Regional Beach Management Plan 2015: Eastbourne to Rye

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.

Regional Beach Management Plan 2015

Eastbourne to Rye

Main Report

Canterbury City Council

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EXECUTIVE SUMMARY

This Beach Management Plan (BMP) has been prepared by **Canterbury City Council** on behalf of **Eastbourne Borough Council, Wealden District Council, Rother District Council, Hastings Borough Council and 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 Eastbourne and the river Rother. 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 RBMP proposes the following activities:

- All units: continued monitoring under the RCMP. Consider recycling beach material from Hastings to Eastbourne via the sea to reduce replenishment requirements.

- Eastbourne: continue recharge and replenishment of material to sections A to D within Eastbourne replacing material lost from the sediment cell. Consider reviewing the bypassing of material into Sovereign Harbour from Langney Point as once this material is removed it needs to be brought into Eastbourne.

- Pevensey: continue monitoring and management as prescribed by PDCL.

- Bexhill: consider using the sediment for emergency recharge works as these bays are well above design.

- Hastings: recharge/recycle to Section G, Carlise Parade. Consider a groyne structure to retain material at this critical area.

- Winchelsea: continue annual recycling from Nook Point to Pett Beach.

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1 INTRODUCTION

1-1 PRESENT SITUATION

1-1-1 SMP AND OTHER STRATEGY POLICY

The coastline between Eastbourne and the River Rother falls within the coastal frontage of the South Foreland to Beachy Head Shoreline Management Plan (2006) including policy units 4c29 (Eastbourne) to 4c18 (River Rother to Cliff End) (Table 1-1). The frontage is managed under the responsibility of the organisations shown in Figure 1-1 overleaf.

TABLE 1-1 SMP POLICIES WITHIN THE BMP

POLICY UNIT	DESCRIPTION	SEDIMENT TYPE	SHORT TERM	MEDIUM TERM	LONG TERM
4c29	EASTBOURNE	SHINGLE	HTL	HTL	HTL
4c28	SOVEREIGN HARBOUR	SHINGLE	HTL	HTL	HTL
4c27	PEVENSEY AND HOOE	SHINGLE	HTL	HTL	HTL
4c26	BEXHILL AND COODEN	SHINGLE	HTL	HTL	HTL
4c25	BULVERHYTHE AND GLYNE GAP	SHINGLE	HTL	HTL	HTL
4c24	HASTINGS	SHINGLE	HTL	HTL	HTL
4c23	FAIRLIGHT COVE WEST TO HASTINGS	SHINGLE	NAI	NAI	NAI
4c22	FAIRLIGHT COVE WEST	SHINGLE	NAI	NAI	NAI
4c21	FAIRLIGHT COVE CENTRAL	SHINGLE	HTL	HTL	MR
4c20	FAIRLIGHT COVE EAST	SHINGLE	MR	MR	MR
4c19	CLIFF END TO FAIRLIGHT COVE	SHINGLE	NAI	NAI	NAI
4c18a**	WINCHELSEA TO CLIFF END	SHINGLE	HTL	HTL	HTL
4c18b**	RIVER ROTHER TO WINCHELSEA	SHINGLE	HTL*	HTL*	HTL*

HTL – Hold the Line, NAI – No Active Intervention, MR – Managed Realignment

**Policy includes maintaining the secondary defence and raising and strengthening it in the second half of the strategy period to mitigate the effects of sea level rise. This does not involve works along the beach frontage except those required for the maintenance of the haul road.*

