continuous dataset of the beach and foreshore.

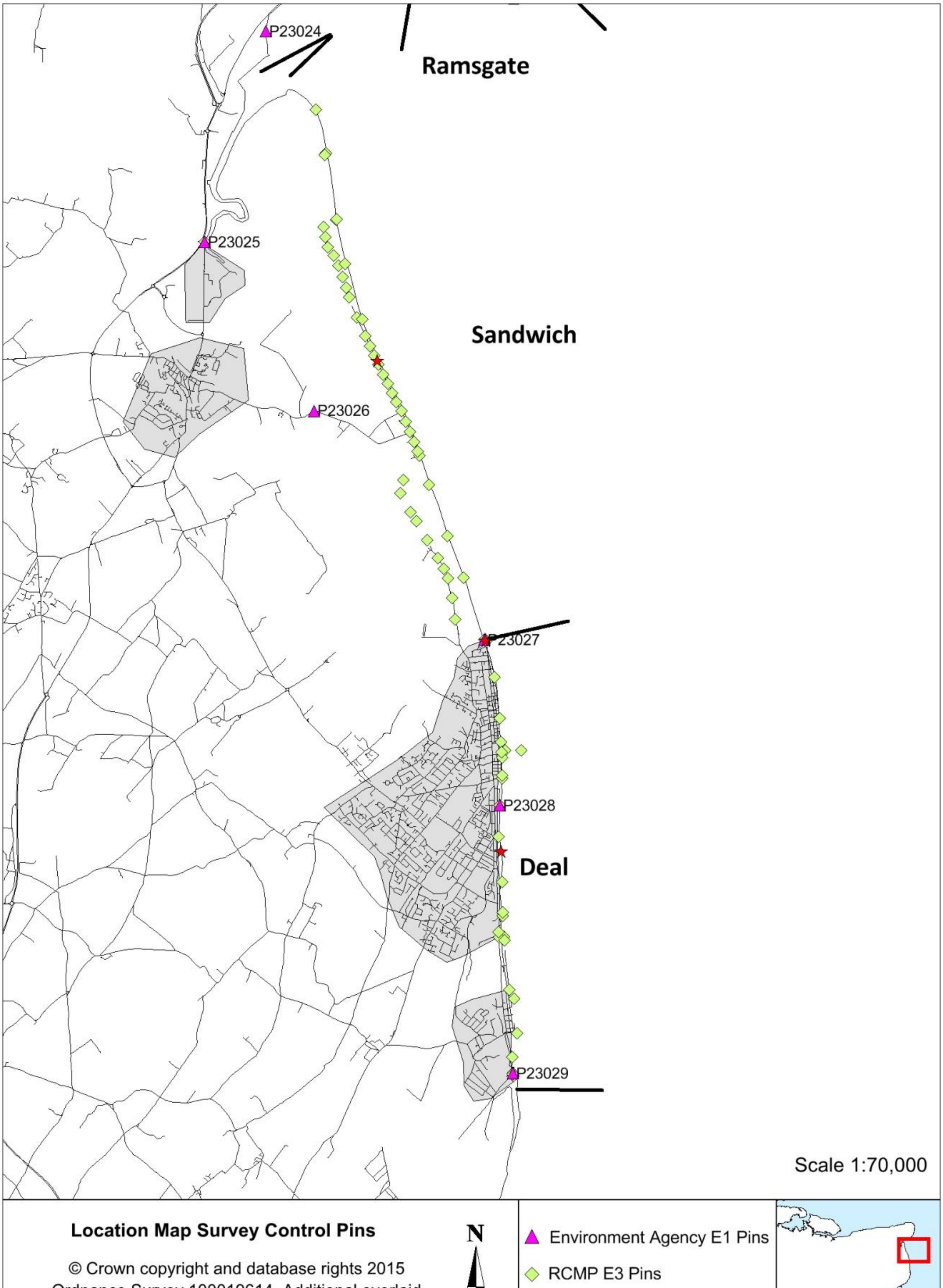
POST STORM SURVEYS

Following a series of storm waves which exceed the storm threshold as set by Channel Coastal Observatory, post storm surveys may be conducted as an additional set of data. The surveys will only be conducted if the Local Authority or Environment Agency managers deem the beach to have had significant damage i.e. large losses or severe drawdown of material which will not return over the course of the next few tidal cycles.

On foot (or quad bike where appropriate) profile and continuous GPS will be concentrated in the specific areas of concern. Data can be turned around within a few days.

IN/OUT SURVEYS

In and Out surveys refer to the pre and post work surveys respectively. The profiles and/or continuous is concentrated on those areas specified by the Local Authority or Environment Agency manager; usually the extraction and deposition sites.



Location Map Survey Control Pins

4-2-2 HISTORIC

The first regular surveys were the Annual Beach Monitoring Survey (ABMS), profiles extracted from photogrammetry, conducted on behalf of the Environment Agency from 1978. The Beach Response Management System (BRMS) for Kingsdown to Deal was proposed in the Strategy Report: "Deal to Kingsdown Coast Defences" and was submitted to the Ministry of Agriculture, Fisheries and Food (MAFF) in July 1997. The objective for the BRMS was to provide Dover District Council with a monitoring and management system for their overall Coastal Defence Strategy. Two types of survey were undertaken, a level and chainage survey conducted in March and September of every year and a General Assessment Survey (visual assessment of the beach condition) conducted in the spring, autumn and post storm. A total of 41 locations were chosen for beach profiles and 15 for visual beach assessment. The profiles were selected on beach morphology, interaction between coastal processes and defence structures and recent experience of beach behaviour to identify 'hot spots' of beach erosion. A total of three surveys were undertaken in 1999, 2000 and 2001.

The Regional Coastal Monitoring programme succeeded this system and used the same beach profiles in order to provide direct comparison.

4-3 BATHYMETRIC SURVEYS

The most recent bathymetry data is the 2013 multi-beam survey. Single beam surveys of the study site were undertaken in 2007 and 2004.

4-4 BMP SITES

Survey units 4bSU05 (Sandwich Bay) and 4bSU06 (Deal) are BMP sites and have historically received three surveys per year. Spring and Autumn survey windows are February to March and October to November respectively. Summer surveys are undertaken between June and September. Each survey unit should have a minimum of two months between each survey (Appendix D - Profile Location Maps).

TABLE 4-1 SURVEYING SCHEDULE

SITE	SPRING	SUMMER		AUTUMN
	ANNUALLY	1 PER PHASE	ANNUALLY	ANNUALLY
SANDWICH BAY	✓		✓	✓
DEAL	✓		✓	✓

4-5 AERIAL SURVEYS

4-5-1 AERIAL PHOTOGRAPHY

As part of the RCMP ortho-rectified aerial photography is flown in the summer at varying intervals. The most recent available photography was flown in 2013 and prior to that in 2001, 2003 and 2008. This is available to download from the Channel Coastal Observatory website.

4-5-2 LIDAR

Lidar is flown annually on behalf of the Environment Agency. Sites chosen for flight are highly dependent on budget and necessity and tend to be selected on a sliding scale; areas of cliff or few coastal defences would be a high priority and headlands or heavily managed beaches through defences or maintenance are low on the priority. The last Lidar flight for Sandwich Bay and Deal was in the winter 2014/2015.

4-6 STRUCTURES

4-6-1 GPS

The defence structures are surveyed every five years by the in-house coastal monitoring team as part of the baseline summer surveys. The most recent structure survey was undertaken in 2012, prior to that 2007 and 2003.

4-6-2 LOCAL AUTHORITIES

Local authorities have a requirement to regularly survey coastal assets. The in-house coastal monitoring team surveys the coastline two-three times per year, which provides an opportunity for any visible structural defaults to be reported. Further information on asset surveys is included in Chapter 100.

4-7 HYDRODYNAMIC MONITORING

4-7-1 WAVE RECORD

A wave buoy is located offshore at Goodwin Sands and a wave radar station is located on Deal Pier. Real time data for the significant and maximum wave height are freely available via the Channel Coastal Observatory website. Wave parameters at Goodwin Sands are recorded using a Datawell Directional WaveRider Mk III buoy. Wave parameters at Deal Pier are recorded using a Rosemount WaveRadar Rex.

4-7-2 TIDE GAUGE RECORDS

A tide gauge is situated on Deal Pier. Tide gauges are important for understanding the local tidal conditions. The real time data can be observed alongside the predicted data on the Channel Coastal Observatory website. The next tide gauge with a long record is Dover.

4-8 ECOLOGICAL MONITORING

4-8-1 HABITAT MAPPING

The beach vegetation within the south east of England was digitised in 2011 by the University of Southampton. The habitat mapping was based on the 2008 ortho-rectified aerial photography to provide an overview to the locations of vegetation along the coast.

4-8-2 TOPOGRAPHIC SURVEYS

As part of the GPS data each point is coded with the material underfoot. In cases of vegetation “vg” or “dv” or “gr” are used to note vegetation, dune vegetation or grass. Although no study has been undertaken to compare these boundaries, it is possible to see the evolution or regression of the beach vegetation. However this data is rather limited in that it does not describe species or population density of the vegetation.

4-8-3 ECOLOGICAL MONITORING

As part of a five year ecological management plan for Kingsdown to Walmer set out by the White Cliffs Partnership, a full assessment of the vegetation on site was undertaken in 2009/2010. The management programme recommended that vegetated shingle monitoring was undertaken every year between June-August.

Some local residents have been recording moths for a number of years and reporting to the National Moth Monitoring Recording Scheme. The results have shown the area is an important site for both common and rarer species.

Wetland Bird Surveys (WeBS) are undertaken once a month over winter at Pegwell Bay. This survey monitors non-breeding waterbirds in the UK. The principal aims of WeBS are to identify population sizes, determine trends in numbers and distribution, and identify important sites for waterbirds. The monitoring scheme is part of a national data collation and analysis run by the British Trust for Ornithology.

5 SEDIMENT BUDGET

5-1 METHODOLOGY

The sediment budget provides transparent and quantitative evidence of beach losses, gains and sediment pathways, in combination with both natural and artificial movements of beach grade material. This sediment budget predominately focuses on the shingle sediment movement, as this has the most relevance to beach management operations.

Data fed into the sediment budget is supplied through the Regional Coastal Monitoring Programme and uses the full dataset (2003 to 2015). To create the budget beach surfaces were combined to create continuous terrain models (gridded at 1m) across the whole frontage, Oldstairs Bay to Sandwich Bay. With the compiled DTM's from all available survey years, it is possible create difference models from which volumetric change between two surveys can be calculated. Negative values represent erosion that has occurred between Year A and Year B, and positive values indicate accretion. Whilst these figures show an overall change in beach volume within each discrete section, it should be recognised that the data is based on the BMP survey, which is undertaken once each year and is a snapshot in time.

Many of the cells in Deal are heavily managed and mask the natural changes. The sediment budget uses Equation 1 to calculate the sediment transport rate leaving the cell, and accounts for measured volume change, management activities and anticipated losses within a cell.

EQUATION 1 $$\boldsymbol{Qoutput = -(\Delta V - P + R - L) + Qinput}$$

Where ΔV is the as surveyed volume change, P is the combined recycling (deposition) and replenishment, R is the Recycling (Extraction), L is the combined Losses from attrition and those associated with recycling and replenishment activities. Qinput in the volume transported from the up-drift cell and Qoutput is the volume of material transported to the downdrift cell. A worked example is outlined in Figure 5-1.

The detailed methodology for the production of the sediment budget is outlined in detail within Appendix E. The outputs are available in spread sheets and graphical plates, an example of which is shown in Figure 5-2. The results are detailed and complex in nature, so to aid understanding summaries of management activities, sediment transport rates, erosion and accretion for individual units and a regional summary are provided in Chapter 0 of this report.

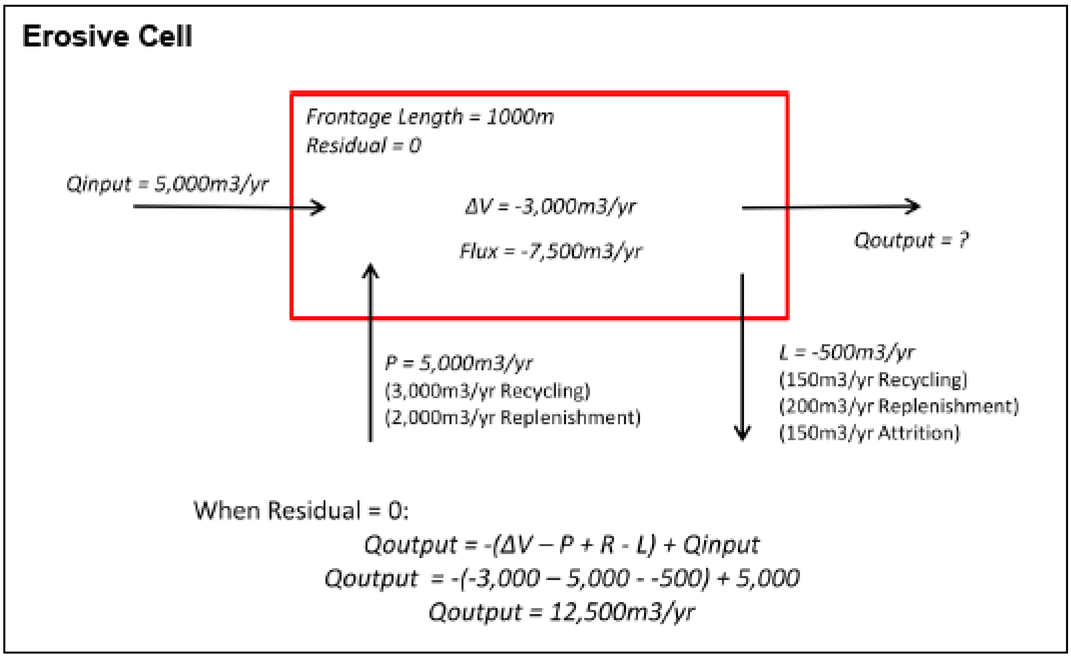


FIGURE 5-1 EXAMPLE OF AN EROSIVE CELL CALCULATED THROUGH THE SEDIMENT BUDGET

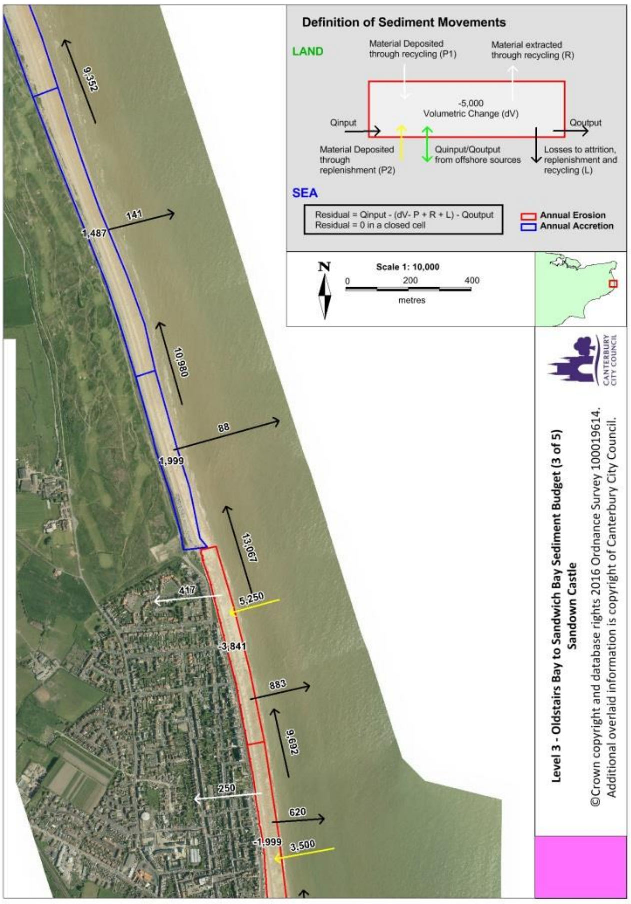


FIGURE 5-2 EXAMPLE OF DETAILED SEDIMENT BUDGET OUTPUTS (APPENDIX E)

5-2 BEACH MANAGEMENT ACTIVITIES

Current management of the beaches has been a combination of beach recycling and replenishment on an ad-hoc basis when required. A summary of the total and average annual rates are listed in Table 5-1. Full details of annual quantities and the locations of the extraction and deposition sites can be found in Appendix E.

TABLE 5-1 SUMMARY OF BEACH MANAGEMENT ACTIVITY 2003 - 2015

LOCATION	TOTAL RECYCLING VOLUME (2003-2015)	AVERAGE ANNUAL RECYCLING VOLUME	TOTAL REPLENISHMENT VOLUME (2003-2015)	AVERAGE ANNUAL REPLENISHMENT VOLUME
SANDWICH BAY	0	0	0	0
DEAL	67,435	5,620	182,300	15,192
NET	67,435	5,620	182,300	15,192

(Volumes provided by coastal management authorities)

5-3 SEDIMENT TRANSPORT RATES

From the budget it is possible to extract average annual sediment transport rates along the whole frontage based on the data collected from 2003-2015. These demonstrate high spatial and temporal variability throughout the frontage.

There are no terminal structures between Sandwich and Deal and therefore sediment transport rates range between 2,300m^3 to 13,000m^3 with the largest transport rates at Sandown Castle and the Royal Cinque Ports Golf club. Transport rates are higher in the south and centre of the study area due to a lower foreshore. Furthermore, due to a lack of input of material, the transport rates at Oldstairs Bay, Deal are also low. Towards the north transport rates are lower from the higher foreshore level which encourages shoaling of waves. The following plates illustrate the changes in more detail. When interpreting the results it should be emphasised that these are average annual values and the observed rates can be considerably higher (or lower) in any given year. These fluctuations are taken into consideration in Chapter 0.

Scale 1:27,000

FIGURE 5-3 SEDIMENT BUDGET FOR DEAL – ESTIMATED ANNUAL SEDIMENT TRANSPORT

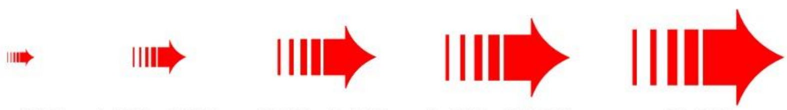
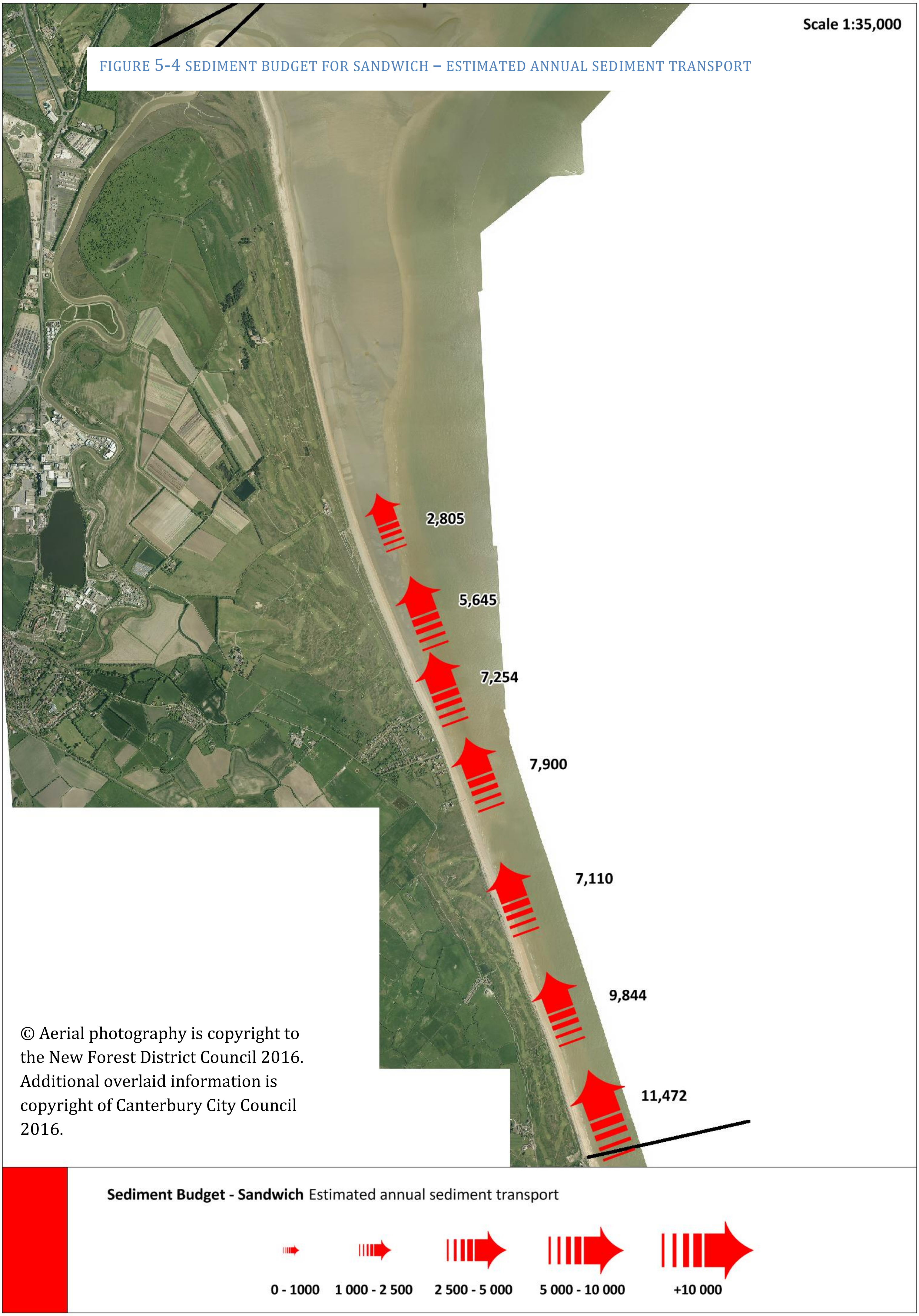