*** Folkestone to Cliff End Strategy 2009*

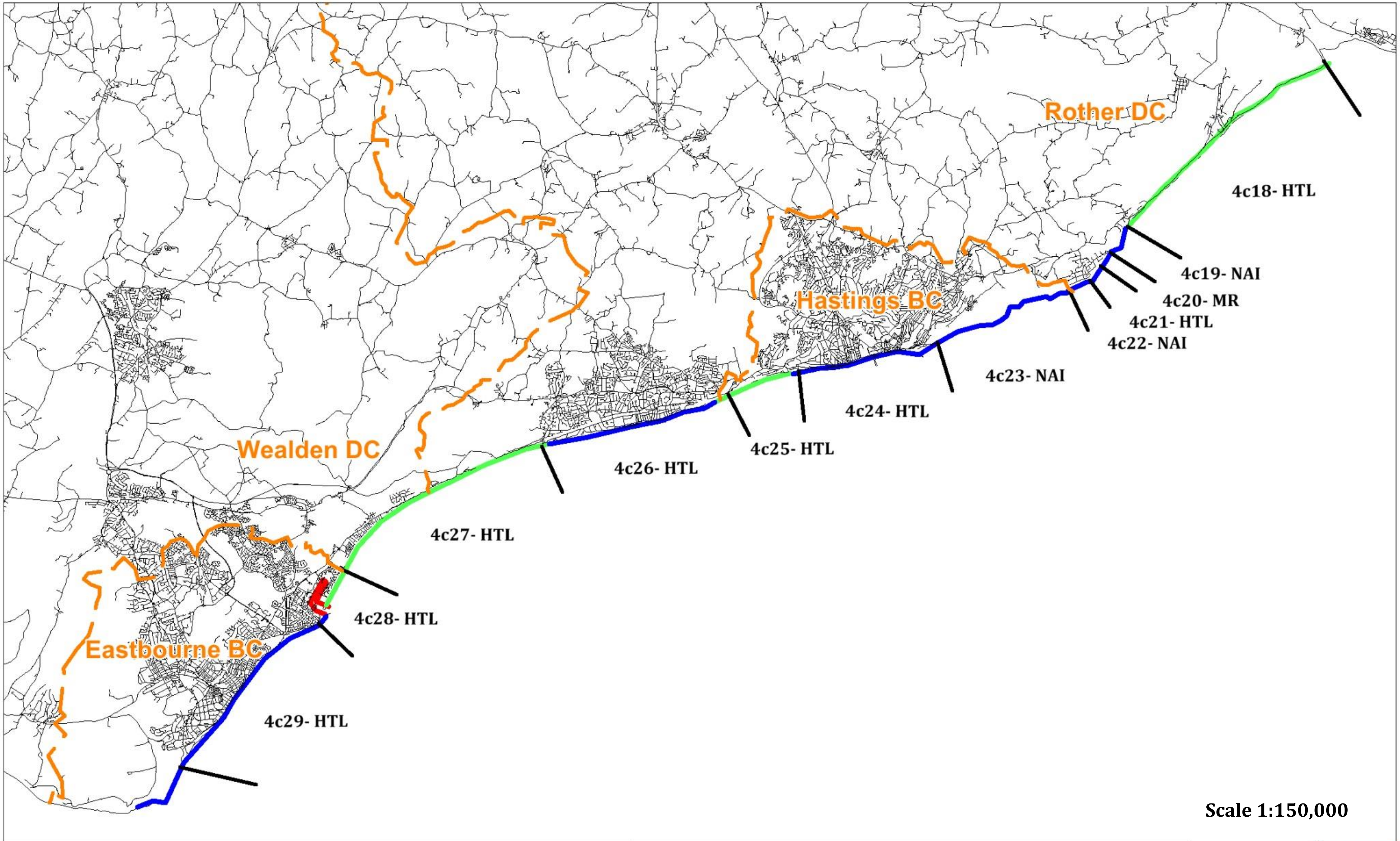

FIGURE 1-1 LOCAL AUTHORITY, MANAGING AUTHORITY AND SMP POLICY BOUNDARIES

Local Authority
Privately Owned
Environment Agency

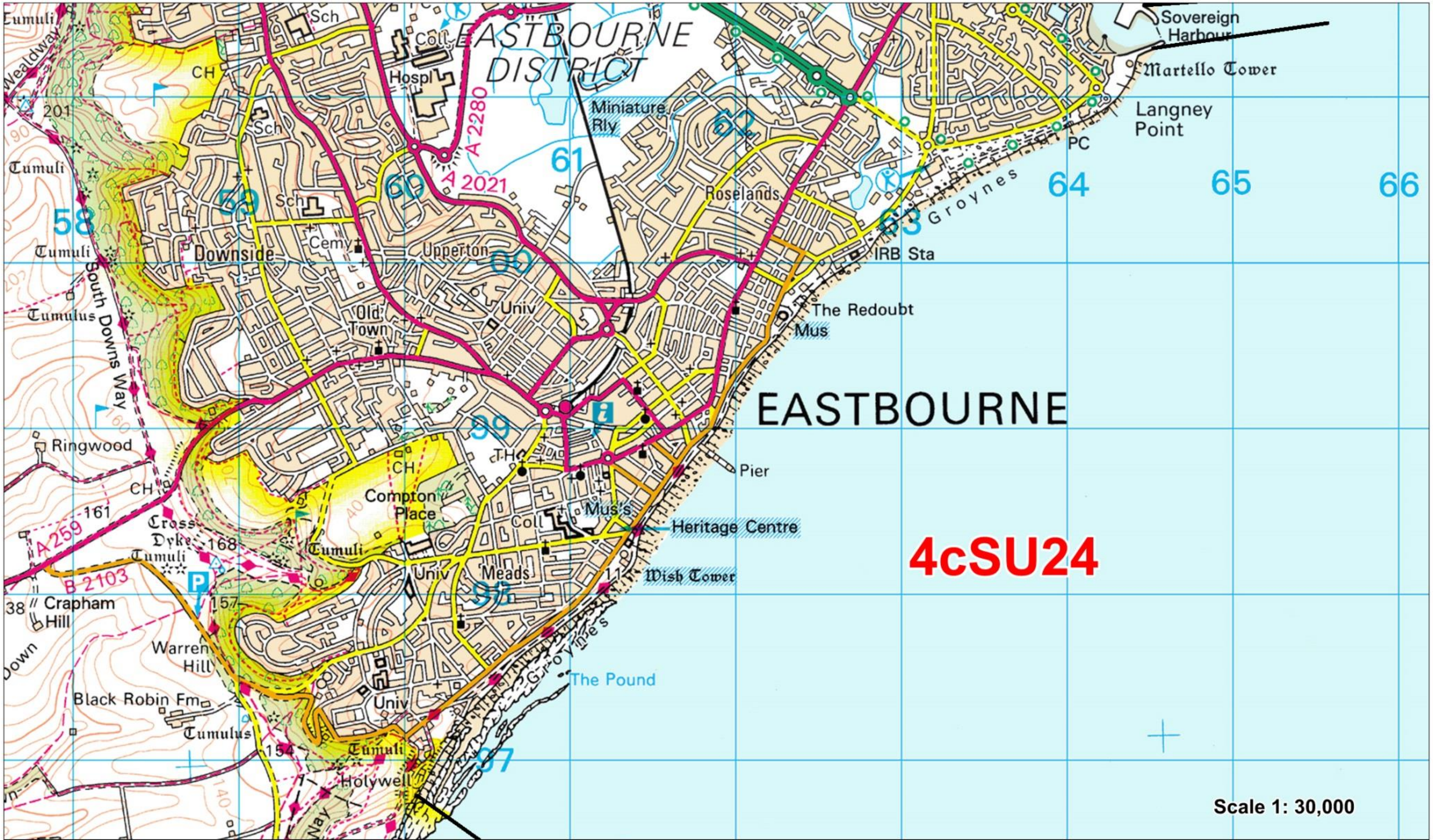

FIGURE 1-2 UNIT BOUNDARY - EASTBOURNE

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RCMP Unit Boundaries

Figure 1-3 Unit Boundary – Pevensey Bay

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RCMP Unit Boundaries

FIGURE 1-4 UNIT BOUNDARY – BEXHILL-ON-SEA

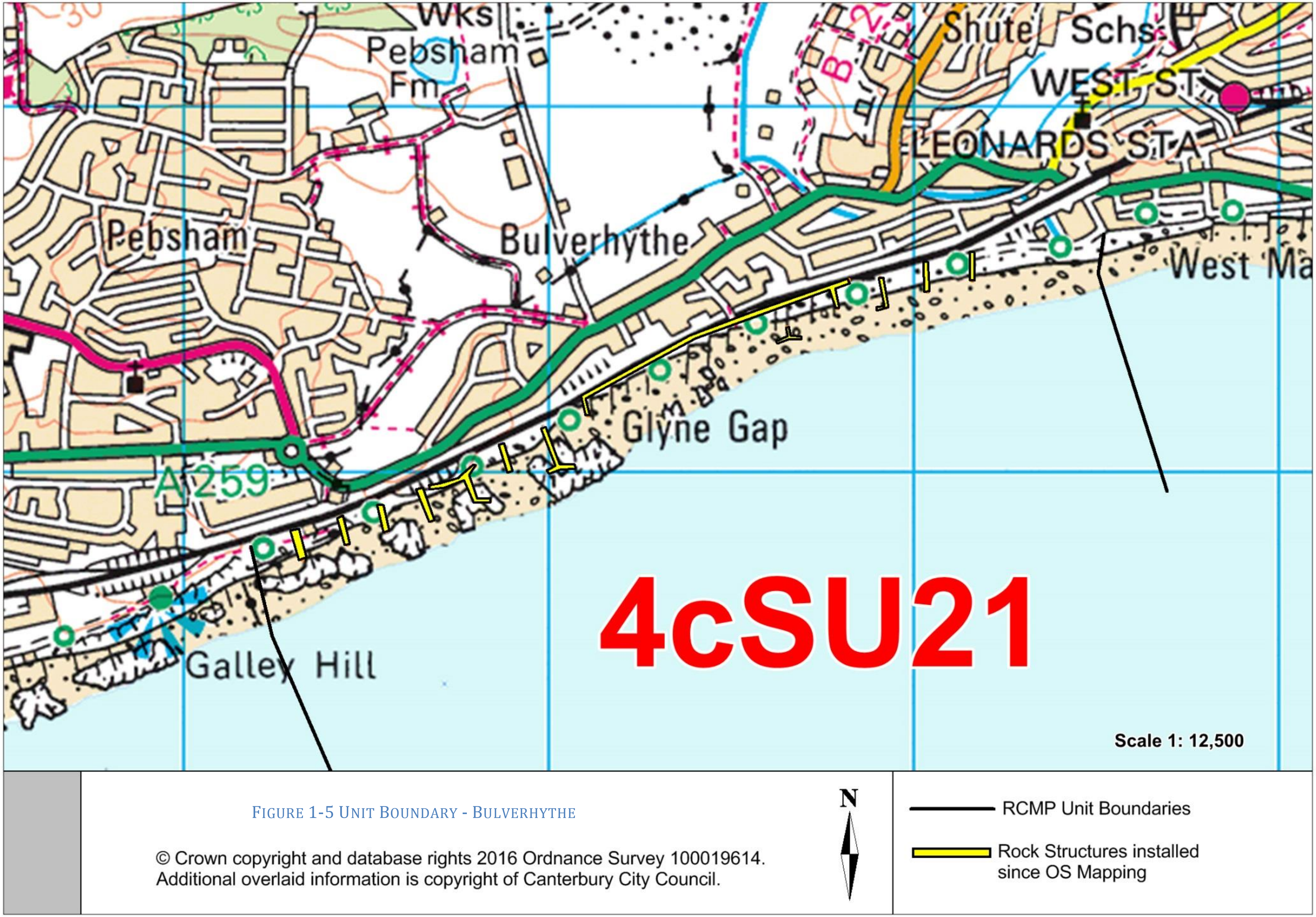

FIGURE 1-5 UNIT BOUNDARY - BULVERHYTHE

FIGURE 1-6 UNIT BOUNDARY - HASTINGS

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RCMP Unit Boundaries

Rock Structures installed since OS Mapping

FIGURE 1-7 UNIT BOUNDARY – FAIRLIGHT GLEN

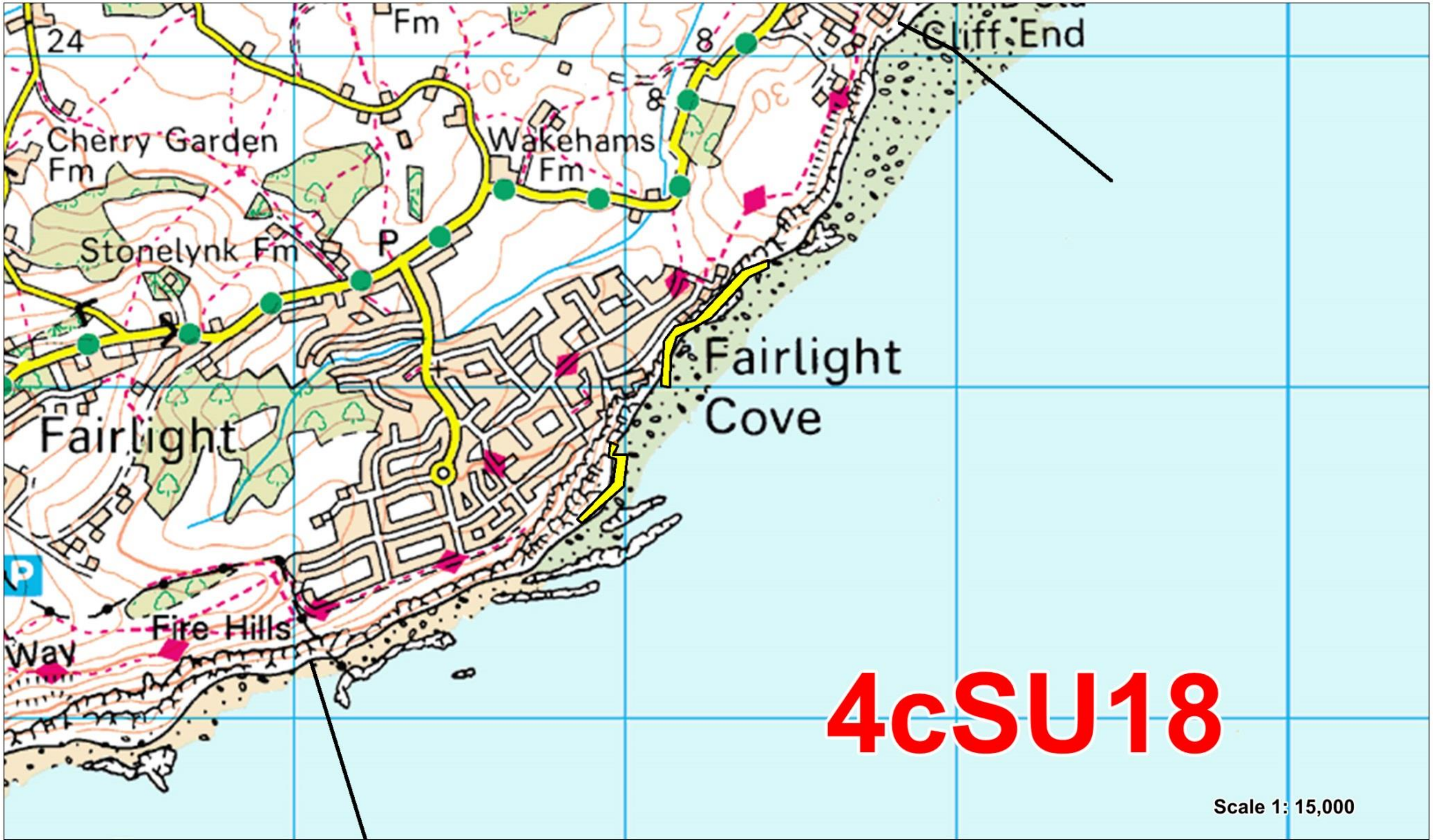

FIGURE 1-8 UNIT BOUNDARY – FAIRLIGHT COVE

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RCMP Unit Boundaries

Rock structres installed since OS Mapping

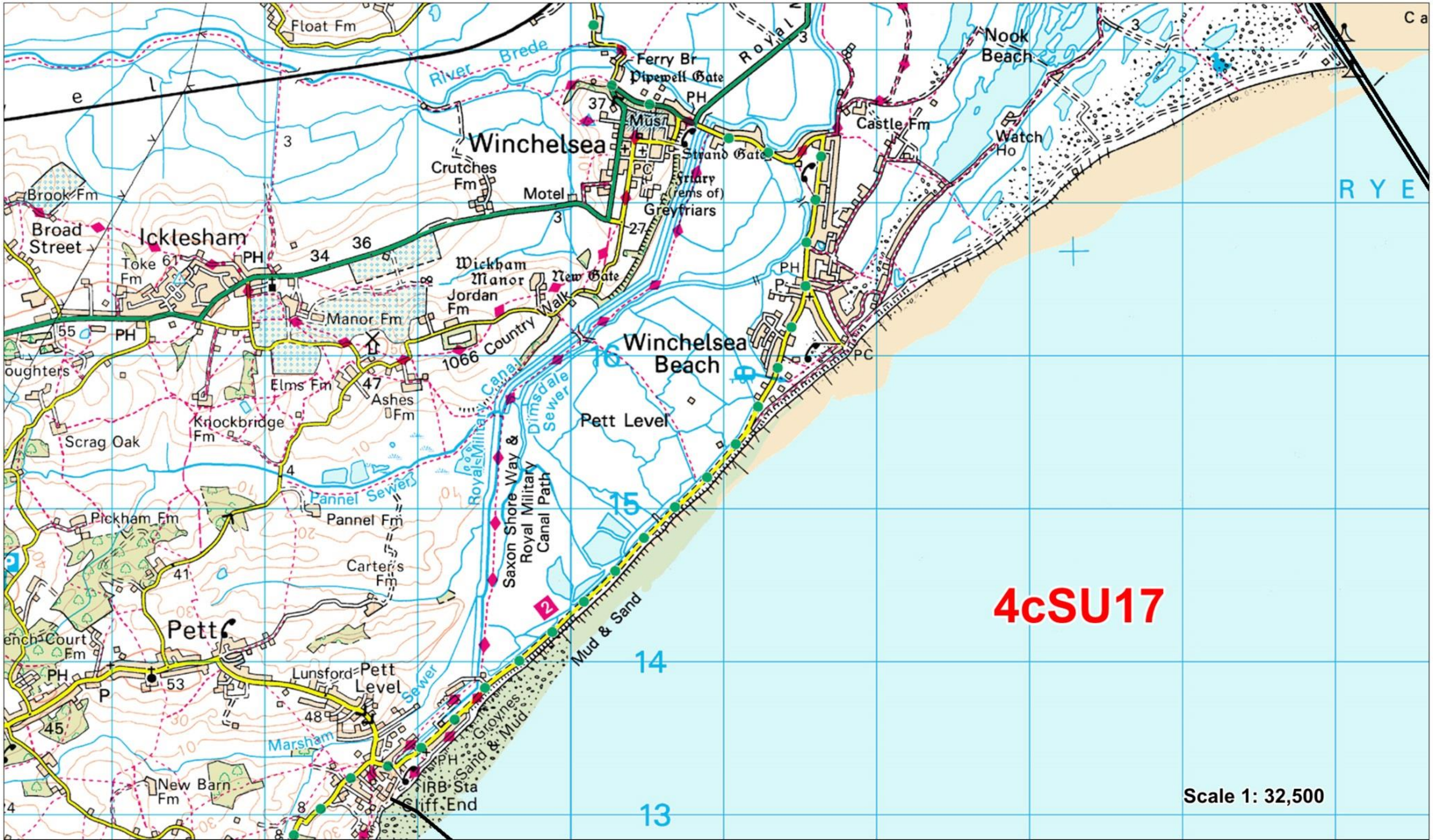

FIGURE 1-9 UNIT BOUNDARY – WINCHELSEA

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RCMP Unit Boundaries

1-1-2 PHYSICAL CHARACTERISTICS AND COASTAL DEFENCES

To the west of the BMP frontage are the unmanaged cliffs of the Seven Sisters and Beachy Head (SSSI, AONB and Heritage Coast). Erosion of the cliffs is not thought to contribute any significant of volume to the sediment cell.

EASTBOURNE

Apart from the short isolated rock revetment at the cliff toe of the Holywell, the Eastbourne frontage is characterised by a shingle beach contained in a dense timber groyne field fronting a Victorian seawall and promenade for most of its length.. The current coastal defences were