FIGURE 5-4 SEDIMENT BUDGET FOR SANDWICH – ESTIMATED ANNUAL SEDIMENT TRANSPORT



5-4 EROSION/ACCRETION

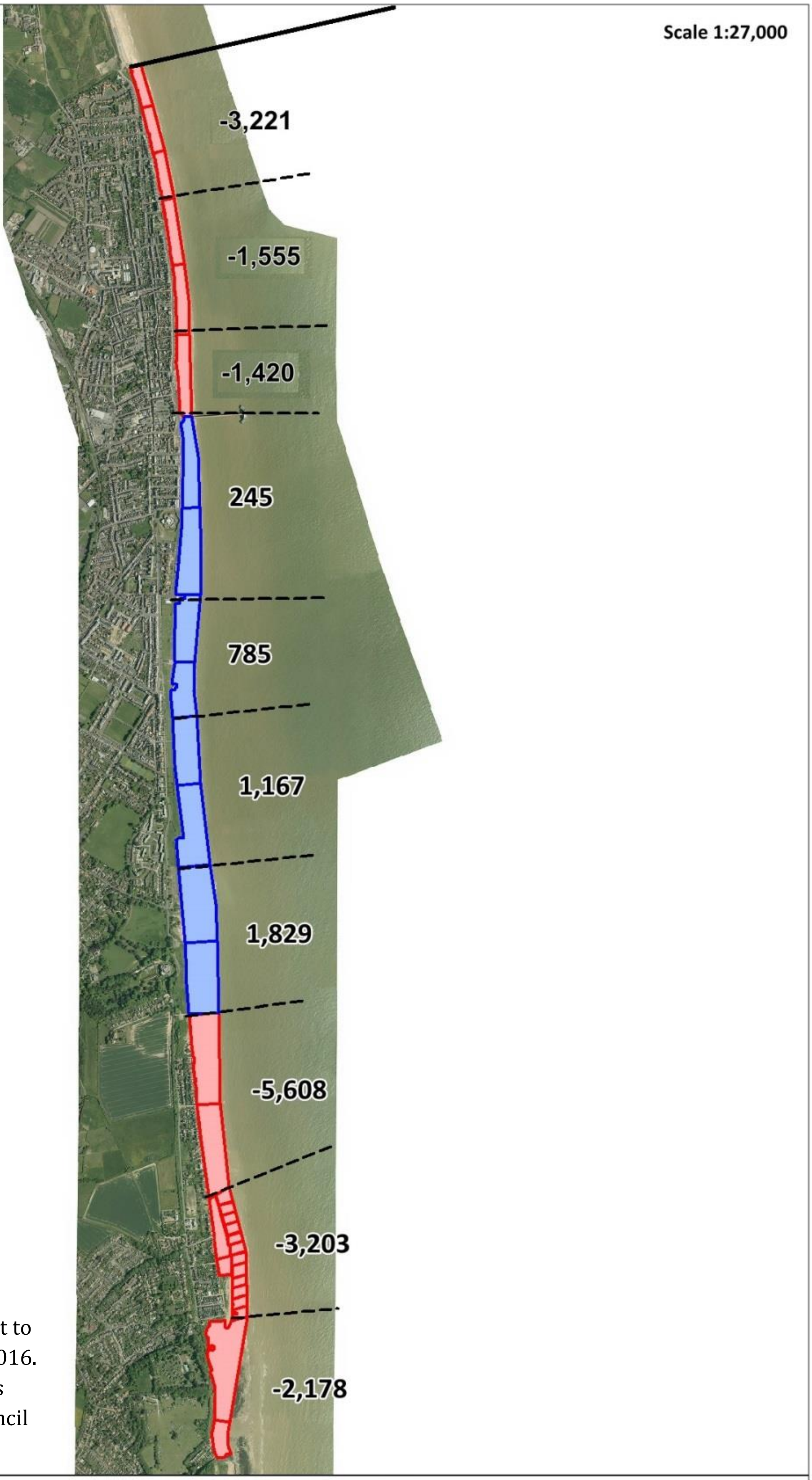
With thirteen years of data it is possible to establish average annual erosion/accretion patterns with a reasonable degree of confidence. Standard difference models that illustrate the difference between pairs of individual surveys are misleading in this regard for the results are influenced by any beach management activities. Replenishment and shingle recycling deposition can mask erosive areas; conversely sites used as a source of recycling material can fail to highlight accretive areas.

Using the results from the sediment budget spread sheets it is possible to calculate the Net erosion/accretion rates, discounting the effects of beach management using Equation 2. Unfortunately due to the coarse nature of replenishment/recycling logs, which usually only define volumes to within the area of the works, this can only be achieved for coarse sediment cells. However, this is usually sufficient to gain an understanding of the erosive areas, the magnitude of the problem, and identify any future sources of shingle for recycling operations.

EQUATION 2: $$\boldsymbol{Net\ Erosion/Accretion = \Delta V - P + R}$$

The following plates illustrate the average annual erosion/accretion across the study area discounting beach management works. Again, it should be stressed that these figures represent the average value you might expect based on 12 years of data. There can be considerable variation year on year and in some cases unusual conditions can result in a reversal e.g. an accretive area may erode due to a prolonged period of waves from a non-dominant direction.

This does however provide a basis for planning the likely necessity of beach management operations for future years based on actual recorded data.



N

FIGURE 5-5 SEDIMENT BUDGET FOR DEAL – NET ANNUAL EROSION/ACCRETION

The net erosion/accretion rate.
(influence of beach recycling and replenishment discounted)

Erosive sub cell
Accretive sub cell
2,840 Volume change (m³)
Sub cell boundaries

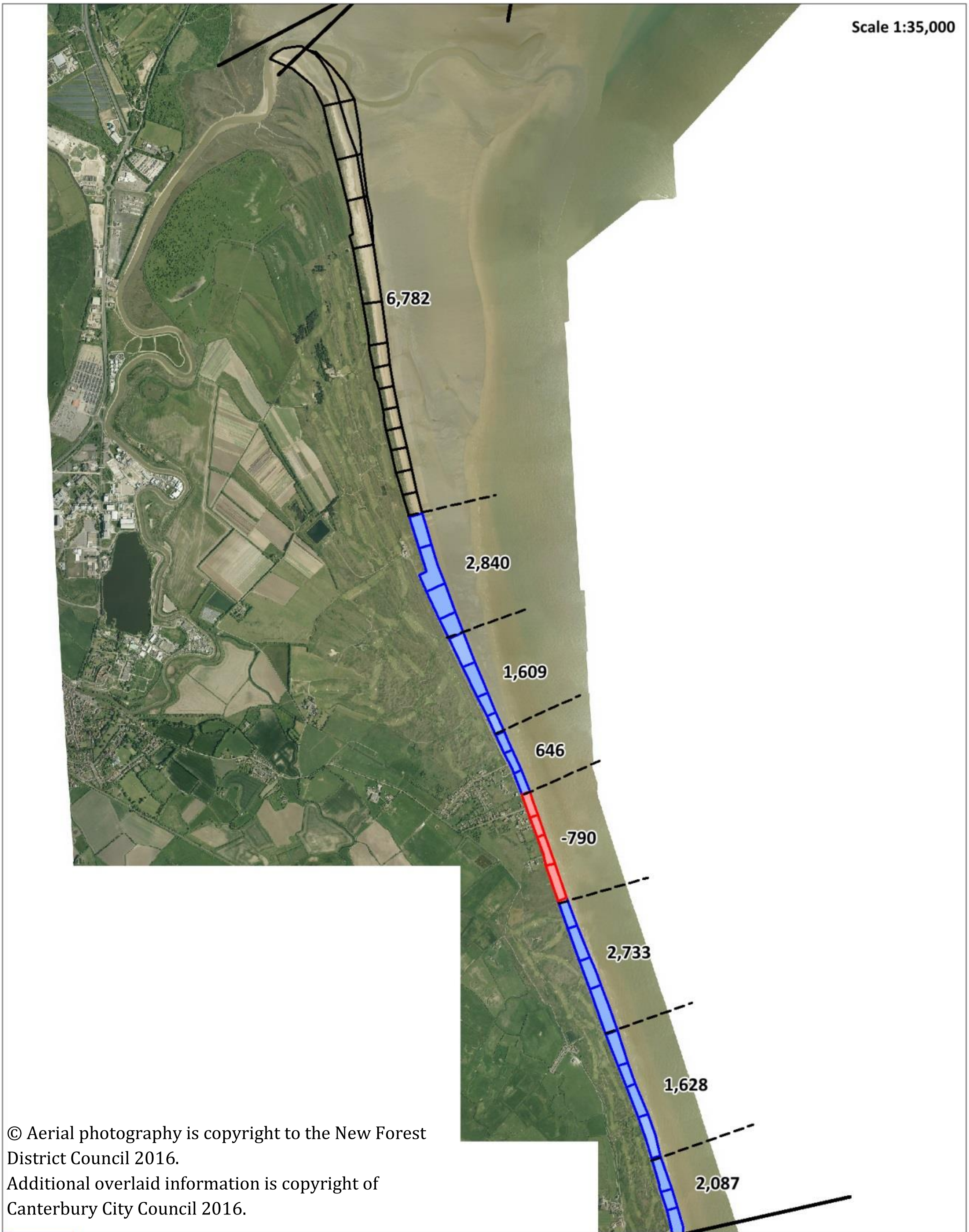


FIGURE 5-6 SEDIMENT BUDGET FOR SANDWICH – NET ANNUAL EROSION/ACCRETION

The net erosion/accretion rate.
(influence of beach recycling and replenishment discounted)

N

Erosive sub cell
Accretive sub cell
2,840 Volume change (m^3)
Sub cell boundaries

5-5 UNIT SUMMARY

The previous section discounted the effect of historic beach management operations, but in order to appraise those practices and consider the influence of natural processes it is important to look at the combined impact. This is considered broadly for each management unit by calculating the changes in total beach volume.

In order to make the charts more easily comparable the scale of the y-axis is consistent for each unit.

5-5-1 DEAL

The longshore drift direction at Deal is from south to north. As the coastline runs approximately parallel to the predominant wave direction and so sediment transport is high. There is minimal sediment feed from the south into Oldstairs which causes the low transport rates to the south of Deal. Sediment flowed through the dilapidated groyne field and accumulated in front of Walmer Castle. Approximately 11,300m^3 is transported into Walmer and only 9,500m^3 leaves Walmer. The recent works are expected to change the sediment flow over the next few years as material will have to flow over the bays rather than through them. North of Walmer Castle the annual sediment transport rates vary from approximately 8,000m^3 to 9,000m^3. 13,000m^3 shingle leaves the Deal frontage towards Sandwich every year. The annual erosion/accretion diagrams show that the Deal Unit has an accretive centre and erosive extremes.

The total beach volume (Figure 5-7) illustrates an erosive beach despite having received several replenishment schemes; 2004, 2007, 2008, 2010 and 2012. The northerly drift direction has transported the majority of this material into Sandwich Bay.

5-5-2 SANDWICH

The longshore drift direction at Sandwich is from south to north. As with Deal the annual sediment transport rates are high but decrease towards the north as the foreshore becomes higher and wave energy and incident angle are reduced. Transport rates in the south of the unit are as high as ~11,000m^3 whilst at the northern extent of the sediment budget calculation area it is as little as 2,300m^3.

As the water becomes shallower to the north, the coastline is more sheltered as waves shoal in the shallow water leading to the deposition of sediment. The net erosion accretion suggest that the sediment sub-cells are accreting up to 2,000m^3 per year except in front of Sandwich Bay estate which loses a small volume of 790m^3 per year.

The increase in total beach volume (Figure 5-8) reflects the south to north sediment transport whereby Deal has been feeding Sandwich as there are no controlling structures between the two units. The beach volume of Sandwich Bay has increased by approximately 200,000m³ since 2003. This material could be used a valuable resource for beach recharge at Deal the majority of material that has accumulated in Sandwich has originated from Deal. A large capital recharge of 120,000m³ was carried out at Deal in September 2011 which can be seen on the graph.

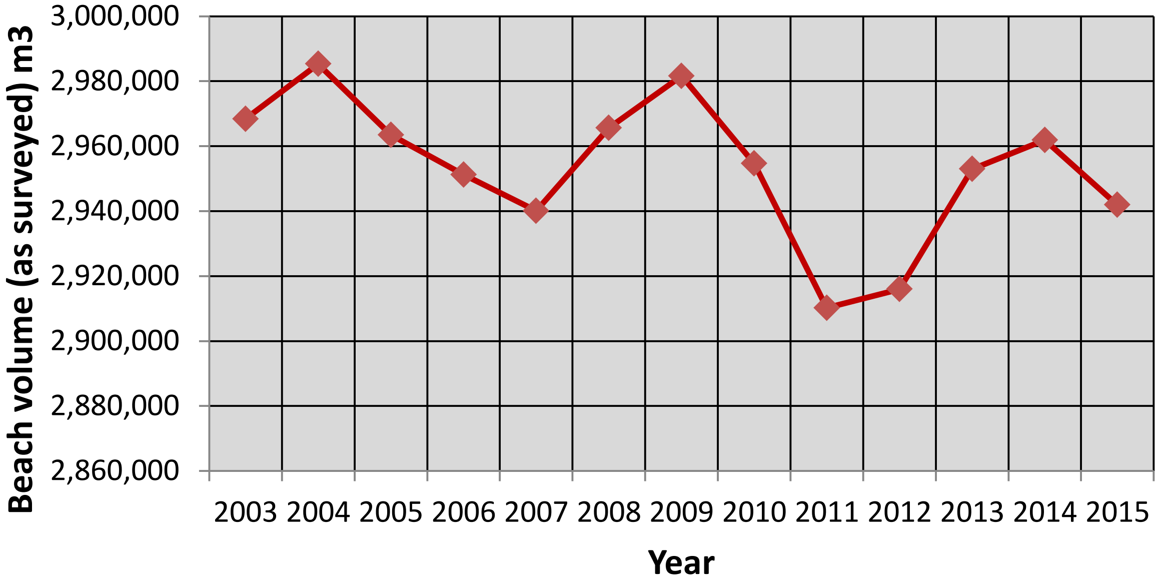


FIGURE 5-7 OLDSTAIRS BAY TO SANDOWN CASTLE TOTAL BEACH VOLUME CHANGE 2003 – 2015 (AS SURVEYED)

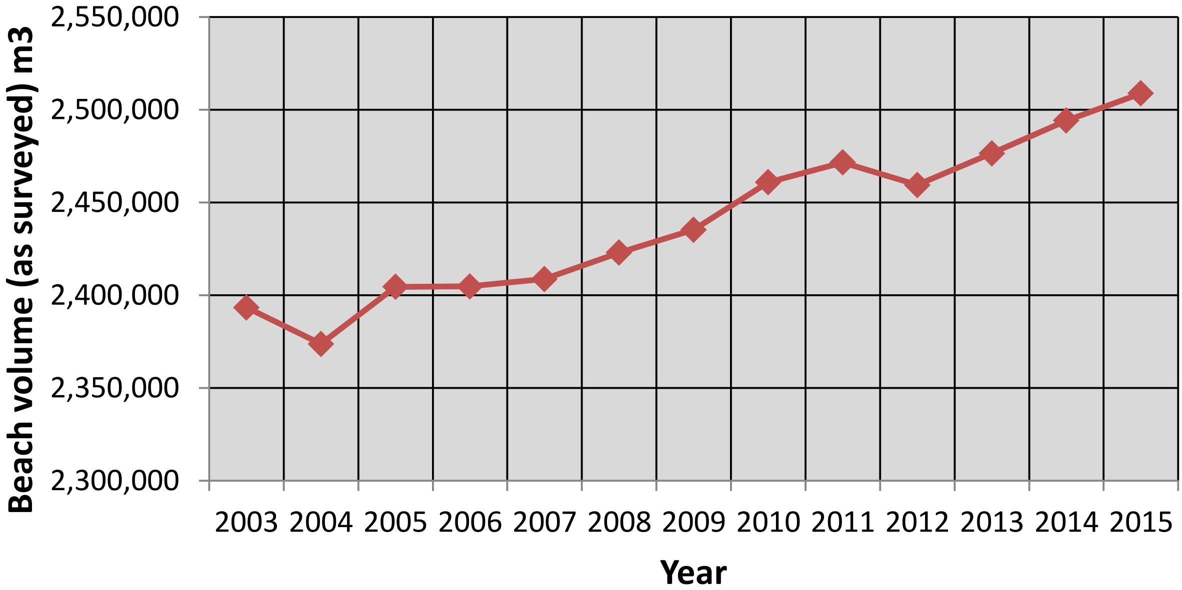


FIGURE 5-8 SANDOWN CASTLE TO PEGWELL BAY TOTAL BEACH VOLUME CHANGE 2003 – 2015 (AS SURVEYED)

6 RISK ANALYSIS

6-1 DEFENCE SECTIONS

In order to perform the risk analysis the coastline was split into representative defence sections based upon sea defence, beach and foreshore characteristics (Figure 6-1-1). Details on the defence type, elevation and geometry, foreshore levels and the calculations performed for each defence section is provided in Appendix G.

FIGURE 6-1-1 EXAMPLE OF DEFENCE SECTIONS FOR DEAL

6-2 METHODOLOGY

6-2-1 OVERTOPPING

The primary short-term threat considered in this report is excessive overtopping of the shingle beaches and structures, causing flooding and damage to property and infrastructure.

Overtopping can pose a risk to pedestrians, vehicles, trains and structures behind the defence through discharge flows and flying shingle. The EurOtop Manual (Pullen et al., 2007) defines the consequences of overtopping into four general categories;

a) *Direct hazard of injury or death to people immediately behind the defence.*
b) *Damage to property, operation and/or infrastructure in the area defended, including loss of economic, environmental or other resource, or disruption to an economic activity or process*
c) *Damage to defence structure(s), either short-term or longer-term, with the possibility of breaching and flooding.*
d) *Localised flooding from overtopping discharge*

Shingle beaches are very efficient at dissipating wave energy (Figure 6-2-1). To calculate overtopping rates under different scenarios a methodology was developed and applied consistently to the whole frontage. This is summarised in Figure 6-2-2 and described in the following text.

FIGURE 6-2-1 DISSIPATION OF WAVE ENERGY ON A SHINGLE BEACH (KINGSDOWN, 2009)

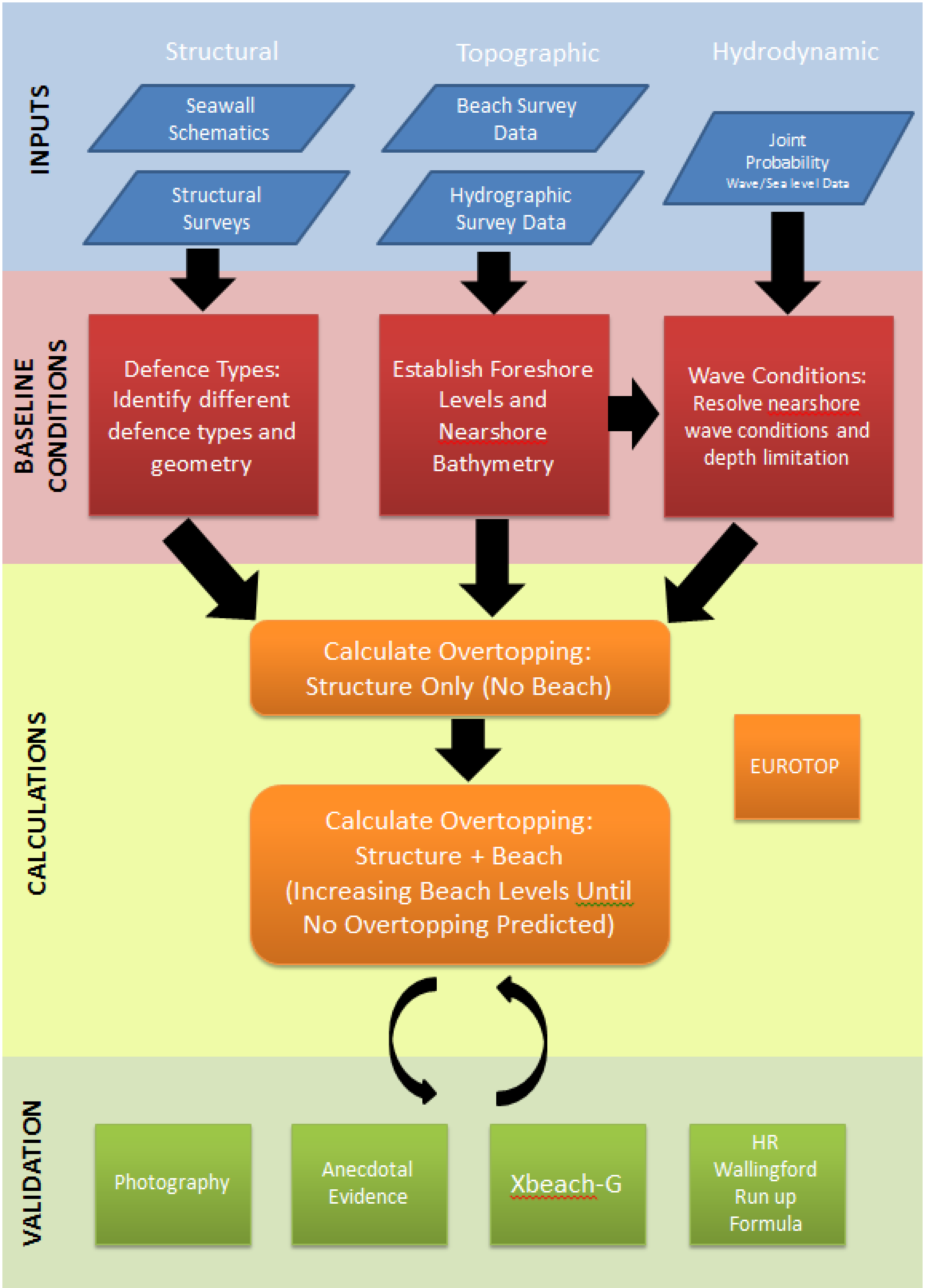


FIGURE 6-2-2 SUMMARY OF OVERTOPPING METHODOLOGY DEVELOPED FOR THIS REPORT

INPUTS

Structural geometry was obtained through seawall schematics/as built drawings where available. These not only provide the crest height of structures but also the hidden portion of the defence and toe levels obscured by current beach levels. In areas where this information was not available the analysis relied on structure surveys of the visible defence carried out as part of the Regional Coastal Monitoring Programme. When the latter provided insufficient detail it was supplemented with LiDAR data.

Beach survey data provided current beach levels and geometry in addition to historical variations dating back to 1999. Where this provided insufficient information on beach toe levels, foreshore heights and the approach to the beach it was supplemented with bathymetric survey data.

Hydrodynamic conditions were defined by the outputs of the joint probability study (Mason, 2014) and provided nearshore conditions for return probabilities from 1 to 200 years.

BASELINE CONDITIONS

Structural geometry and foreshore levels were used to break down each management unit into defence sections (see Section 6-1). These then formed the basis for each different set of overtopping calculations. In order to calculate the worst set of conditions for each set of joint probability values it was necessary to account for the effects of depth limitation and define wave conditions at the toe of the structure/beach (Figure 6-2-3).

All management units in the study area have depth limited waves under the higher return period events. To calculate the depth limited spectral significant wave height at the structure/beach toe the results from a simple 1D energy decay model (Van der Meer, 1990) are used, in which the influence of wave breaking is included. The model converts deep water wave steepness, local water depth and the slope of the foreshore into a breaker index (Pullen et al., 2007). The latter defines the reduction in significant wave height.

Results produce a wave height limited to between 50-60% of the water depth; precise figures for each defence section are included in the results spreadsheets in Appendix G.

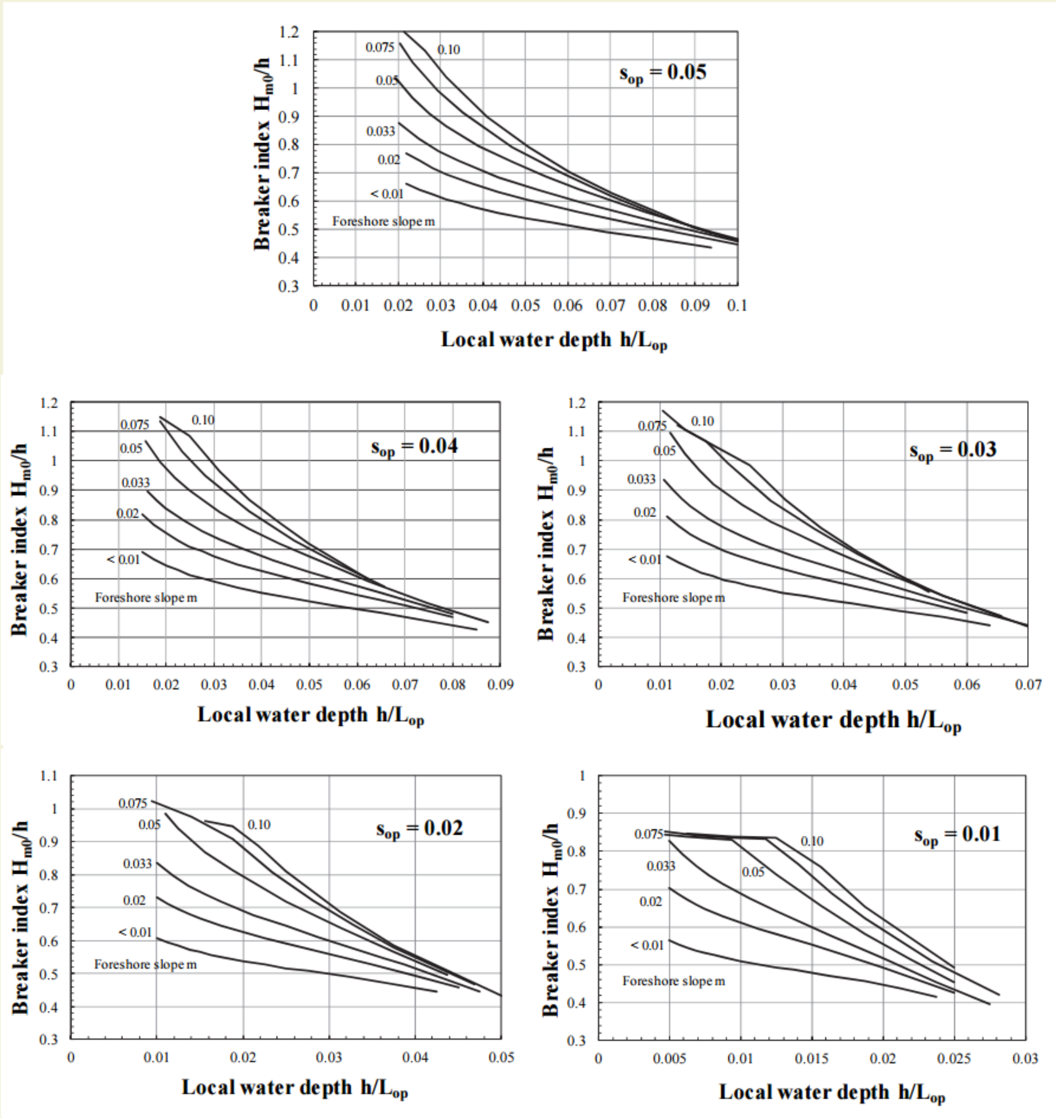


FIGURE 6-2-3 CALCULATION OF DEPTH LIMITATION USING THE BREAKER INDEX (PULLEN ET AL, 2007)

CALCULATIONS

For most calculations the EUROTOP research was used (Pullen et al., 2007), based on significant previous research and physical model testing it provides a tool for calculating overtopping at a variety of seawall and structure types.

Initial calculations were run for each defence type without a beach present (Figure 6-2-4); this provided a worst case scenario for each section. As there is more confidence in the overtopping results for standalone structures it also provided a baseline for further calculations.

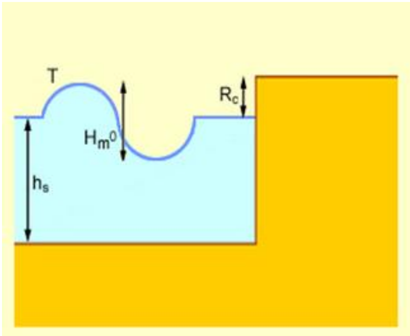


FIGURE 6-2-4 EUROTOP - CALCULATION OF OVERTOPPING AT A SIMPLE VERTICAL SEAWALL

The reason that there is more confidence in predicted results for standalone structures is that the geometry is simple and fixed. They are also well suited to Physical model testing with limited scaling effects; this also largely applies to more complex structures and rock revetments. Introducing a shingle beach to the defence geometry creates a higher level of uncertainty owing to the very limited number of laboratory or field tests.

When calculating wave run-up on shingle beaches there are a number of factors that will affect the result and are also subject to change in the short term. These include beach volume, beach shape and beach composition. The first two can be constrained by locally known variability from the coastal monitoring programme but beach composition, including grain size and grading, permeability and roughness factors can only be approximated, especially as they change both spatially (within a management unit) and temporally (over various time scales).

In order to improve on current methods of calculating beach run-up a sub-project to this report was commissioned, *Wave run-up on shingle beaches: a new method* (HRW, 2014). The report contains a comparison between a set of measured run-up data taken at Worthing beach and several established formula for predicting run-up. These include some of the methods available in EUROTOP, Figure 6-2-5 illustrates the results from one of the more simplistic approaches.

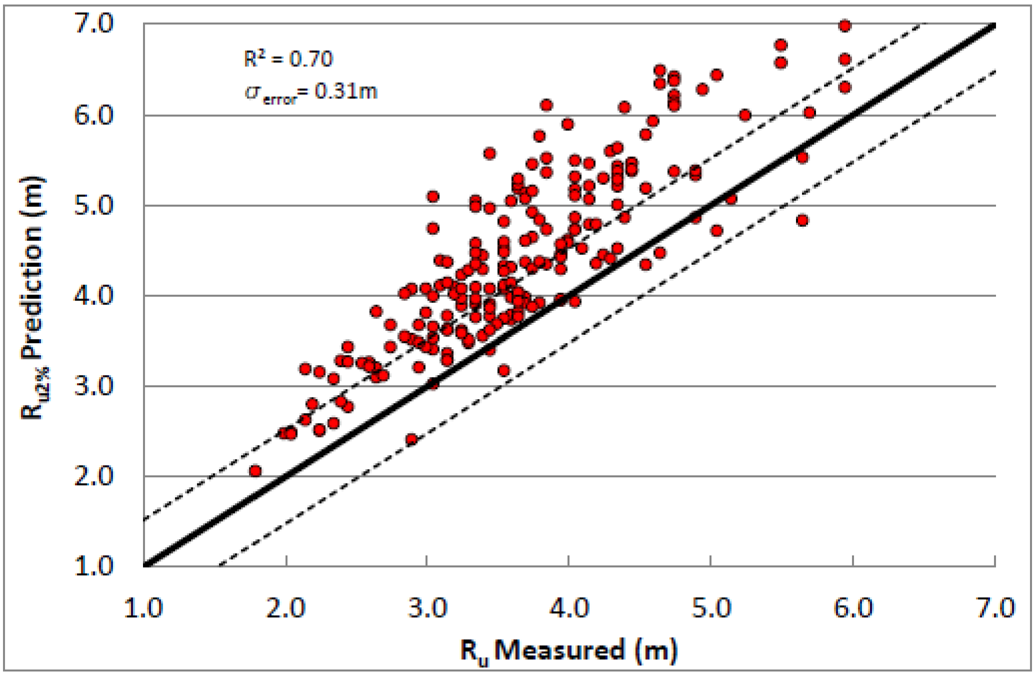


FIGURE 6-2-5 SIMPLISTIC EUROTOP METHOD VS ACTUAL MEASURED DATA AT WORTHING (HRW, 2014)

The main output of the report was an improved formula for calculating run-up on shingle beaches. The formula uses a representation of the spectral wave data, and in particular takes good account of the swell component, producing a much better fit to measured data at Worthing and smaller samples taken elsewhere on shingle beaches in the Southeast.

For this study the new formula was not used for the bulk of the calculations but was used as a validation tool to sense check the results from EurOtop, for example overtopping can only start once run-up has reached the beach crest level. There are two main reasons for this;

a) *The new formula uses spectral wave data and although recorded spectral data is available from the local wave buoys there is no way to predict the swell component of larger storms and their return periods.*

b) *There is no simple way to incorporate the new run-up formula into the EUROTOP calculation tools when assessing overtopping for a combined beach and structure.*

There are plans to update EUROTOP to include the formula, there is also on-going research at HR Wallingford to assess the effects of bi-modal seas and overtopping of shingle beaches and structures. When this is complete it may be possible to improve on the results of this study, but the results presented are produced using current EUROTOP methodology, however the improved formula is used to help validate results.

For each defence section the structure only results were used as a starting point, a small beach was then introduced to the geometry and overtopping rates calculated (Figure 6-2-6). The size of the beach was then steadily increased until the point was reached where no overtopping was predicted. In order to make the results more comparable with surveyed beach levels and design levels each beach size was converted to a representative cross sectional area (CSA).

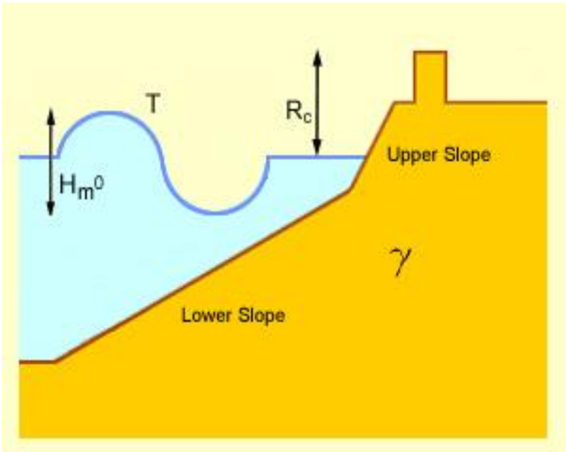


FIGURE 6-2-6 EUROTOP- CALCULATION USING MORE COMPLEX STRUCTURES

In order to calculate the influence of wave return walls with beaches it was necessary to perform an adjustment outside of EurOtop. The general principle applied within EurOtop is that a wall with a large freeboard has the biggest reduction in wave overtopping as the wave has room to be channelled by the wave return. As water levels increase the effect of the wave return declines until it reaches a point where it has no effect at all in reducing overtopping. The same principle applies to shingle beaches, where crest levels towards the top of the wall diminish the effect. This is not accounted for in EUROTOP so the equations were adapted and applied as an adjustment to the overtopping figures. The full methodology is described in Appendix G.

While the authors concede that the EUROTOP methodology used for this study has a propensity to over predict run-up on shingle beaches, and therefore overtopping, it effectively calculates the maximum run-up/overtopping for a given set of input conditions. The variability introduced by not fully accounting for inputs such as swell conditions means that the actual values may be lower, but rarely higher. This is important when establishing critical defence levels, and also builds in a factor of safety to the final results; hence we have carried out the validation.

VALIDATION

Given the potential uncertainty in overtopping results it was important to validate the results, this was done with four methods.

1. Photographic evidence of large overtopping events and retrospective comparison with predicted overtopping (e.g. Figure 6-2-7).

Waves crash against the seafront in a dramatic high tide at Deal beach this afternoon. Picture: Claire Steer

FIGURE 6-2-7 WAVE OVERTOPPING, DEAL (DECEMBER, 2013)

2. Anecdotal evidence in the form of information that is not well documented or photographed. The prime example of this is shingle on the promenade, which is indicative of small scale overtopping (e.g. Figure 6-2-8). Where management authorities have to periodically clear this it is evident that the defence is subject to minor overtopping on a regular basis. Results can be queried to ensure these events are predicted.

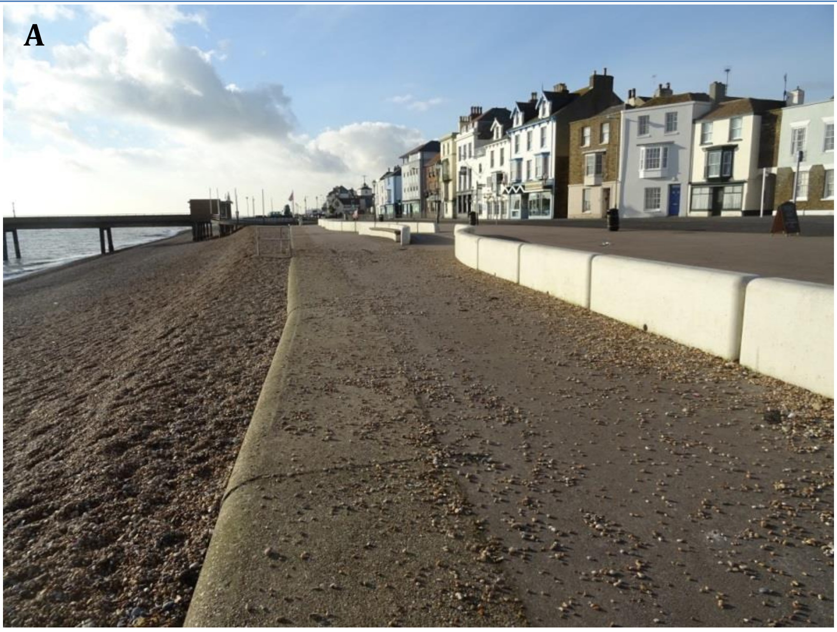


FIGURE 6-2-8 EVIDENCE OF OVERTOPPING IN DEAL (A) ON THE PROMENADE IN CENTRAL DEAL AND (B) AT KINGSDOWN (BOTH PHOTOS 2016)

3. XBeach-G is a software tool developed in collaboration between Plymouth University and Deltares (Masselink et al, 2014). It simulates storm impacts on gravel beaches and computes wave-by-wave flow and surface elevations over the duration of a storm. Sample data along the study area was run in XBeach-G to check the results were comparable (Figure 6-2-9).

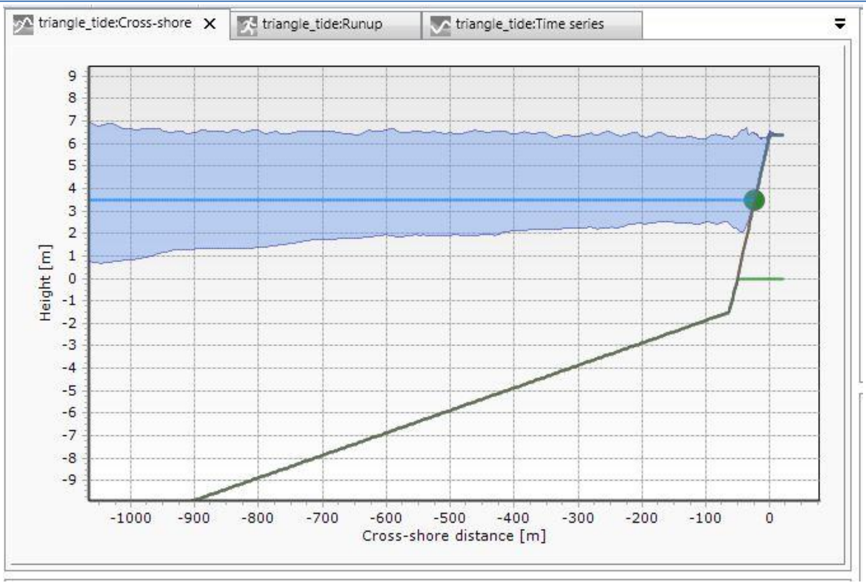


FIGURE 6-2-9 XBEACH-G SAMPLE SCREENSHOT

4. The improved formula presented in Wave run-up on shingle beaches: a new method (HRW, 2014, see Figure 6-2-10) was used in areas that were prone to green water overtopping (No structure and run-up exceeds crest). By running calculations for a number of swell components results could be verified as reasonable and ensure that an underestimate had not been made.

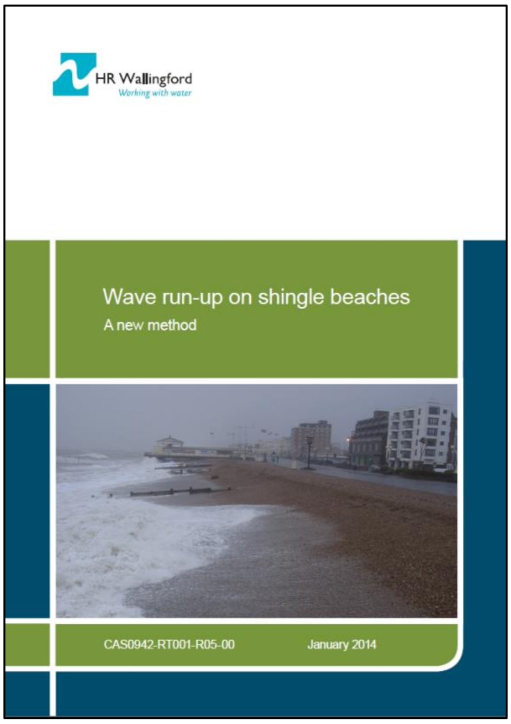


FIGURE 6-2-10 SUB-PROJECT RESEARCH AND DEVELOPMENT OF IMPROVED RUN-UP FORMULA

6-2-2 SEAWALL FAILURE

Coastal defences in the Southeast are most commonly comprised of a beach and structure combination. These work in unison with the beach absorbing wave energy, breaking waves and protecting the sea wall from direct wave attack. The wall acts to further reduce the risk of overtopping from waves that run up past the crest and present a significant barrier to overtopping and erosion should the beach levels drop to lower levels. Consequently these elements should not be considered in isolation, but as two parts of the same defence with each one playing a critical role.