completed in 1999 at the cost of £30 million, following a period of severe storms in the later 1980s and early 1990s which caused significant material draw-down from which it never recovered (Waters, 2002). The timber groyne (54) and recharge scheme was designed to a standard of protection against a 1:200-year overtopping event, with a 50 year design life that includes regular beach management. At Holywell, South East Water constructed a 75m rock revetment at the base of the cliffs to protect the water source located there. This scheme was supplemented by an annual recharge of shingle at Holywell.

From the western end of the defence to just east of the Pier, the beach is backed by a seawall and promenade fronting rising ground. The frontage susceptible to flooding extends for the remainder of the length to Sovereign Harbour. Spanning 500m between Redoubt Fortress and the tennis courts, just south of the second section of isolated rock revetment, the promenade is protected by a wide shingle barrier. For the northern 1.8km, a seawall and rock revetment secures the link with the western Harbour Arm. The intertidal platform fronting the beach is a Gault formation with an elevation of -1.0mOD at Holywell, gradually lowering to -2.8mOD at Sovereign Harbour. From the Wish Tower towards Sovereign Harbour, the platform is made of sand.

Remedial works were undertaken in 2009 to increase beach levels once again, following a spell of no maintenance works during 2004-2008. In places the beach was approaching failure levels which increased the risk of undermining of the seawall. Further work was required in 2011 to increase the beach to design level; 200,000m^3 shingle was dredged off the Isle of Wight and pumped ashore via