As beach levels lower due to erosion, draw down in a storm, or failure of groynes that act as controlling structures the seawall becomes increasingly exposed to direct wave attack. In addition to a probable increase in overtopping rates, this significantly increases the risk of seawall failure.

FIGURE 6-2-11 DILAPIDATED GROYNES, LOW BEACH AND SEAWALL FAILURE AT KINGSDOWN (2013)

As beach levels continue to drop there is an additional threat of undermining of the seawall foundations. This can cause the structure to collapse and/or a draining of the fill material from behind the seawall that reduces the structural integrity (Figures 6-2-11 and 6-2-12). A beach also provides a lot of support and weighting in front of the structure, without which toppling or sliding of seawall sections can occur (Figure 6-2-13).

Typically, before beach levels get low enough to pose a credible threat to the structure the standard of protection has already become sub-standard due to the increased likelihood and severity of overtopping. There are instances where the structure itself provides a sufficient barrier to overtopping, but often in these cases a beach is required to be maintained in order to protect the structure and prevent undermining.

FIGURE 6-2-12 EXAMPLES OF UNDERMINING AT TANKERTON (LEFT) AND RECULVER (RIGHT) (BOTH PHOTOS 1999)

Calculating failure probabilities for all stretches of structures along the study frontage is outside the scope of this report. Additionally, the conditions of seawalls are often unknown especially if covered by beach for many years. The report does however highlight areas where the loss of beach would result in the potential for undermining and/or increased exposure to wave attack that may result in a significantly increased risk of failure.

For coastal management authorities should undertake regular asset condition inspections in order to assess the need for any maintenance. Historically these may have been picked up by NFCDD inspections. It is anticipated that this will shortly be replaced by AIMS, but in the interim each coast protection authority should conduct their own regular coastal asset inspections.

FIGURE 6-2-13 FAILURE OF A SEAWALL AT ALL HALLOWS DUE TO SLIDING/TOPPLING OF DEFENCE SECTIONS (2015)

Two types of seawall failure are considered in this method; undermining and structural failure (breach or partial breach). For seawalls in good condition undermining is assumed to be the critical failure mechanism, and for seawalls in bad condition (where there is a risk that wave attack will cause failure) structural failure is assumed to be the critical failure mechanism. These calculations are dependent upon the type, construction and condition (where known) of the sea defences (all known defence schematics are provided in Appendix F).

For undermining calculations a beach level was calculated that prevents the defence foundations from being exposed, allowing for a 1:10 slope (due to draw down during a storm event) and a 50cm depth of scour (Figure 6-2-14). The full methodology is provided in Appendix G.

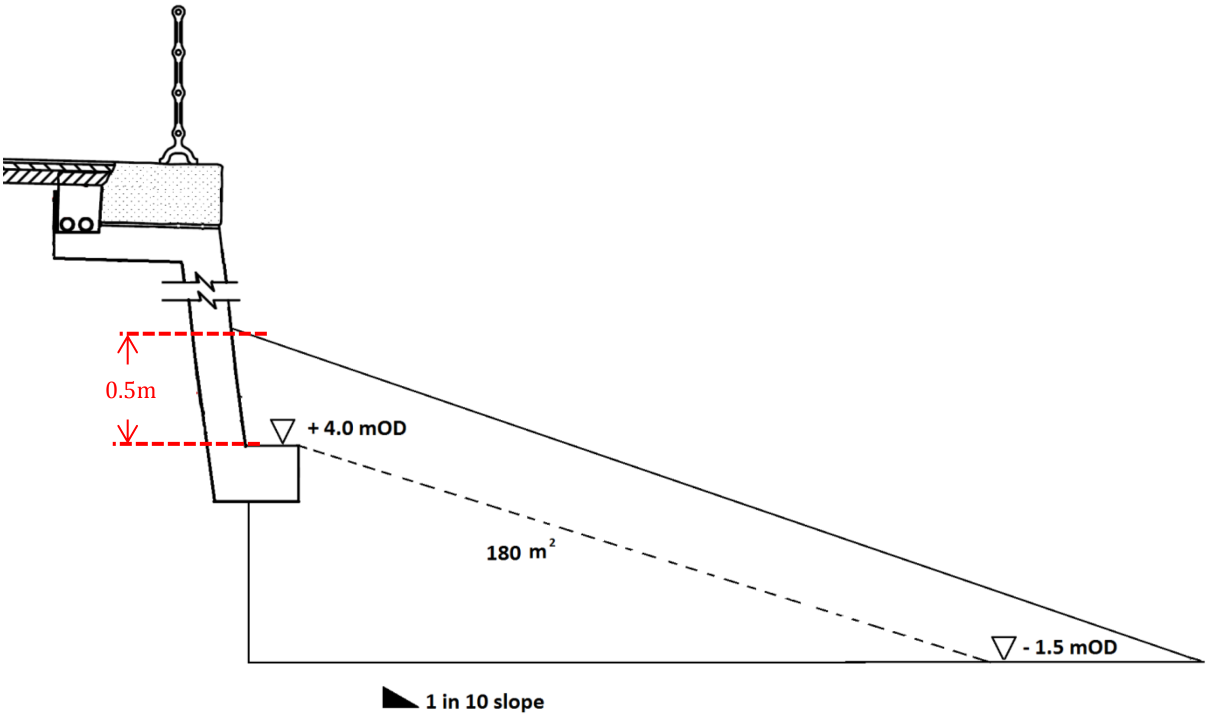


FIGURE 6-2-14 CRITICAL BEACH LEVEL TO PREVENT UNDERMINING OF THE DEFENCE FOUNDATIONS INCLUDING A 50CM ALLOWANCE FOR SCOUR

For structural failure a beach cross section is calculated that prevents critical overtopping (and wave attack) of the defence structure, using the Eurotop allowable overtopping limits (see Appendix C).

6-2-3 FLOODING & BREACHING

Flooding can occur through excessive overtopping, seawall failure or breaching of barrier beaches. All of these scenarios can result in flooding when the hinterland is below the extreme sea level or defence height.

In order to calculate the properties at risk from a 1:200 year event (4.5mOD) a planar still water level flood map was created using LiDAR data (most recent dataset, 2015) and combined with the Ordnance Survey's AddressBase property layer (Figure 6-2-15). There is a large flood basin extending from the sand dunes at Sandwich to the pier at Deal, a smaller basin at Walmer and three pocket basins at Kingsdown.

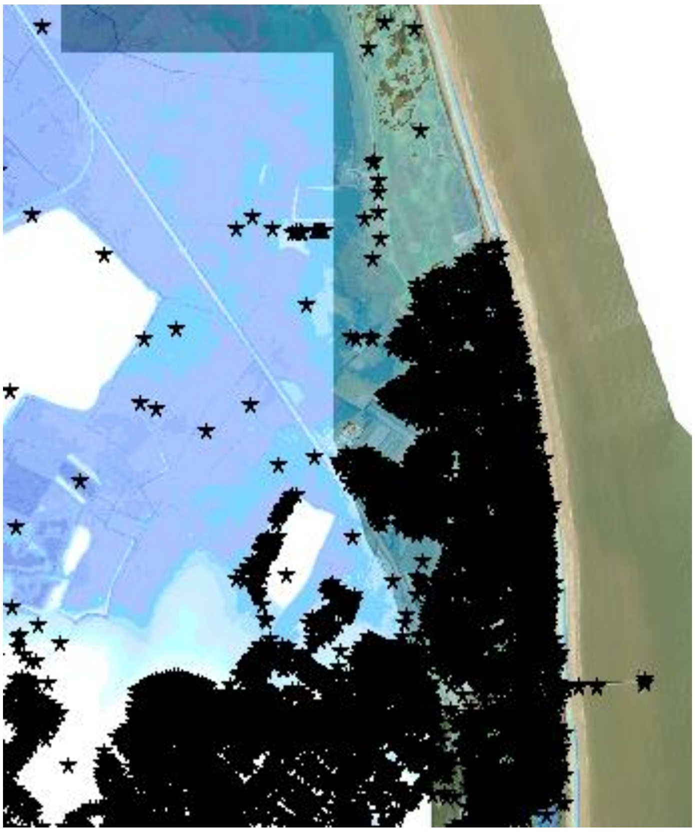


FIGURE 6-2-15 EXAMPLE OF PROPERTIES (STARS) WITHIN THE 1:200 YEAR EXTREME WATER LEVEL PLANAR FLOODPLAIN (NORTH DEAL)

A database of at-risk properties was created with information including, property type (Detached, Semi-detached, Terrace, Flat etc.), council task banding, postcode and street address. This detailed information is then combined with the ZOOPLA house price database to produce cost estimates for those properties at risk of flooding (Table 6-1).

TABLE 6-1 ESTIMATED PROPERTY DAMAGE COSTS

PLACE	PROPERTIES AT RISK	APPROX. VALUE (£K)
SANDWICH TO DEAL	3,811 THEORETICAL (1:200 YEAR CONTOUR) 1,418 PRACTICAL (HALCROW, 2012)	1,086,957 483,866 (PV)
WALMER	214	64,200
KINGSDOWN	46	13,800

In total this equates to a theoretical value of over £1 billion of property that is reliant on the sea defences not breaching on a large scale along this frontage. There are several important caveats; firstly that the planar still water level floodplain does not account for flood pathways, and secondly that above ground properties have not been removed from the total count. In reality, the most likely flooding events would result in only a partial inundation of the flood plain, however modelling numerous individual breach and overtopping scenarios is outside the scope of this report. The most recent in depth flood modelling was undertaken by Halcrow (2012) which suggests for Deal a smaller total of 1,418 properties within the 1 in 200 year floodplain.

6-3 OVERTOPPING OUTPUT

In order to visualise the results for each defence section they are presented on a chart (Figure 6-3-1) which compares the predicted overtopping rate with the size of the beach cross sectional area (CSA). This shows the decrease in overtopping for each of the return period conditions (1 to 200 years) as the size of the beach increases. For sections where a rock revetment is present, a single overtopping calculation is performed for overtopping over the revetment.

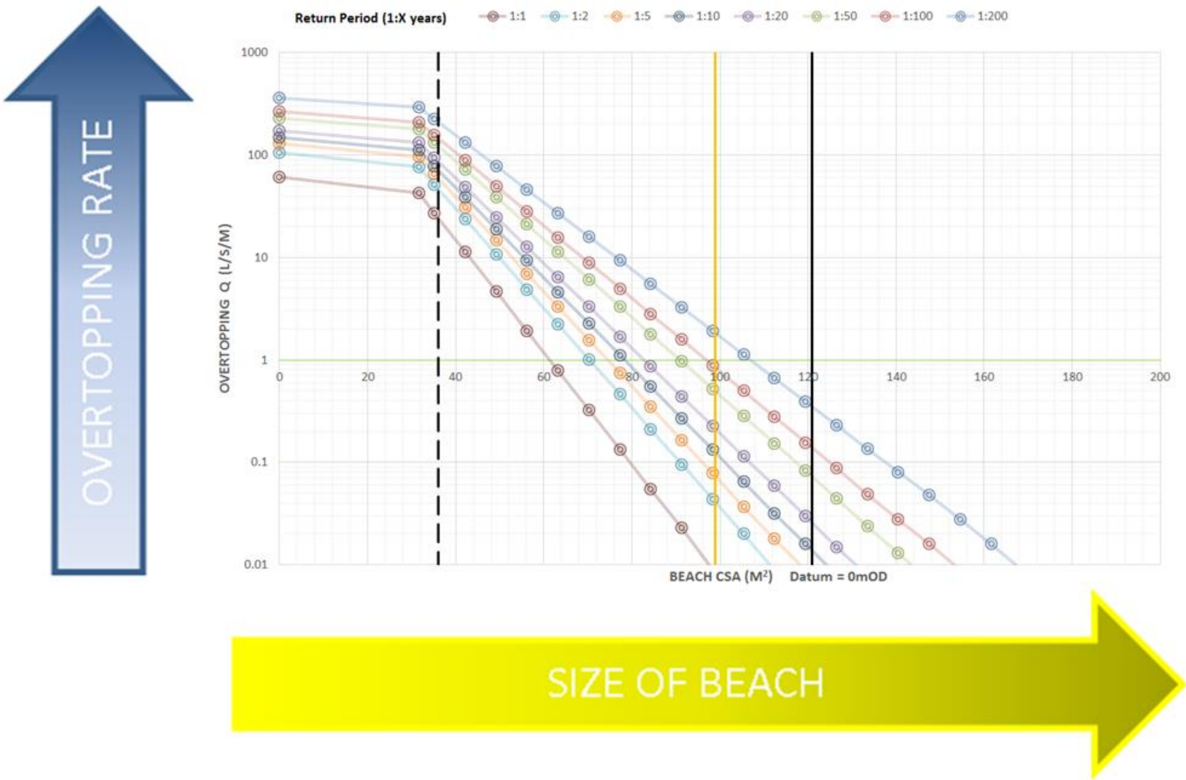


FIGURE 6-3-1 EXAMPLE OF OVERTOPPING RESULTS CHART

From the chart it is possible to read off a predicted overtopping rate for a particular beach size under different conditions. The jump from zero CSA to the next point reflects the fact that CSA is calculated above a datum (normally the beach toe level), but in reality some of that area is composed of foreshore and lower structure geometry, however to aid clarity calculations solely conducted on structures (no beach) are plotted at zero.

Three vertical lines are plotted on the chart to add context to the results.

Dashed black - the lowest CSA values recorded for the smallest beach profile (2003-2015) Solid black – the highest CSA values recorded for the largest beach profile (2003 – 2015) Amber line - the current (summer 2015) lowest CSA value recorded for any profile in that defence section.

All three of these lines could represent different profiles within the section. Details for each profile can be found in Figures 7-3-1 (Deal) and 0 (Sandwich) in Chapter 0.

The majority of these frontages have a combination of beach and seawall and the overtopping calculations consider them both; presenting the results according to the actual structural configuration seen on site.

Where the beach is the only forward defence (i.e. no hard structure or rock armour) the calculations are based on the beach only and an additional line is plotted (red dashed), showing the minimum CSA at which the modelled crest height can be maintained at a 1:7 slope. The calculations for cross-sectional areas less than this threshold value are based upon a reduced crest height (Figure 6-3-2). This threshold CSA value is denoted by a dashed red line on the graphs.

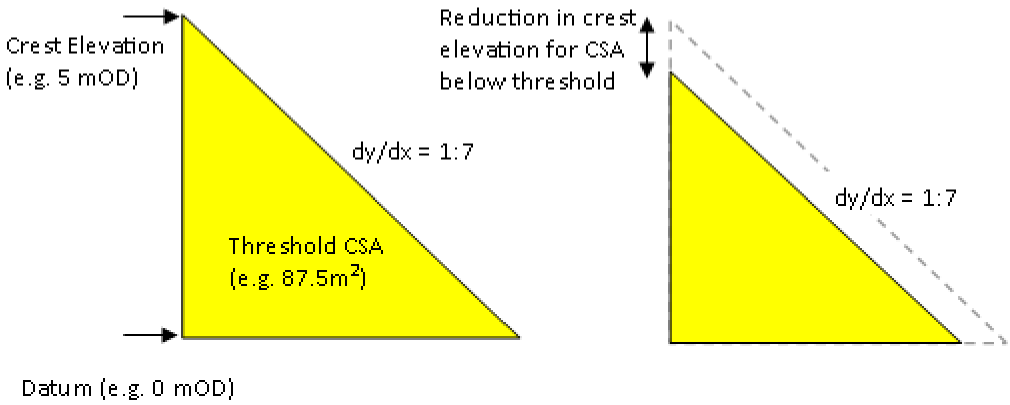


FIGURE 6-3-2 REDUCTION IN CREST HEIGHT FOR PROFILES BELOW A THRESHOLD CSA

Where defence structures have both a front wall and a rear wall results are presented for both components of the defence. The notation is a 2 after the section name for the rear wall, for example Deal J describes the results for the front wall, and Deal J2 describes the results for the rear wall. An example results graph is shown in Figure 6-3-3; full results and details of the input conditions are provided for each set of calculations within appendix G. The relationship to the defence standard of protection is shown in Chapter 0, and the implications of the results are discussed in Chapter 0.

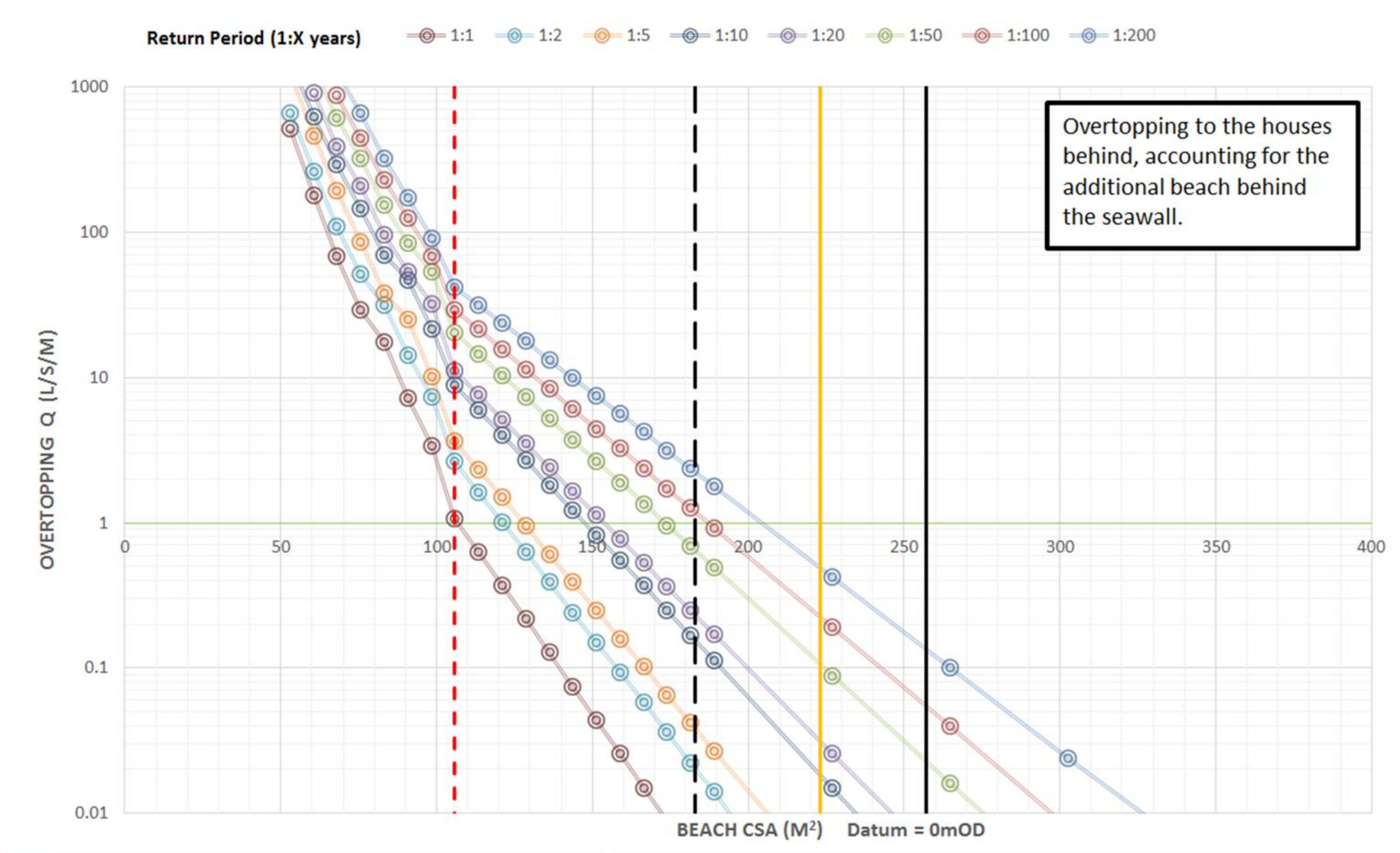


FIGURE 6-3-3 OVERTOPPING RATES:
DEAL – SECTION C2 (BIG BEACH)

Profile Range 4b00516 to 4b00521

- Highest CSA of any profile in this section (2003-2015)
- Lowest CSA of any profile in this section (2003-2015)
- Lowest Current CSA of any profile in this section (Summer 2015)
- CSA threshold at which crest width disappears under 1 in 7 slope

CANTERBURY CITY COUNCIL

7 STANDARD OF PROTECTION

7-1 BASELINE CRITERIA

This chapter provides technical analysis and advice on management of shingle beaches. A shingle beach performs two coastal protection functions by breaking waves and absorbing wave energy, in addition to providing a physical barrier;

1. ***Prevention of Flooding:*** Reducing wave overtopping and preventing inundation

2. ***Protection of Coastal Structures:*** Preventing structural undermining and reducing wave impact damage, whilst providing toe weighting and structural support

These two factors are considered in unison in order to calculate the current standard of protection (SoP) and recommended beach levels. Typically the primary failure mechanism is excessive overtopping, flooding and damage to structures close to the beach. In this respect the defence can be considered to have a sub-standard level of protection, in most cases there will have to be a further reduction in beach levels before a breach or seawall failure becomes a significant risk.

Minimum beach levels are calculated by defining a maximum allowable overtopping limit for each section based on the tolerable discharge limits and the overtopping results for a 1:200 year storm (see Appendix G). Maintaining a beach level above this threshold achieves a present day standard of protection of > 1 in 200 years. **A 1 in 200 year SoP has been used throughout this report and all sister reports, throughout the South East, in order to provide consistency in reporting.**

It is not possible to present standard of protection results for every return period, instead for SoPs other than the 1:200 year the required trigger levels can be calculated from the overtopping graphs, calculated for a range of return periods from 1:1 to 1:200 years and these are provided in Appendix G.

A full structural assessment of sea defence structures, and failure probabilities, is outside the scope of this report. It does however consider the risk of structural undermining, based on the structure toe levels of the sea defence schematics (Appendix F). The analysis takes into account beach draw down during a storm in addition to calculating the potential scour depth at the structure. This allows for the calculation of a minimum beach required to prevent undermining.

In the event that this is larger than the threshold calculated for overtopping the undermining CSA is used in preference when establishing trigger levels.

It should be noted that although the overtopping limit is based on providing a 1 in 200 year standard of protection, structural damage and undermining can result from relatively minor storms once the beach level has dropped below the critical threshold.

7-2 TRIGGER LEVELS

The naming convention and definition of trigger levels varies significantly between previous beach management plans and other reports. For the purpose of this report three trigger levels are used and described below for clarity. These were designed to help aid interpretation of coastal monitoring data and to inform beach management works.

CRITICAL LEVEL – This is the minimum beach level required to prevent overtopping exceeding tolerable limits in a 1:200 year storm event and/or a significant risk of structural damage or undermining. A Sub-Critical level is also defined which is the equivalent level for a standard of protection of 1:10 (approximately equal to half the CSA of the 1:200 event).

The problem with a critical level from a beach management perspective is that any beach at or just above this level may drop below it during a single storm or in short time under exposure to average conditions. This would require regular intervention and beach works to increase the beach level throughout the year, and even then potentially leave the area with a sub-standard standard of protection during a storm. As such it is unlikely a beach would be maintained at the critical level, but it provides a good reference for when emergency works are required and the urgency.

MAINTENANCE LEVEL – This level is higher than the critical level. The difference in beach cross sectional area is defined by the largest observed annual drop in beach level (since monitoring began in 2003), or where greater the largest loss during a storm event.

If beach levels are maintained above this level then it is highly unlikely that the beach size will reduce to below the critical level within a year or during a storm event. In reality in most years the beach level will only reduce by a fraction of this amount. Having a beach this size gives the coast protection authority time to plan works and be more efficient with little risk of levels dropping below the critical level.

DESIGN LEVEL – This is higher than the maintenance level and takes into consideration the impact of the defence failing (though undermining or significant overtopping), and builds in an appropriate factor of safety. When carrying out works, where possible, the beach size should be increased to this level.

Due to the maintenance level only referencing actual changes in beach size since 2003, there is always the possibility of a larger storm, or series of storms, that would reduce the beach size by more than the maintenance level. The design level accounts for this by adding a factor of safety, this is not a consistent figure for all locations but based on the potential impact of the defence being significantly overtopped or failing. For example a heavily urbanised area with properties below MHW would have a larger safety factor than a defence section protecting farmland. It also follows that erosive beaches have a higher design threshold than stable or accreting sections. This also allows time for remedial action and beach works following a storm event.

However, a larger beach may also be prone to higher rates of longshore transport, in particular in groyned sections of the coast.

It is important to note that CSAs within the Design Range (Yellow) and Maintenance Range (Orange) are above the 1:200 standard of protection. These areas give a factor of safety to allow time for coastal managers to intervene before the beach conditions drops below the required level of protection (Figure 7-1).

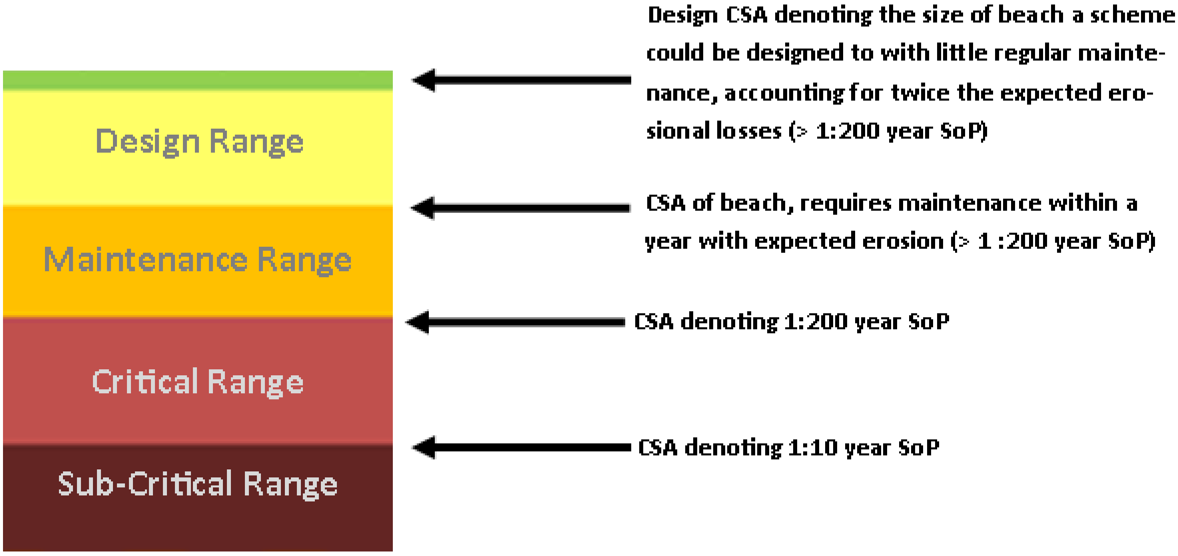


FIGURE 7-1 DESIGN, MAINTENANCE, CRITICAL AND SUB CRITICAL RANGES BASED ON TRIGGER LEVELS

7-3 CURRENT STANDARD OF PROTECTION

Having defined the trigger levels it is possible to ascertain not only the current standard of protection, but also to appraise how the beach has performed historically. Trigger levels are calculated as a beach cross sectional area (CSA) which are be plotted for each profile location along the frontage and compared to the surveyed beach CSA through time. Profile locations overlain on aerial photography are provided in appendix D.

In order to condense this information so that the current standard of protection and historical performance can be viewed on a single graph for each management unit it is necessary to summarise the data for each profile as shown in Figure 7-2.

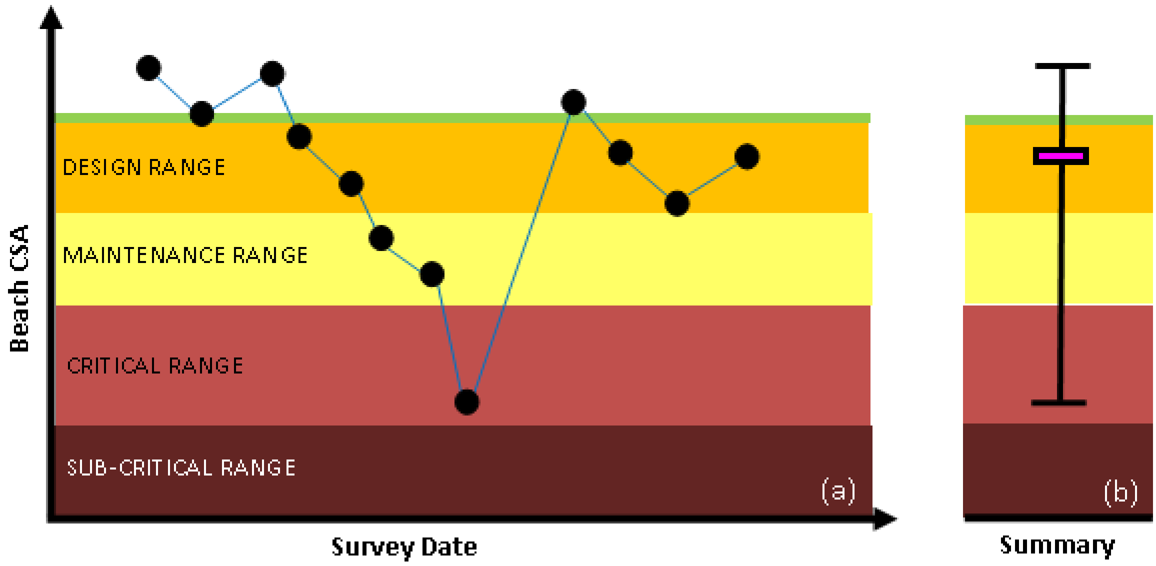


FIGURE 7-2 PRESENTATION OF STANDARD OF PROTECTION AND TRIGGER LEVELS

(a) historic variation of beach levels (csa)

(b) summary of data, pink bar – current beach level, black bars – historic high and low

The following pages provide a graphical summary of the SoP for each management unit alongside key parameters for each defence section including the primary risk, critical cross-sectional area and defence types.

IMPORTANT NOTE:

Standards of protection and trigger levels defined in this report are based on current information and historic data at the time of writing. This report focusses on the 1 in 200 year SoP for consistency but please note it may not be appropriate at all sites to provide this SoP as the required protection could be higher or lower. The chosen SoP should be economically viable and site-appropriate. Coastal managers should be aware that several factors can result in a change to the SoP and/or trigger levels. These include, but are not limited to the following;

- Deterioration of seawall condition leading to an increase in required beach
- Seawall raising or repair reducing beach requirements and trigger levels
- New development behind the sea defence may necessitate a higher standard of protection and larger trigger levels
- Groyne failure can result in higher trigger levels due to increased susceptibility to erosion.
- Introduction of new or larger controlling structures
- Reduction of input sediment to the system due to changes to management practices down drift
- A significant change to the grading characteristics of the beach material
- Drop in foreshore levels allowing larger waves to reach the beach
- Climate change
- A change to the management regime for example from 'little and often' to 'large and infrequent' or vice versa.

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7-3-1 OLDSTAIRS BAY TO SANDOWN CASTLE (DEAL, 4BSU06)

The Kingsdown, Walmer and Deal frontage is highly variable with several sections having dropped to within the critical range at some point in time. Oldstairs Bay does not have beach trigger levels as the rock armour and splash wall provide a 1 in 100 SoP with no beach material.

Currently, the most critical section is at Wellington Parade (Section E, south) as beach crest is narrowing to expose the timber crib wall and is a known management hotspot which regularly scours. The centre of the unit is has surplus shingle material, well above a 1 in 200 SoP and suitable location for shingle extraction.

Moving north, the beach levels for Deal (south) are within the design and maintenance ranges and require no immediate attention.

Historically, beach levels north of the Pier and towards Sandown Castle, have fallen into the critical ranges (below a 1 in 200 SoP). Since the 2012 the beach management recharge scheme within Sections G-K, the frontage here was either above the suggested design or within the design range (the top of the black bar for each profile across this whole section represents the CSA following the works). This scheme was completed in 2014 and maintenance to sustain these levels was suggested annually or biannually, depending on monitoring data. Works have since been undertaken in April (2015). The levels are currently within the design and maintenance ranges; all above the 1 in 200 SoP.

VARIATIONS FROM FIGURE 7-3-1

The Kingsdown sections (C and D) appear critical; which in summer 2015 they were. There has since been an extensive recycling scheme which deposited 65,000m^3 within the bays. Future monitoring will be required to determine the new beach levels and the behaviour trends.

TABLE 7-1 DEAL INTERPRETATION TABLE: RISK MECHANISM AND CONSEQUENCES

Defence Section	Operator	Primary Defence	Secondary Defence	Key Risk mitigated by beach	Critical Cross Sectional Area (m^2)	Allowable OT rate (if applicable) $lm^{-1}s^{-1}$	No. of properties in flood plain	Hinterland	Notes
A (Oldstairs Bay)	Dover DC	Splashwall and rock armour	-	Overtopping	-	50	Rising Ground	Residential	
B		Shingle Beach	-	Overtopping	100	50	Rising Ground	Residential	
C		Shingle Beach and Seawall (with return)	Shingle beach behind seawall	Sea wall failure	56	1	-	Residential	Very recent scheme (2016) to restore groynes. Back beach behind sea wall.
D		Shingle Beach and Seawall	Shingle beach behind seawall	Sea wall failure	56	1	46	Residential	
E		Shingle Beach	-	Overtopping	190	1	214	Residential	Areas of both scour and shingle accretion.
F		Shingle Beach and Seawall (with return)	-	Overtopping	95	1		Residential	
G		Shingle Beach and seawall	Curved wavewall	Overtopping	100	1		Residential	
H		Shingle Beach and Seawall	Rearwall	Overtopping	105	1		Residential	
I		Shingle Beach and Seawall	Rearwall	Sea wall failure/ Overtopping	65	1	3,811* theoretical	Residential	
J		Shingle Beach and Seawall	Rearwall	Sea wall failure/ Overtopping	85	1	1,418 practical	Residential	
K		Shingle Beach and Seawall	Rearwall	Sea wall failure/ Overtopping	60	1		Residential	
L (Sandown Castle)		Seawall and Rock Armour		Sea wall failure/ Overtopping	95	10		Residential	

** theoretical value from SWL 1:200 Year, practical is Halcrow flood modelling (2012) (See Chapter 6)*

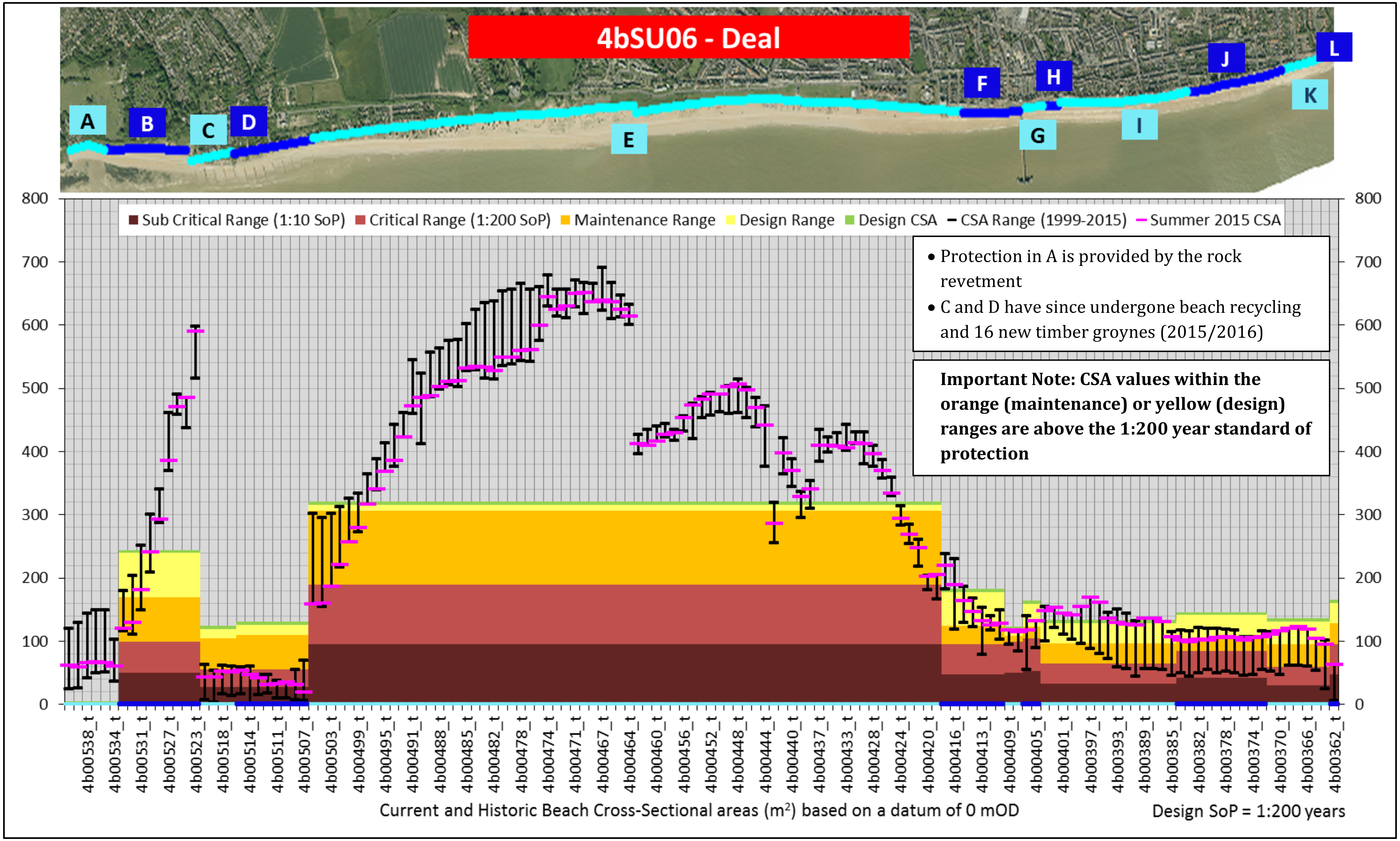

FIGURE 7-3-1 OBSERVED CSA CHANGES IN DEAL (4BSU06) WITHIN THE CONTEXT OF BEACH TRIGGER LEVELS

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7-3-2 SANDOWN CASTLE TO PEGWELL BAY (SANDWICH, 4BSU05)

The Sandwich frontage is consistently above the 1 in 200 SoP (top of the red); the beach levels are lowest near to the slipway but again, still above the 1 in 200 SoP. There are no breach trigger levels in front of the rock revetment as the revetment alone is designed to a 1:300 SoP.

Section C should not contain any shingle sediment; however shingle is present relatively close to the embryonic sand dunes. Figure 7-3-2 illustrates where the shingle stops and sand beach begins and the extents of the NAI.

The frontage generally accretes material due to the northerly transport (Chapter 5), and will most likely to continue to gain shingle every year.