sunken pipeline from a dredger. In addition 40,000m^3 of shingle was recycled from beaches that were overfull and placed on the beaches at the Holywell end of the frontage, a result of the environmentally sensitive nature of this frontage which is designated as a Site of Special Scientific Interest (SSSI).

SOVEREIGN HARBOUR

Sovereign Harbour breakwater arm was constructed in 1992 and forms the eastern boundary of the harbour mouth. Its purpose is to retain material south of Sovereign Harbour. In 2002 a rock spur was added to the southern harbour arm to retain shingle closer to the shore so that it could be easily removed from the beach and bypassed round the marina. The northern harbour arm connects to a 450m long rock revetment that extends north east in front of the Northern Harbour estate.

PEVENSEY BAY

Pevensey Bay stretches from the rock groyne north of Sovereign Harbour to Cooden. Apart from the section that is backed by the Sovereign Harbour rock revetment, the seawall at Normans Bay and the timber seawall at Herbrand Walk it is a shingle barrier of varying width fronted by an intertidal platform that includes quite stable pebble and cobble material at Sovereign Harbour with a beach toe at -2.0m to -2.2mOD, but is otherwise largely composed of sand with the foreshore generally rising towards the East and -1.0m to -1.3mOD at Cooden, which occasionally exposes estuarine clay beds. From East Stream eastwards mudstone/claystone outcrops appear in the intertidal platform depending on the sand cover. The beach has been managed since 2000 as an increasingly open beach with removal of dysfunctional groynes, the improvement of individual groynes at strategic location and an intense programme of beach recycling.