TABLE 7-2 SANDWICH INTERPRETATION TABLE: RISK MECHANISM AND CONSEQUENCES

Defence Section	Operator	Primary Defence	Secondary Defence	Key Risk mitigated by beach	Critical Cross Sectional Area (m^2)	Allowable OT rate (if applicable) $lm^{-1}s^{-1}$	No. of properties in flood plain	Hinterland	Notes
A	EA	Shingle Beach and Rock Revetment	-	Defence failure	-	25	3,811 theoretical* 1,418 practical (shared floodplain with Deal)	Golf course, flooding of Deal from North	Embankment built from colliery material.
B	EA	Shingle Beach with Shale embankment	-	Defence failure	120	10		Golf course, flooding of Deal and Sandwich	
C	Kent Wildlife Trust / Dover District Council	Shingle Sand Beach	-	Overtopping	170	25	-	sand dunes/golf course	
D	Kent Wildlife Trust	Sand Beach	-	Overtopping	280	50	-	sand dunes	

** theoretical value from SWL 1:200 Year, practical is Halcrow flood modelling (2012) (See Chapter 6)*

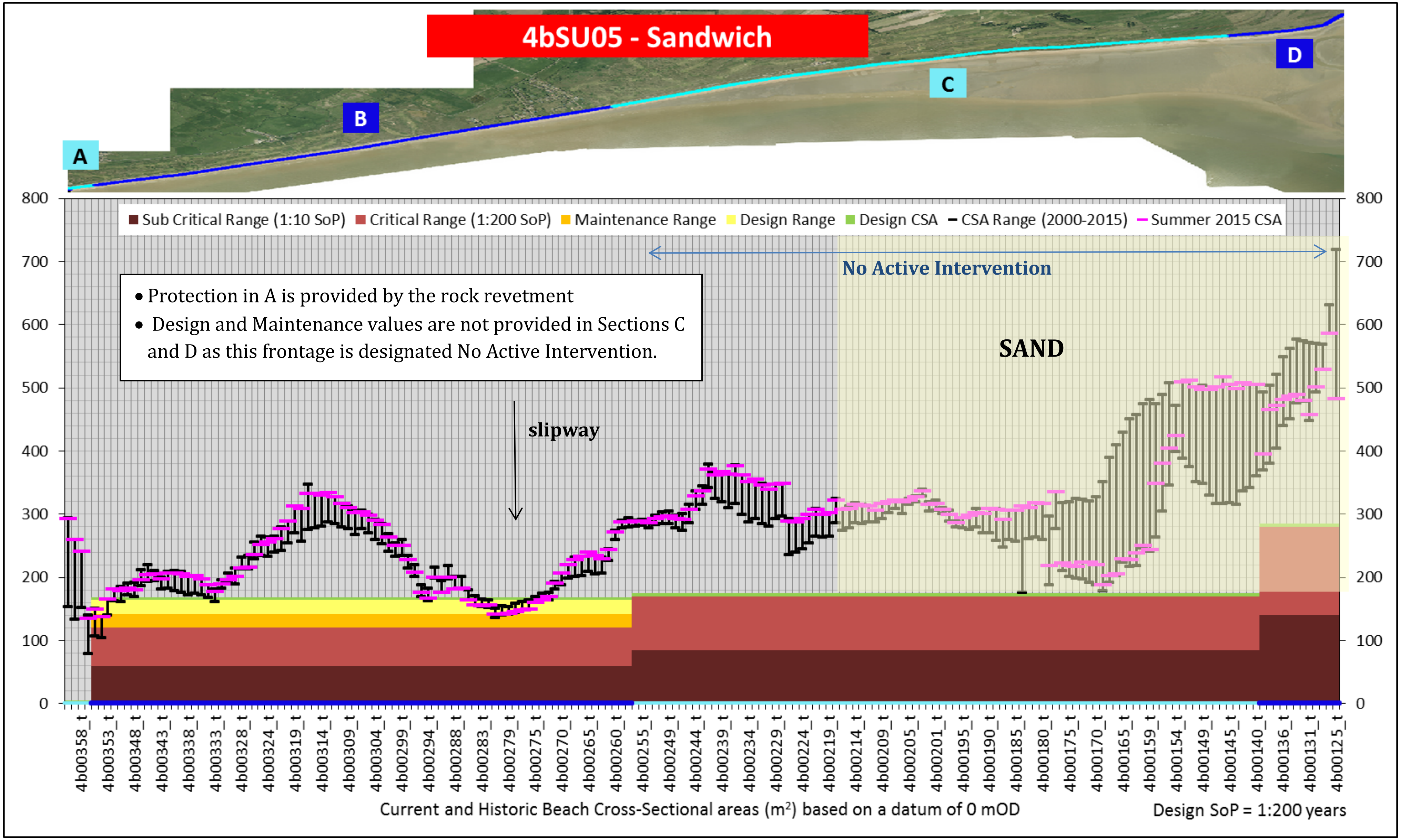


FIGURE 7-3-2 OBSERVED CSA CHANGES IN SANDWICH BAY (4BSU05) WITHIN THE CONTEXT OF BEACH TRIGGER LEVELS

8 BEACH MANAGEMENT PLAN

8-1 4bSU06 – DEAL

8-1-1 MANAGEMENT SUMMARY

TABLE 8-1 A SUMMARY OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE DEAL FRONTAGE (SURVEY UNIT 4BSU06)

Defence Section	Operator	SMP Policy (short term)	Current SoP (allowable OT*) and Defence Type	Sediment Budget Annual Losses in m³)+	Recommended Management	Plant Access and Environmental Restrictions
A Oldstairs Bay South	Dover DC	Hold the Line	1:100 (50) Rock Revetment	-1,876 (-15,899 to 7,685)	Monitor rock revetment and groynes	
B Oldstairs Bay North		Hold the Line	1:200 (25) Beach	-575 (-7,302 to 6,028)	Monitor beach CSA	Vegetated shingle on back beach
C Kingsdown South		Hold the Line	< 1:1 (Seawall) > 1:200 (Beach) (1)	-1,375 (-7,085 to 12,142)	Recycling as required to maintain SoP	Vegetated shingle on back beach
D Kingsdown North		Hold the Line	< 1:1 (Seawall) > 1:200 (Beach) (1)	-2,207 (-8,219 to 3,592)	Recycling as required to maintain SoP	Vegetated shingle on back beach
E Wellington Parade to Walmer Castle		Hold the Line	1:45 (1) Beach	-2,649 (-35,345 to 12,848)	Regular recycling to restore and maintain SoP) - take sediment from areas of accretion	Vegetated shingle on back beach
F Deal South of Pier		Hold the Line	> 1:200 (1) Seawall	274 (-6,374 to 15,896)	Recycling as required to maintain SoP	
G Deal North of Pier		Hold the Line	> 1:200 (1) Seawall with rear return wall	-254 (-2,758 to 808)	Recycling as required to maintain SoP	
H Royal Hotel		Hold the Line	> 1:200 (1) Seawall with small rear wall	-254 (-2,758 to 808)	Recycling as required to maintain SoP	
I Royal Hotel to Horsa Road		Hold the Line	> 1:200 (1) Seawall with small rear wall	-2,174 (-22,970 to 16,620)	Recycling as required to maintain SoP	
J Horsa Road to Godwyn Road		Hold the Line	<1:200 (1) Seawall (just under 1:200)	-2,693 (-25,972 to 16,870)	Recycling as required to maintain SoP	
K Sandown Road		Hold the Line	1:200 (1) Seawall	-1,790 (-20,198 to 4,322)	Recycling as required to maintain SoP	
L Sandown Castle		Hold the Line	1:100 (10) Seawall	-359 (-4,470 to 1,570)	Recycling as required to maintain SoP	
Section to the north of Deal	EA	Hold the Line	Shingle allowed to bypass Sandown Castle to protect shale embankment			

Sandwich Bay Estate	EA	Prevent shingle ingress into the embryonic sand dune habitat north of Sandwich Bay Estate

* Allowable overtopping is measured in l/m/s and determines the SoP

+Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

8-1-2 MANAGEMENT HOTSPOTS

There are two management hotspots along the Oldstairs Bay to Sandown Castle stretch; Wellington Parade which suffers from scour and Deal town, north of the Pier, which will require regular maintenance.

WELLINGTON PARADE

The presence of controlling structures at Kingsdown reduces the flow of sediment feed to the Wellington Parade frontage. The south to north longshore drift naturally transports material just north of the groyne field along the open beach in front of Wellington Parade and enhances scour at the southern end of Section E. Wellington Parade was subject to large shingle losses during 2015 which exposed the timber crib wall constructed in the 1980s (Figure 8-1). Scour at Wellington Parade has been a reoccurring issue since the wall and groyne fields was constructed. Despite 12,000m^3 recycling in 2013/14 and a further 65,000m^3 early 2016, from Walmer Castle, the beach remains vulnerable. However; the timber crib wall is in good condition and provides some protection to the properties 15 metres behind the wall.

FIGURE 8-1 EXPOSED TIMBER BREASTWORK AND CLIFFING AT WELLINGTON PARADE (JAN 2016)

DEAL

The northern Deal frontage (sections G-K) tends to lose shingle to the north of Sandown Castle and provides protection to the shale embankment. Breach of the shale embankment will result in flooding of the Deal floodplain. The Deal scheme that commenced in 2012, was designed to have regular maintenance (3,500m^3/year or 7,000m^3 every two years) (Halcrow, 2012). The Halcrow design beach (2012) buries the existing groynes to allow shingle to travel through this section into Sandwich Bay. Increasing the beach height above the timber groynes in an erosive area will increase the sediment transport rate. Transport rates cannot be quantified in the sediment budget (Appendix E) for a few years whilst topographic data is collected and analysed as the rates will be higher than the pre-scheme beach, when the groynes were exposed. Recent maintenance works, following a persistent set of south westerlies required 12,000m^3 of shingle to be redistributed between Sandown and Deal Pier; prior to this no maintenance had been undertaken since the completion of the scheme in 2014.

The sediment budget (Appendix E) indicates an average annual loss of 13,000m^3/year transported from Deal north of Sandown Castle into Sandwich Bay. As there are no controlling structures north of Sandown Castle and there have been no attempts to recover shingle back from Sandwich Bay in recent years we could estimate that over 12 years approximately 156,000m^3 has entered Sandwich Bay. Due to the presence of embryonic sand dunes in Sandwich, shingle is not permitted north of the slipway, south of Sandwich Bay Estate; management to remove some of the shingle from Sandwich is required urgently.

8-1-3 RECOMMENDED FUTURE WORKS

KINGSDOWN

The capital scheme at Kingsdown, which installed new timber groynes and increased the beach levels, has improved the SoP in Sections C and D. The Walmer to Kingsdown Timber Groyne Replacement PAR (2014) advises regular monitoring of the beach levels and maintenance works to reprofile the beach every year or every other year as required. Subsequent to monitoring, biannual top-ups of 2-3,000m^3 shingle may be required. Historically, an extremely stormy year may require a greater quantity of material.

WELLINGTON PARADE

The SoP at Wellington Parade frontage was restored to 1:200 through extensive beach recycling, as part of the Kingsdown scheme, 2016. This is an ongoing issue and will require attention annually. Historic trends indicate an annual loss of 6,000m^3 but historic losses have been as high 39,000m^3/yr. Further, the construction of new groynes at Kingsdown may reduce sediment drift to the frontage, and so the losses could be higher in the future. Updated transport rates, which consider the new groyne field cannot be quantified in the sediment budget (Appendix E) for a few years whilst topographic data is collected and analysed.

As there are no controlling structures between Kingsdown and Walmer, consideration, through a more detailed study, may be given to a terminal structure to reduce the distance in which shingle is recovered and brought back to Wellington Parade.

DEAL

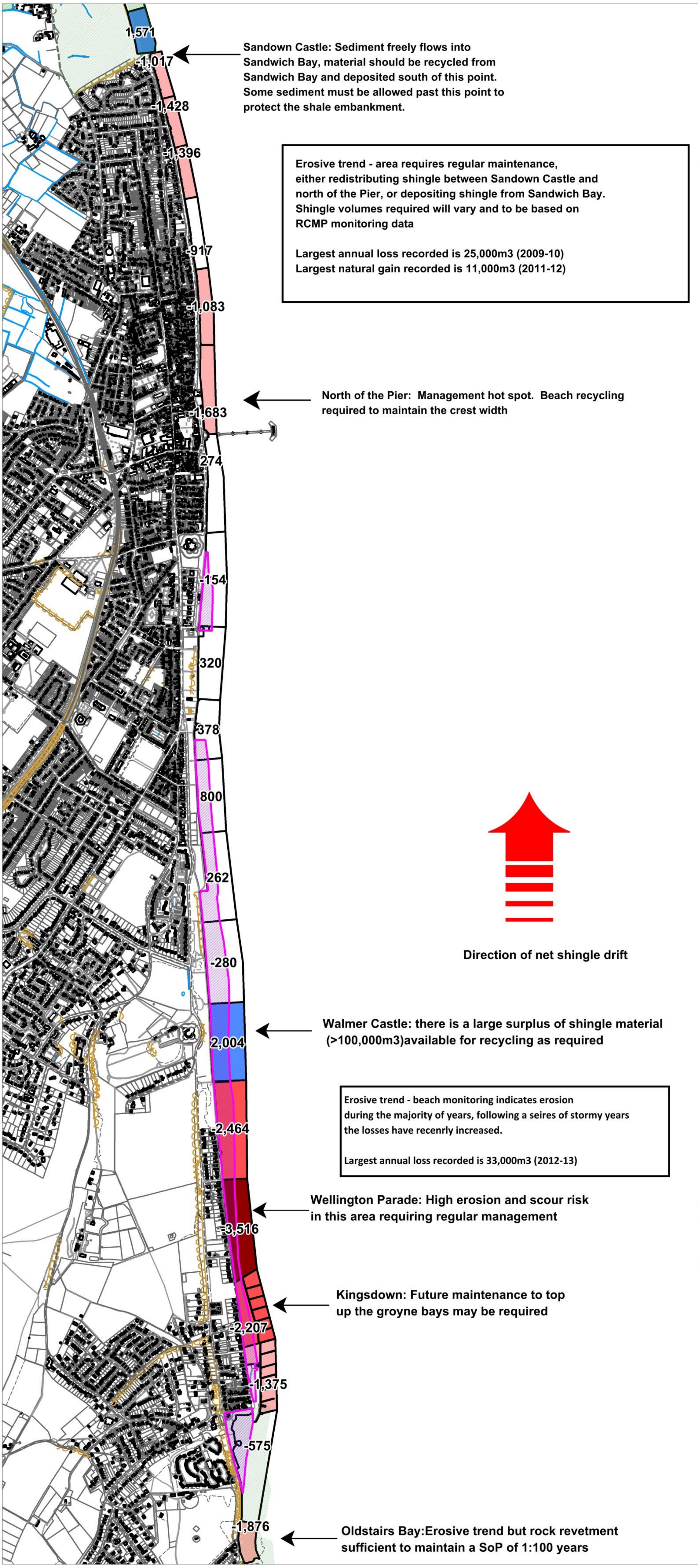
Directly north of the pier is a known weak spot as shingle can be quickly transported northwards in a single storm event. The presence of the pier substructure protrudes onto the beach face and reduces the sediment flow to the beach crest and once the crest has reduced in width natural recovery is difficult. Sediment must be artificially replaced through beach recycling.

The BMP (Halcrow, 2012) suggests an allowance of material to move unhindered past Sandown Castle toward Sandwich to provide protection to the shale embankment but shingle should not pass the slipway to the South of the Sandwich Bay Estate. Kent Wildlife Trust does not wish for shingle to move beyond Sandwich Bay Estate, as there are embryonic sand dunes. Shingle entering this area would negatively affect the growth of the sand dunes and would change their environmental importance. Currently there is shingle 1.7km further north of the slipway; consideration should be given to a programme of maintenance which will move material back into the Deal frontage.

8-1-4 EMERGENCY WORKS

In the event of storm damage requiring urgent attention it is recommended that shingle be extracted from Walmer Castle and transported to fill the scour at Wellington Parade. The beach in front of Walmer Castle (Section E, north) has excess shingle above the 1 in 200 SoP. Recycling works would need to avoid the areas of vegetated back beach and the stored fishing boats. If extensive recycling is required consultation with Natural England may be required.

FIGURE 8-2 SUMMARY OF SEDIMENT TRANSPORT RATES, ENVIRONMENTAL RESTRICTIONS, AREAS OF CONCERN AND RECOMMENDED MANAGEMENT ALONG THE DEAL FRONTAGE



Map Legend

Polygons: Annual Average Natural Change

- < -3000 m3 / year
- -2000 to -3000 m3 / year
- -1000 to -2000 m3 / year
- -1000 to 1000 m3 / year
- 1000 - 2000 m3 / year
- 2000 - 3000 m3 / year

Environmental Constraints

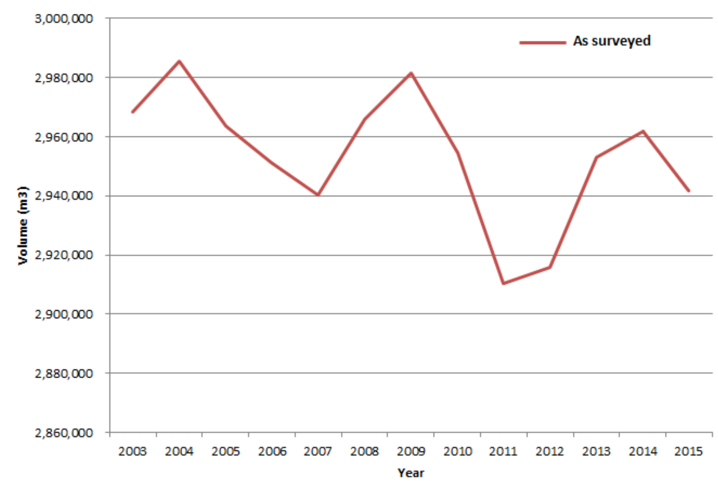
- National or International Designation
- Site of Vegetated Shingle - Restrictions on use of Plant

Floodplain Map

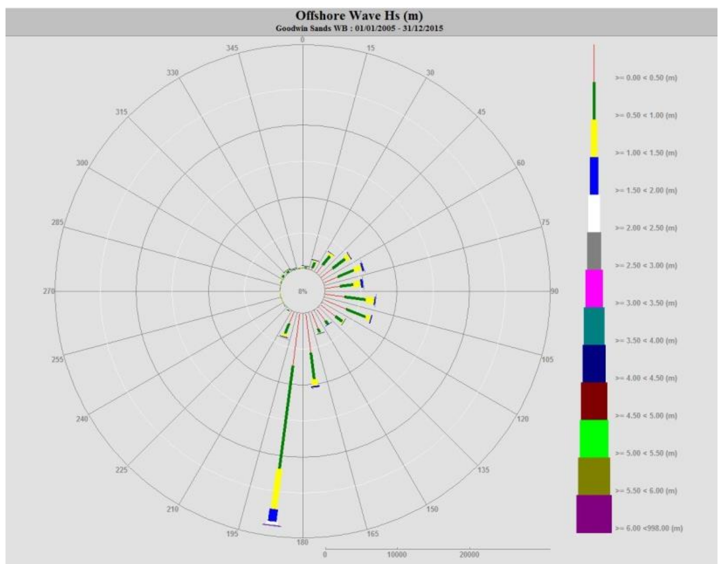
- 1:200 year extreme still water level planar flood map

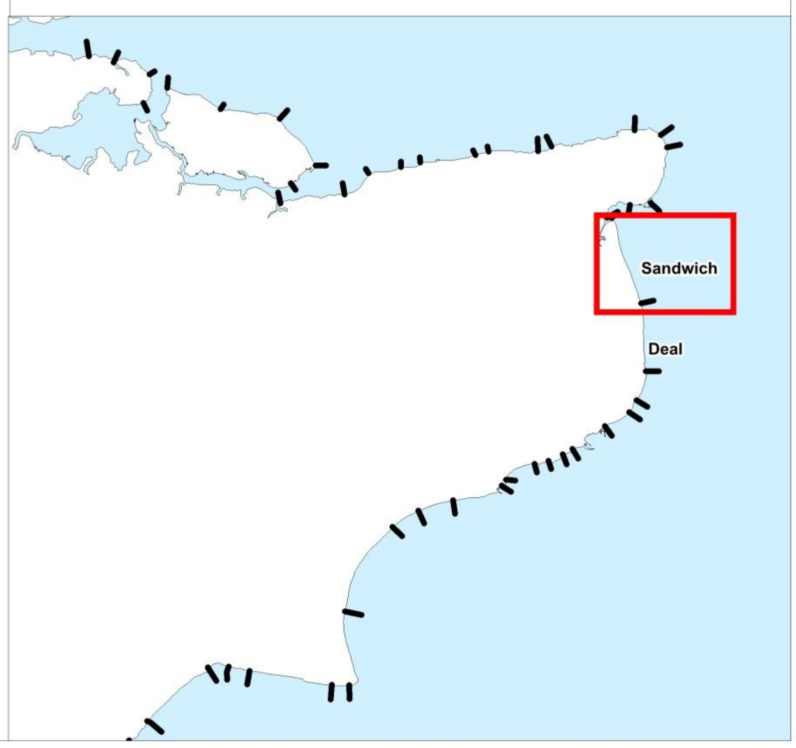
Map Scale 1: 33,000

Total Volume of Beach Material in Sandwich Bay, as surveyed (2003-2015)



Wave Rose for Goodwin Sands showing direction, frequency & magnitude of waves, May 2003 - December 2015





8-2 4bSU06 – SANDWICH BAY

TABLE 8-2 A SUMMARY OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE DEAL FRONTAGE (SURVEY UNIT 4BSU06)

Defence Section	Operator	SMP Policy (short term)	Current SoP (allowable OT*) and Defence Type	Sediment Budget Annual Losses (m³)+	Recommended Management	Plant Access and Environmental Restrictions
A	Environment Agency	Hold the Line	> 1:200 Rock Revetment	1,571 (-3,950 to 8,082)	Monitor rock revetment	SSSI, SPA, Ramsar Designations
B Sandwich Bay Estate	Environment Agency	Hold the Line	> 1:200 Big Beach/Shale Embankment	4,158 (-16,325 to 13,150)	Monitor bund	SSSI, SPA, Ramsar Designations
C	Kent Wildlife Trust / Dover District Council	No Active Interventio n	> 1:200 Big Beach	15,913 (-21,084 to 37,675) HALF SAND	No active intervention – monitor only	SSSI, SPA, Ramsar Designations
D	Kent Wildlife Trust	No Active Interventio n	1:2 Big Beach	-4,943 (-15,608 to 8,652) SAND	No active intervention – monitor only	SSSI, SPA, Ramsar Designations

* Allowable overtopping is measured in l/m/s and determines the SoP

+ Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

8-2-1 MANAGEMENT HOTSPOTS

SANDOWN CASTLE

The shingle beach just north of the rock revetment is protecting a shale embankment which in turn is protecting the north of Deal from flooding. Sufficient shingle is required to pass through from the Deal frontage and transport the length of the shale embankment. Failure of either the shale colliery bank or the rock revetment between Sandown Castle and Sandwich Bay Estate would put approximately 3,811 properties at risk of flooding in Deal (Chapter 0), and so it is recommended that these defences are inspected on an annual basis.

SANDWICH BAY ESTATE/ ROYAL CINIQUE PORTS GOLF CLUB

Shingle should not pass the slipway, however there is a substantial shingle beach for 1.7km north of the slipway.

As much of this frontage is No Active Intervention the main concern here is shingle ingress north into the embryonic sand dune habitat (Figure 8-3). The sediment budget (Chapter 5, Appendix E) shows gains at Sandwich and with the net northerly drift direction, it is likely that shingle will continue to migrate north if unattended.

8-2-2 RECOMMENDED MANAGEMENT

On average there is 13,000m^3/yr shingle gain within the Sandwich frontage. A large proportion of this is not accessible for recycling due to environmental restrictions, private beach ownership and the further north, between the slipway and the Royal Cinque Ports Gold Club it is heavily mixed with sand. As this shingle should not enter the embryonic dunes system, consideration should be given to a programme of maintenance which will move this material back into the Deal frontage.

SANDOWN CASTLE

The Environment Agency actively manages the section backed by the Colliery Shale embankment, undertaking beach recycling within the sub unit.

SANDWICH BAY ESTATE/ ROYAL CINIQUE PORTS GOLF CLUB

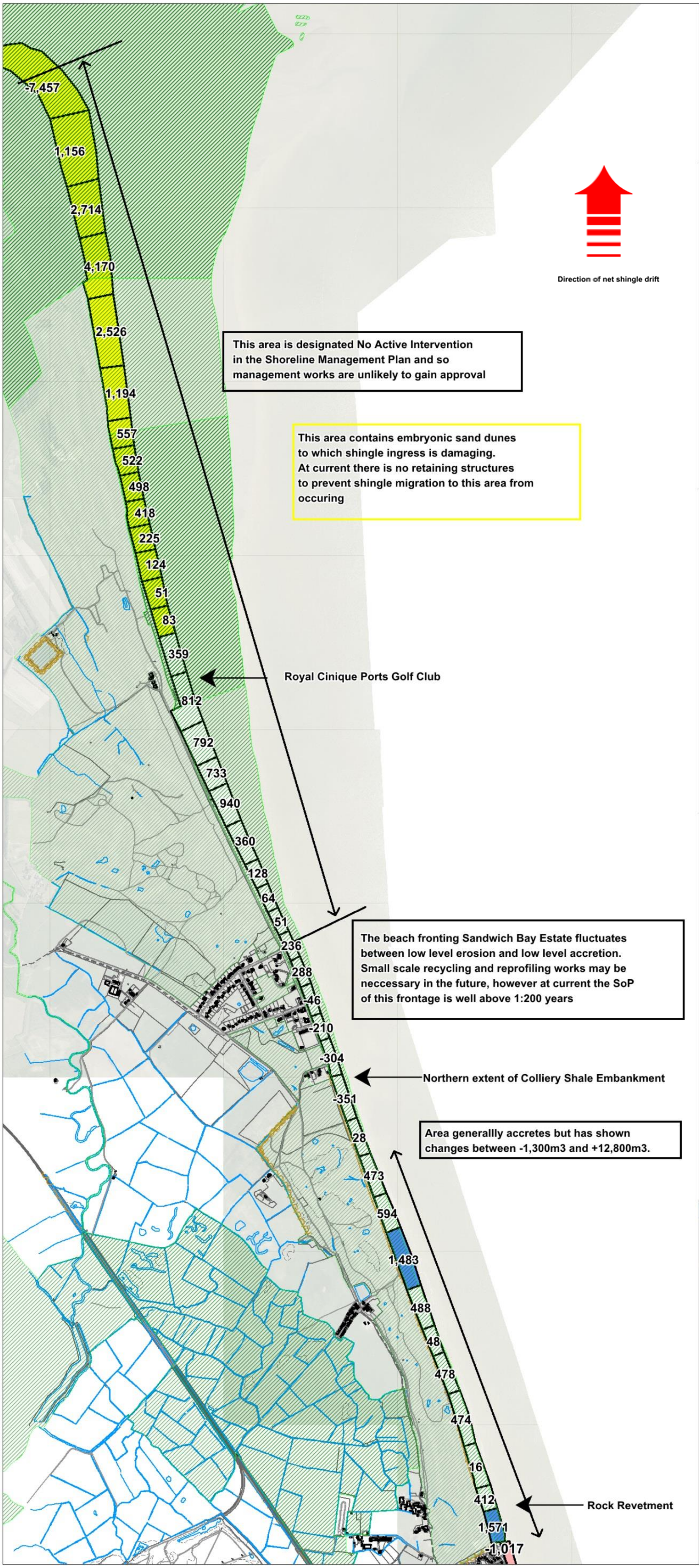
Beach management works north of the embankment (the beach fronting Sandwich Bay Estate) are likely not possible without consultation as the frontage here is privately owned above the MHW.

Works north of Sandwich Bay Estate require agreement from Natural England, Kent Wildlife Trust, Dover District Council and the Environment Agency and would require additional consents, namely an HR01 and a CRoW Act Appendix 3 agreement (Halcrow, 2012).

8-2-3 EMERGENCY WORKS

The frontage is well protected and is unlikely to require any emergency recycling works. Damage to the colliery shale embankment or rock revetment may require emergency repairs: access to this section is possible either from Sandown Castle (to the South) along the access track on the embankment or from the Sandwich Bay Estate road (to the North) (Appendix I).

FIGURE 8-3 SUMMARY OF SEDIMENT TRANSPORT RATES, ENVIRONMENTAL RESTRICTIONS, AREAS OF CONCERN AND RECOMMENDED MANAGEMENT ALONG THE SANDWICH BAY FRONTAGE



Map Legend

Polygons: Annual Average Natural Change

- < -3000 m3 / year
- -2000 to -3000 m3 / year
- -1000 to -2000 m3 / year
- -1000 to 1000 m3 / year
- 1000 - 2000 m3 / year
- 2000 - 3000 m3 / year

Environmental Constraints

- National or International Designation
- Site of Vegetated Shingle - Restrictions on use of Plant

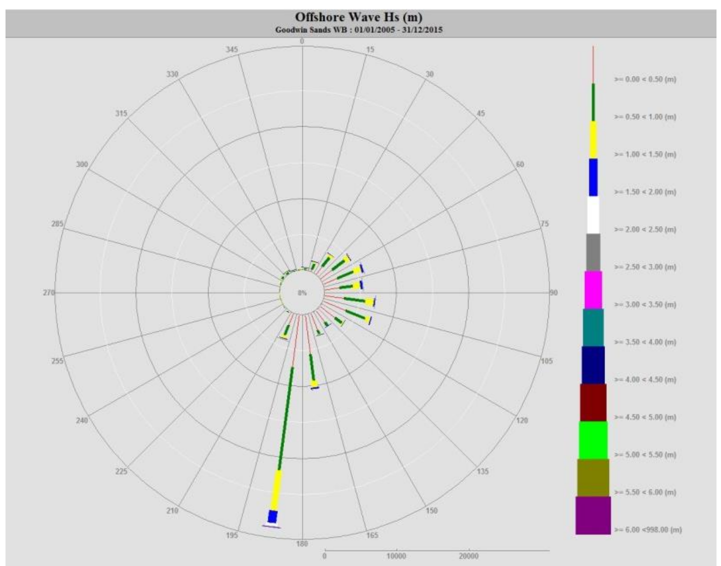
Floodplain Map

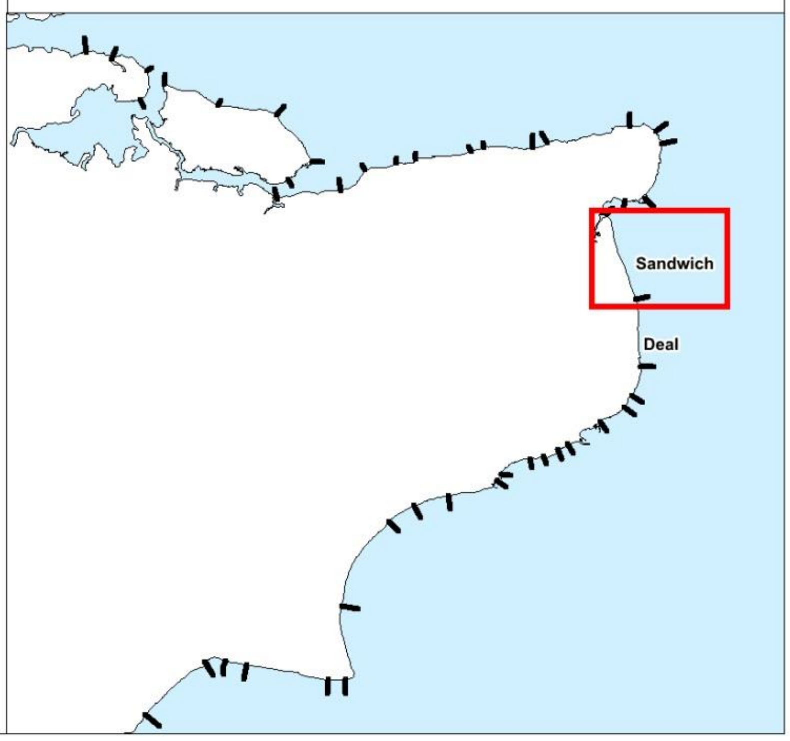
- 1:200 year extreme still water level planar flood map

Map Scale 1: 33,000

Total Volume of Beach Material in Sandwich Bay, as surveyed (2003-2015)

Wave Rose for Goodwin Sands showing direction, frequency & magnitude of waves, May 2003 - December 2015





8-3 REGIONAL OVERVIEW

TABLE 8-3 A REGIONAL OVERVIEW OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE DEAL FRONTAGE (SURVEY UNIT 4BSU06)

Unit	SMP Policy	Current SoP	Sediment Budget Annual Losses (m^3)*	Management	Restrictions
Deal	Hold the Line	1:45 to 1:200	-15,931 (-89,033 to 20,537)	Monitoring, Recycling, recharge	Some vegetated shingle
Sandwich	North – No Active Intervention South – Hold the line	1:2 to 1:200	**16,699 (-42,246 to 44,901)	Monitoring	Environmental designations Private landowners

* Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

** Includes sand

Due to the relatively small quantities of shingle available at Sandwich (13,000m^3), and the need to actively manage this sediment, by barge recycling from Sandwich to the start of the sediment cell at Oldstairs Bay is not a viable option for this frontage.

The frontage may benefit from a controlling structure, or two, strategically placed along the frontage to try and capture the shingle before it moves too far north into the embryonic dunes. Wellington Parade needs some consideration as to the way to best manage this frontage but for now beach recycling must be undertaken regularly to maintain the beach crest. A controlling structure may reduce the distance over which beach recycling takes place and could reduce future costs of beach management. The beach crest just north of the Pier needs regular monitoring and recycling is to be undertaken on an ad-hoc basis as required.

9 MONITORING

Future monitoring is imperative to ensure all aspects of the coastline are maintained and recorded using a controlled method which meets the minimum requirements for individual beaches along the Oldstairs Bay to Sandwich Bay stretch.

The three main sources include the Regional Coastal Monitoring Programme (RCMP), which is a national project dedicated to collecting topographic, bathymetric, hydrological and photogrammetry data along the English coastline. For the Oldstairs Bay to Sandwich Bay stretch, the project is currently in its third Phase (2012-2017) and set to continue into its fourth Phase (2017 to 2021). All data is freely available from www.coastalmonitoring.org. The Environment Agency run Lidar flights, formerly available via Geomatics, are now freely available through Opening Up Government (OGL) www.data.gov.uk. Lastly, asset surveys, recycling and replenishment logs, photographic evidence of storms and storm damage are available through the Local Authorities.

9-1 TOPOGRAPHIC SURVEYS

9-1-1 BEACH SURVEYS

Regular beach surveys are extremely useful for providing historic trends, assessing future behaviour and recording the effect of storms or replenishment campaigns on the beach level. Beach levels are monitored against Design, Maintenance and Critical Levels which ensure the beach remains above a level which could cause damage to infrastructure or the public. Regular monitoring of beach levels allows deterioration of the beach to be noted early so pre-emptive works can be undertaken, opposed to remedial works after a failure. Beach levels are used for planning coastal maintenance or larger schemes and monitoring recycling and replenishment volumes.

Beach levels can be acquired through beach profiles, collected using a rover on a detail pole at a known elevation and measuring beach elevations along a known transect on the beach). Beach levels can also be acquired through continuous surveys, conducted either on foot or using an ATV. The GNSS kit is mounted onto a backpack or the ATV and shore parallel lines are walked/driven to collect elevation data along each crest and trough to create a 3D model of the beach.

Profiles are to be spaced at regular intervals, to be determined by the presence of a groyne field, change in orientation and risk – classified by the hinterland (flood basin, soft cliff and dense urban areas). Profiles are referred to as intermediate and designated. Designated profiles are the key profiles which can provide a general oversight to the beach condition, spaced at 200-500m intervals. Intermediate profiles allow full coverage of the beach once per year and are much more closely spaced, between 30-100m apart.

The RCMP has surveyed the beaches along this stretch of coastline since 2003 and has set profiles according to the orientation, risk and groyne fields. From Autumn 2016 data will be collected along this frontage twice per year, Spring and Autumn. The survey requirements of the individual locations are listed in Table 9-1.

TABLE 9-1 FUTURE SURVEY REQUIREMENTS 2017-2021

LOCATION	RISK	SEVERITY	SURVEY REQUIREMENTS
DEAL	DENSELY POPULATED, LARGE SETTLEMENTS AND FLOOD BASIN	SEVERE DAMAGE TO PROPERTY, SERVICES, HUMAN LIFE AND INFRASTRUCTURE	▪ ONE FULL BMP SURVEY (PROFILES AND 3D MODEL) IN THE SPRING, ONE ADDITIONAL PROFILE SURVEY IN THE AUTUMN ▪ PROVISION FOR POST STORMS ▪ LIDAR SURVEY BI-ANNUALLY
SANDWICH BAY	LOW LYING FLOOD PLAIN	SEVERE DAMAGE TO SERVICES, AND INFRASTRUCTURE	▪ ONE FULL BMP SURVEY ON THE SHINGLE BEACH (PROFILES AND 3D MODEL) IN THE SPRING, ONE ADDITIONAL PROFILE SURVEY IN THE AUTUMN ▪ PROVISION FOR POST STORMS ▪ LIDAR SURVEY BI-ANNUALLY

9-1-2 POST STORM SURVEYS

In the event of a storm, additional profiles are surveyed to provide an instant overview of any damage; allowing comparison of post storm levels to the design, maintenance and critical levels and should be used to inform any remedial works.

To instigate a post storm survey, a member of the RCMP will contact the Operating Authority (OA) within 12 hours of the storm for guidance on the post storm requirements. If beach is drawn down and it is thought to recover within a few tidal cycles then it is for the OA to decide if a survey will be beneficial. If the beach has been severely eroded and remedial works are imminent, a post storm survey is required immediately. If you have not heard from the RCMP, contact them immediately as they can mobilise for the next low tide.

A post storm survey will collect the data most useful to the OA. If damage has occurred along the whole frontage, a selection of designated profiles will provide an overview. Or, if the damage is more localised the OA should request a survey in a specific area. The RCMP will then survey a feasible number of profiles during a tidal cycle.

It is advised that a post storm survey is undertaken to recalculate the standard of protection provided by the beach using the overtopping charts.

9-1-3 BEACH MANAGEMENT SURVEYS

When beach management works are to be undertaken it might be useful to carry out a pre works (IN) and/or a post works (OUT) survey. Requests should be made to the RCMP as soon as the timing of the works are known to potentially tie at least one of these extra surveys into the regular survey schedule. This might allow a better quantification of sediment volumes added or moved. Similar to the post storm survey, it is carried out to the preference of the OA; as either a general coverage of the beach through designated profiles, a concentrated selection of profiles on a shorter frontage or a full laser scan of the beach. These surveys are likely to have to be funded from maintenance or project specific sources other than the RCMP. There is also a need to fill out a maintenance log when beach management works have been undertaken (see Section 9-8-7).

9-2 BATHYMETRIC SURVEYS

The seabed requires surveying as the cross shore transport of sediment is rarely captured in the laser scans. Ideally, one bathymetric survey per year would provide a clearer indication to the seabed movements but due to the financial implications of each bathymetric survey it is not feasible to commission them regularly. With this is mind, a full multi-beam survey was undertaken in 2013 which captured the whole coastline from Oldstairs Bay to Sandwich Bay in a 3D model, recording the substrate and elevation. To reduce the cost of future surveys the chalk or rock platform could be disregarded for the foreseeable future as it would not change to allow funding for areas of fine substrate.

9-3 AERIAL SURVEYS

9-3-1 LIDAR

For sections of coastline which are difficult to access or have soft cliffs, Lidar is a suitable method of data collection for monitoring. Lidar data will be collected along this whole stretch of coastline biannually as part of the RCMP in Phase IV.

9-3-2 ORTHORECTIFIED PHOTOGRAPHS

Ortho-rectified photographs provide a visual comparison of the coastline and allow GIS data to be overlaid onto the most updated photographs. As the coastline is continuously changing it would be recommended to update the photographs every three to five years.

9-3-3 Unmanned Aerial Vehicle (UAV)

The UAV is a piece of quickly evolving technology which can be used to produce photogrammetry of the beach from the air; similar to Lidar. A control network would need installing to provide control points for the UAV to survey to ensure the data was accurate.

9-4 ASSET MONITORING

9-4-1 FULL INSPECTION

In accordance with the Flood and Water Management Act (2010) OAs are required to maintain a record of flood and coastal defence assets, and it is recommended that this record is updated annually with the condition of these assets.

Each asset should be recorded with the location, defects, recommended repair works and a time frame for completion. All assets should be photographed and compared against previous asset surveys to monitor any deterioration.

Seawalls should be assessed in terms of parapet or capping beam, wall section and wall toe against spalling, cracking, holes, missing or damaged sealant, slippage of precast concrete blocks, sinking, slumping of concrete revetment, vegetation growth, exposed rebar.

In addition, groynes (timber and rock) should be assessed for missing or burnt planks, eroding piles, conditions of landward connection, seaward roundhead, groyne capping beam, sheet piling; or rock groynes, slippage or holes.

9-4-2 VISUAL INSPECTION

In addition to the full asset survey it is recommended that the OA carry out a visual inspection of their coastline once per month between October and March to check for damage to the frontage caused by persistent wave attack. Waves can reduce the crest width without exceeding the storm threshold, and if the wave direction is persistently from the same direction then large volumes of sediment can be transported along the coastline leaving weak areas exposed. Any damaged sections should be photographed and dated.

Following a storm, additional visual inspections are recommended to monitor damage until remedial works can be undertaken. Again, photographs should be taken and logged with the location and date of the storm as this can verify future overtopping calculations.

A full visual inspection is recommended in the spring each year to assess any damage from the winter period and allow sufficient time to organise remedial works in preparation for the following winter. This visual inspection could be combined with the full asset survey or performed as a separate check.

9-5 ENVIRONMENTAL SURVEYS

Construction work within the coastal zone can be disruptive to the plant life. However with a good understanding on the location and distribution of vegetation works can be planned to avoid any damage. A site visit and/or use of recent, high resolution aerial photography, such as that produced by the RCMP, should be used to identify the need for a vegetation survey.

If a site is identified as sustaining a significant community of shingle vegetation then monitoring should be carried out pre and post works. A suitable method is described within Appendix A of the East Sussex Vegetated Shingle Management Plan (Smith, 2009). It is preferable to undertake the surveys between June and August.

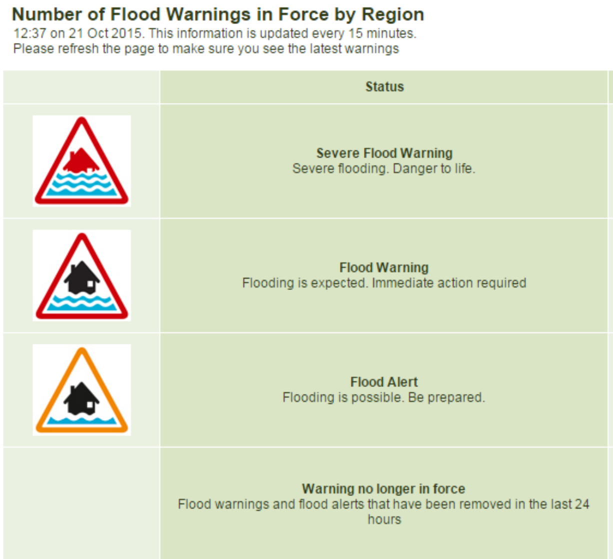
9-6 HYDROLOGICAL MONITORING

Wave and weather data is required along this coastline. The RCMP has several buoys placed around the coast. This data supports the beach monitoring but more importantly records the wave heights which informs the OA if the waves have exceeded the storm thresholds. Data are freely available from www.channelcoast.org.

Tide gauges are also placed around the coast with the nearest to this frontage placed at Dover and Herne Bay. The Met Office provides detailed weather and marine conditions for several areas around the coast.

9-7 WARNING PROCEDURES

It is a requirement for Lead Local Flood Authorities (LLFA) to have flood warning systems in place. It is recommended that the Environment Agency's Flood Warning System is used to inform the engineers or on-call staff of any imminent or predicted flood warnings (Figure 9-1). Email and text alerts can be set up for all involved staff. It is also recommended to monitor the wave buoys before, during and after a storm; text alerts for waves exceeding the storm threshold at individual wave buoys can also be set up at channelcoast.org/alerts.


Number of Flood Warnings in Force by Region
12:37 on 21 Oct 2015. This information is updated every 15 minutes.
Please refresh the page to make sure you see the latest warnings

	Status
	Severe Flood Warning Severe flooding. Danger to life.
	Flood Warning Flooding is expected. Immediate action required
	Flood Alert Flooding is possible. Be prepared.
	Warning no longer in force Flood warnings and flood alerts that have been removed in the last 24 hours

FIGURE 9-1 ENVIRONMENT AGENCY FLOOD WARNING CATEGORIES WWW.ENVIRONMENT-AGENCY.GOV.UK

9-8 REPORTING AND INTERPRETATION

9-8-1 ANNUAL BEACH REPORT

The Operating Authority (OA) can expect an annual beach report detailing the wave conditions, recycling works and the results of the topographic survey indicating the beach response throughout the year which will be issued by the RCMP. This report will highlight areas of concern and any repeatedly eroding or accreting sections as well as suggesting areas to monitor during the next year.

The CSA of the beach will be plotted on a graph to compare the most recent survey to the design, maintenance and critical levels as described in Chapter 7. The most recent CSA will also be plotted onto a series of overtopping graphs to illustrate the risk of overtopping along the frontage (Appendix G).

9-8-2 POST STORM REPORT

Following a post storm survey a short analysis report will be sent to the OA to identify the effect of the storm compared to the pre storm condition. It will highlight any areas of coast that have become vulnerable by plotting the latest CSA against the design, maintenance and critical levels. This report will be sent out by the RCMP.

9-8-3 PRE AND POST WORK REPORT

If a survey was requested before the maintenance or scheme works this will be compared to the post works survey to determine the total volume of sediment transported. The two surveys will be analysed further in the annual report to monitor how the works have responded to the wave climate. This report will be sent out by the RCMP.

9-8-4 WAVE REPORT

A report for each wave buoy is issued once per year, by the Channel Coastal Observatory, to summarize the significant wave heights and any events what exceed the storm threshold. The only wave buoys currently in action are Goodwin Sands and Deal Pier.

9-8-5 SANDS

After each survey the topographic and Lidar data is uploaded to SANDS and sent to all OA after all surveys in their database are complete. The survey units covered by this report (4bSU05 – Sandwich) and 4bSU06 – Deal) are within the Dover database.

9-8-6 ASSET REPORTS

In the event of a storm, it is advised that the OA survey the assets along their stretch of coast and report any large defects such as seawall collapse or groyne failure to Canterbury City Council with a photograph, exact location and accompanying text, to allow a recalculation of the standard of protection.

9-8-7 MAINTENANCE LOGS

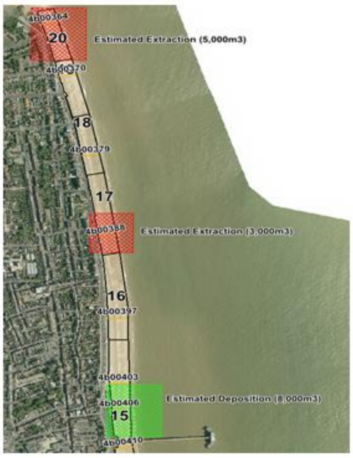
It is important that all beach management works (recycling, beach recharge, reprofiling) should be logged on the appropriate form to indicate the extraction and deposition locations, the quantities moved and the start and end date of the activity (Figure 9-3).

Maintaining these records allows differentiation between artificial beach movement and natural beach transport. These volumes feed into the shingle sediment budget (Appendix E) and the annual reports released by the RCMP. Re-profiled beaches require a log to indicate the location; no further information is required.

It is the responsibility of the OA to issue the maintenance log within one month of completion of the works and sent to the RCMP based at Canterbury City Council. A blank maintenance form is attached on the following page, to be completed following each artificial movement of shingle or sand.

Maintenance Log: Deal

☒ Deposition ☒ Extraction ☐ Reprofiling



Date	April 2015	Logged by	Andy Stevens

Description of Works/Notes
8,000m³ recycling at North Deal from Sandown Castle to north of pier. Quantities from Alistair Pitcher, area estimated

Description of Frontage			
Before		After	

Quantify extraction/deposition (Note: If volume unknown conversion used is 1 tonne: 1.8 m³ of material)

Profile/Groyne No.	Profile/Groyne No.	Quantity (m³)		Lorry Capacity (m³)	Number of lorry loads	Material Description (click in cell for drop down)
			Or			

Total: m³

FIGURE 9-2 EXAMPLE OF COMPLETED RECYCLING LOG FOR DEAL (2015)

Maintenance Log: [place name here]

☐Deposition ☐Extraction ☐Reprofiling

Date		**Logged by**	

Description of Works/Notes

Description of Frontage			
Before		**After**	

Quantify extraction/deposition (Note: If volume unknown conversion used is 1 tonne: 1.8 m^3 of material)						
Profile/Groyne No. Start	Profile/Groyne No. End	Quantity (m^3)		Lorry Capacity (m^3)	Number of lorry loads	Material Description (click in cell for drop down)
			Or			

Total: m^3

GLOSSARY

Accretion The addition of sediment vertically or horizontally due to the natural action of waves, currents and wind.

Accumulation Any addition of sediment, either natural (accretion) or man-made.

Alluvium A deposit resulting from the action and products of rivers or streams.

Apron A layer of stone, concrete or other material to protect the toe of the sea wall against scour.

Armour Resistant rocks or specially shaped concrete blocks of a specific size, geometry and weight which are placed as primary protection against wave action on the seaward side of other structures (see revetment).

Asset This refers to something of value and may be environmental, economic, social, recreational and so on.

Backshore A morphological term for the area of beach that lies between high water and the landward limit of marine (storm wave) activity.

Backwash The seaward return of the water following the up-rush (swash) of the waves. For any given tide stage the point of farthest return seaward of the backwash is known as the Limit of backwash. Depending on the permeability of the beach the water volume in the backwash is smaller than in the swash.

Bar An elongated deposit of sand, shingle or silt, occurring slightly offshore from the beach and submerged at high tide. The bar may be parallel to the beach or connected and at an angle.

Barrier Beach A sand or shingle bar above high tide with low lying land or a lagoon on the landward side.

Bathymetry Topography of the sea floor usually below low water.

Beach The zone of non-cohesive material (e.g. sand, gravel) that lies between the mean low water line and the place where there is a marked change in material or physiographic form, or to the line of permanent vegetation (the effective limit of storm waves and storm surge). The beach or shore can be divided into the foreshore and the backshore.

Beach crest width The horizontal distance of the crest measured from the seaward edge of the promenade (or other determined point, see beach) to the point where the beach slope angle drops down towards the sea. This usually assumes a uniform crest level but can also include a gentle slope. A better term is 'beach width at xmOD'.

Beach face Upper surface of the beach.

Beach Profile Cross-section (side view) of the beach perpendicular to the shoreline. The profile extends from a point landwards of the backshore to low water or beyond.

Beach recharge This is the management practice of adding new beach sediment (such as sand or gravel) to a beach using material from outside the sediment cell (for example offshore dredging sites or inland quarries). This is also known as beach replenishment or beach (re)nourishment.

Beach recycling The movement of sediment along a beach, typically from areas of accretion to areas of erosion.

Beach re-profiling The shaping of the beach profile to achieve a desired crest height, width or slope, typically using bulldozers or other plant.

Berm A constructive ridge located along the higher part of a beach, above high water as a result of cross shore transport moving sediment towards the swash limit. It is marked by a break of slope at the seaward edge. There are usually a sequence of berms present with storm berms located in the back beach area.

BMP Beach Management Plan. It provides a basis for the management of a beach for coastal defence purposes, taking into account coastal processes and the other uses of the beach.

Brackish water Freshwater mixed with seawater.

Breach Failure of a barrier beach or coastal protection structure allowing flooding through tidal water exchange for at least half of the tidal cycle, i.e. the level of the breach is at or below 0mOD.

Breaching Process of removing or lowering a beach or structure to form a breach.

Breaker zone Area in the sea where the waves break.

Breakwater A protective structure of stone or concrete used to break the force of waves, reducing wave energy and hence enhancing protection to the shore.

CCO Channel Coastal Observatory. Based at the National Oceanography Centre in Southampton, responsible for the distribution of data collected under the six Regional Coastal Monitoring Programmes.

CD Chart Datum – an arbitrary local datum or plane to which depths or heights are referred. (Also see OD).

Cliffing Cliffing on beaches refers to the development of seaward slopes in beach material that are at the angle of repose (Depending on the beach material properties [grain size composition, moisture, compaction, cementation] the angle of repose can vary between ~35 and 90 degrees.), usually with a sharp break of slope to the beach below developing near the wave run-up limit.

Climate Change Long term changes in climate. The impact of climate change along the coast is usually associated with changes in sea level and wave climate.

Coastal defence General term used to encompass both coast protection against erosion and sea defence against flooding.

Coastal processes Collective term covering the action of natural forces on the shoreline and nearshore seabed.

Coastline The generalised shape, outline, or boundary of a coast, which marks the area between the seaward limit of terrestrial influence and the landward limit of marine influence.

Consequence An outcome or impact such as economic, social or environmental impact. It may be expressed quantitatively (e.g. monetary value), categorically (e.g. high, medium, low) or descriptively.

Crest Highest part in cross section of a beach or structure (e.g. breakwater or sea wall)

Crest level The height of the crest (usually the highest point), generally in mOD.

Deep water Area where surface waves are not influenced by the sea-bed, i.e. where water depth exceeds half the wavelength.

Defence Manmade structure (e.g. sea wall, embankment, recharged beach) or natural feature (e.g. beach, dune) that prevents seawater from reaching the hinterland under varying conditions.

DEFRA Department for Environment, Food and Rural Affairs, formerly the Ministry of Agriculture, Fisheries and Food (MAFF).

Delta Sediment body, which is formed where a sediment-laden current enters an open body of water, and deposits its sediment load as a result of a reduction in velocity of the current.

Depth limited (waves) Situation in which wave propagation is limited by water depth.

Downdrift Direction of longshore movement of beach materials.

Dredging Excavation, digging, scraping, drag lining, suction dredging to remove sand, silt, rock or other underwater sea-bed material.

Drift reversal A switch of an indigenous direction of littoral transport.

Drift-aligned A coastline that is orientated obliquely to prevailing incident wave fronts. The coast is characterised by strong longshore transport.

Dune A landform produced by the action of wind on unconsolidated material, normally sand, to produce ridges or mounds of loose sediment.

Dynamic equilibrium A state of balance between environmental conditions acting on a landscape and the resisting earth material which themselves fluctuate around an average that is itself gradually changing.

Embankment A linear mound of earth that stretches some distance along the coast that protects the hinterland behind from flooding.

Environment Agency (EA) UK non-departmental government body responsible for delivering integrated environmental management including flood defence, water resources, water quality and pollution control. It has the strategic overview of all flood and coastal erosion risk management.

Environmental Impact Assessment (EIA) Environmental Impact Assessment. Detailed studies that predict the effects of a development project on the environment. They also provide plans for mitigation of any significant adverse impacts.

Erosion The removal of any material (clay, rock, soil, sand, gravel) by such agents as running water, waves, wind, moving ice and gravitational creep or falls from its original location. The landward retreat of a shoreline due to these processes.

Estuary Mouth of a river, where fresh river water mixes with the seawater.

Flint Micro-crystalline nodules or bands of silica found in the chalk. It is dark grey or black when recently released from the chalk or brownish in colour when it has been removed from the chalk for tens of thousands of years.

Flooding Refers to inundation by water of land whether this is caused by breaches, overtopping of banks or defences, or by inadequate or slow drainage of rainfall or underlying ground water levels due to tide locking of the coastal outfall structures.

Foreshore A morphological term for the lower shore zone/area on the beach that lies between mean low and high water.

Geographic Information System (GIS) Software which allows the spatial display and interrogation of geographic information such as ordnance survey mapping and aerial photography.

Groundwater The zone in a soil or rock that is saturated with water, mostly derived from surface sources.

Groyne A structure, which is generally built approximately perpendicular to the shoreline in order to control the movement of beach material and reduce longshore currents and/or to trap and retain beach material. Most groynes are made of timber, rock or concrete and extend from a sea wall or the backshore wall onto the foreshore and rarely even further offshore. They can also take the form of T-shaped groynes, fish-tail and terminal groynes. Other structures perpendicular to the coastline (e.g. outfalls, ramps) can function as a groyne.

Groyne bay The bay between two groynes.

Groyne field Series of groynes acting together to protect a section of beach.

Hazard A situation with the potential to result in harm. A hazard does not necessarily lead to harm.

Hinterland The land directly adjacent to and inland from a coast, extending landward from the upper limit of extreme wave and tidal energy.

Hold the Line (HTL) Shoreline Management Plan policy to hold the existing defence line by maintaining or changing the standard of protection. This policy should cover those situations where work or operations are carried out in front of the existing defences (such as beach recharge (see the glossary), rebuilding the toe of a structure, building offshore breakwaters and so on) to improve or maintain the standard of protection provided by the existing defence line.

H_s See significant wave height.

Hydrodynamic	The process and science associated with the flow and motion in water.
Intertidal areas	The area between mean high water level and mean low water level in a coastal region.
Inundation	An overflow of water or an expanse of water submerging land.
Joint Probability	The probability of two (or more) variables occurring together.
Joint Return Period	Average period of time between occurrences of a given joint probability event.
Land Reclamation	Process of creating new, dry land on the seabed.
Landslides	The large-scale mass movement of sub-aerial material down-slope, or its vertical movement down a cliff face.
Longshore drift/ transport	Transport of sediment along the shore by the combined effect of swash and backwash set up by wave driven currents. Currents produced in the surf zone are caused by waves breaking at an angle and the current running roughly parallel with the shore. (Also see drift-aligned, drift convergence, drift divergence, drift reversal).
Long term	Refers to a time period of decades to centuries.
Managed Realignment (MR)	Shoreline Management Plan policy to realign the shoreline by allowing the shoreline to move backwards or forwards, with management to control or limit movement (such as reducing erosion or building new defences on the landward side of the original defences).
Mean Low Water (MLW)	The average of all low waters observed over a sufficiently long period.
Mean High Water (MHW)	The average of all high waters observed over a sufficiently long period.
Mean Low Water Spring (MLWN)	The lowest level to which neap tides retreat on average over a period of time (often 19 years).
Mean Low Water Spring (MLWS)	The lowest level to which spring tides retreat on average over a period of time (often 19 years).
Mean Sea Level (MSL)	Average height of the sea surface.
Medium term	Refers to a time period of decades.
Met Office	UK Meteorological Office.
Metres Ordnance Datum (±mOD)	Elevation in metres above or below Ordnance Datum.

Natural Processes Those processes over which people have no significant control (such as wind and waves).

Nearshore The zone, which extends from the swash zone to the position marking the start of the offshore zone, typically at water depths of the order of 20m.

No Active Intervention (NAI) Shoreline Management Plan policy where there is no investment in coastal defences or operations. This assumes that existing defences are no longer maintained and will fail over time or undefended frontages will be allowed to evolve naturally.

Offshore The zone beyond the nearshore zone where sediment motion induced by waves alone effectively ceases and where the influence of the seabed on wave action is small in comparison with the effect of wind.

Offshore Bank A large scale unconsolidated body of soft sediment, such as sand, gravel and mud which can form topographic highs on the seabed. They are located in the offshore zone and are permanently covered by shallow sea water, typically at depths of less than 20 m below chart datum.

Operating Authority A body with statutory powers to undertake flood defence or coast protection activities, usually the Environment Agency or maritime District Council.

Ordnance Datum (Newlyn) A universal zero point/datum used in the UK, equal to the mean sea level at Newlyn in Cornwall.

Overtopping Water carried over the top of a coastal defence due to wave run-up or still water level exceeding the crest height. See 'green water', 'white water' and 'overwashing'.

Overwashing Overtopping that leads to water and sediment transported landward which does not return back to the sea following the event.

Percolation The process by which water flows through the interstices of sediment. Specifically, the infiltration of water during swash into the unsaturated beach material which reduces wave run-up on the beach but which can also lead to water seepage at the landward side, potentially causing instability of the landward slope or a barrier.

Pile Long heavy section of timber, concrete or metal, driven into the ground or seabed as support for another structure. Especially around/or at the toe of a shore protection structure.

Recession Movement of the shoreline to landward.

Reef A ridge of rock or other material lying just beneath the surface of the sea.

Regression A fall in sea-level resulting in withdraw of the sea from the land.

Relict Geomorphological feature formed or sediment deposited under past processes and climatic regimes.

Return Period A statistical measure denoting the average probability of occurrence of a given event over time.

Revetment	A sloping surface of armour used to protect an embankment, sea wall or natural shoreline against erosion.
Rock platform	Gently seaward sloping, intertidal bench cut into the land mass by the action of waves and also known as a wave-cut platform.
Roll back	The gradual net landward migration of the coastline, includes rollover of a subaerial sediment barrier, mainly shingle and gravel.
Saltmarsh	An area of soft, wet land periodically flooded by saline water. Usually characterised by grasses and other low vegetation. Also known as a salting.
Scour	Permanent or temporary erosion of underwater material by waves or currents, especially at the interface between sediment and a structure.
Sea wall	A shoreline structure primarily designed to prevent flooding, erosion and other damage due to wave action. Structure types include solid, near vertical steel of concrete structures of different profiles. A stronger deviation from the vertical indicates a 'revetment'.
Sediment	Particles of rock covering a size range from clay to boulders.
Sediment cell	A length of coastline and its associated near shore area within which the movement of coarse sediment (sand and shingle) is largely self-contained. Interruptions to the movement of sand and shingle within one cell should not affect beaches in an adjacent sediment cell.
Sediment sub-cell	A smaller part of a sediment cell within which the movement of coarse sediment (sand and shingle) is relatively self-contained.
Sediment supply	The source of sediment.
Sediment transport	The movement of a mass of sedimentary material by the forces of currents, waves or wind.
Setback	Prescribed distance landward of a coastal feature (e.g. the line of existing defences).
Shingle	Gravel-sized beach material, normally well rounded as a result of abrasion.
Shoreline	A boundary line between land and water.
Shoreline Management Plan (SMP)	A non-statutory plan, which provides a large-scale assessment of the risks associated with coastal processes and presents a policy framework to reduce these risks to people and the developed, historic and natural environment in a sustainable manner. The first SMP (SMP1) was completed for the Isle of Wight in 1997. The SMP is periodically reviewed. The second SMP (SMP2) is being competed in 2010.
Short term	Refers to a time period of months to years.
Significant wave Height (Hs)	The average height of the highest of one third of the waves in a given sea state.

Sink Area at which beach material is irretrievably lost from a coastal cell, such as an estuary, a deep channel in the seabed or dunes inland.

Spit An elongated accumulation of sand or gravel, which projects into the sea or across a tidal inlet. Longshore drift of material is usually responsible for the development of a spit.

Standard of Protection (SoP) The level of return period event which the defence is expected to withstand without experiencing significant failure.

Still Water Level (SWL) Average water surface elevation at any instant, excluding local variation due to waves and wave set-up, but including the effects of tides and surges.

Storm Surge A rise in water level in the open coast due to the action of wind stress as well as a change in atmospheric pressure on the sea surface. A surge typically has a duration of a few hours. See 'surge'

Subtidal Part of the coast that is permanently below water.

Surge Changes in water level as a result of meteorological forcing (wind, high or low barometric pressure) causing a difference between the recorded water level and that predicted using harmonic analysis, may be positive or negative.

Suspended Sediment A mode of sediment transport in which the particles are supported, and carried along by the fluid. See 'bedload transport'.

Swell Waves Remotely generated wind-waves (i.e. Waves that are generated away from the site). Swell characteristically exhibits a more regular and longer period and has longer crests than locally generated waves.

Tidal range Difference in height between high and low water levels at a point.

Tide Periodic rising and falling of large bodies of water resulting from the gravitational attraction of primarily the moon and sun acting on the rotating earth.

Toe level The level of the lowest part of a structure, generally forming the transition to the underlying ground.

Tombolo An accumulation of sediment from the shore to an offshore island, formed by the deposition of material when waves are refracted and diffracted around the island. In a tidal environment a tombolo may exists at all states of the tide or only during lower states leaving a 'salient' at high tide.

Topography Configuration of a surface including its relief and the position of its natural and man-made features.

Transgression The landward movement of the shoreline in response to a rise in relative sea level.

Trigger Levels A set of criteria that trigger an intervention. The intervention can range from increased monitoring to preparation of interventions to an intervention. There is a sequence of Trigger Levels with an increasing level of action and associated costs.

Undermining Erosion at the base, e.g. of a sea wall, so that the feature above becomes unstable and is vulnerable to collapse. Usually the consequence of 'scour'.

Updrift Direction opposite to the predominant movement of longshore transport.

Wave Climate The seasonable or annual distribution of wave height, period and direction measured over a longer period of time.

Wave Direction Direction from which a wave approaches.

Wave Height The vertical distance between the crest and the trough.

Wave Hindcast The retrospective forecasting of waves using measured wind information.

Wave Period The time it takes for two successive crests (or troughs) to pass a given point.

Wave Return Wall A sea wall whose seaward face is designed to reflect wave energy.

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