BEXHILL-ON-SEA

Bexhill-on-Sea extends from Cooden to Galley Hill. The Pevensey shingle barrier connects to rising ground at Cooden and continues as a shingle beach in front of low sandstone cliffs. At Cooden the shingle ridge is wide and backed by a grassy embankment. Moving eastwards towards Veness Gap, the shingle ridge reduces in width and is backed by a promenade with a splash wall. Further eastwards, again, the topography of the coast rises and then starts to descend into West Parade. In this region, the shingle is retained by a series of timber groynes and is backed by a vertical concrete wall and promenade, which protects Western Bexhill.

The existing defences consist of a near vertical block work wall with promenade fronted by a shingle beach and timber groynes. At Sutton Place the coastline begins to rise to form the sedimentary rock slopes at Galley Hill. A shingle beach and timber groynes defend this frontage. To the rear of the beach the slopes are protected by a concrete wall. The intertidal platform is covered with sand though bedrock comprising Tunbridge Wells silts and sandstone frequently outcrops along this frontage. There are hardly any remains of the Bronze Age forest beds left on the foreshore.

BULVERHYTHE

Bulverhythe is located between Galley Hill, Bexhill, and Cinque Ports Way, Hastings. The low shingle beach fronts the railway line bund to the west, with seven rock groynes slowing beach transport; the coastline rises at the sandstone cliffs and falls towards the rock revetment. The east of the unit is defined by a large shingle beach and a further three rock groynes. The sand foreshore is interspersed with bedrock comprising Tunbridge Wells silts and sandstone, which frequently outcrop along this frontage.

In 2006 the Environment Agency removed 36 dilapidated timber groynes to construct 9 rock groynes and 750m of rock revetment. In addition, 60,000m^3 of material was deposited in front of the revetment and in the new groyne bays. The structures are designed to protect the railway line and low lying land behind against breaching by storms with a minimum return period of 1 in 200 years, for a period of 100 years.

HASTINGS

Hastings extends from Cinque Ports Way, West Marina through to East Hill. With the exception of East Hill, the frontage is relatively low lying and raises further inland. The coastline is fairly straight, a relatively recent characteristic, as originally it was much more indented. The erosion of White Rock headland has aided the smoothing of the coastline (Halcrow, 2000). The only protrusions are now man made with the three perpendicular structures; the concrete Harbour Arm with stabbits and two concrete groynes. The beach at the east consists of coarse, loose shingle and to the west has a higher sand content.

Hastings is defended by a concrete seawall of varying types which were constructed in the 1930s and upgraded in the 1980s/1990s. Timber groynes were encased in concrete or completely reconstructed at the same time. The groynes were installed at 50-100m intervals and have been well maintained through replanking. An additional 53m length rock groyne was constructed just east of Hasting pier in 2009. The groyne was placed at +5.0mOD at the seawall sloping down to the foreshore as this was the weakest section of coastline and prone to overtopping.

FAIRLIGHT

Fairlight covers East Hill to Cliff End, Pett Levels and is an area of undefended clay cliff of international environmental, geological and ornithological importance with high landscape value, and no significant cliff top developments, for the most part.

Fairlight can be split into three sections; Fairlight Cove (west) is bedded on sands and clay that form the vertical cliff along this stretch. The central section of Fairlight (Rockmead Road) is currently defined by relic landslides, attributed to a combination of elevated ground water and cliff toe erosion. There is a 240m rock revetment at the base of this cliff for toe protection which was constructed in 2008. The eastern section of Fairlight (Sea Road) has a cliff toe defence structure to reduce erosion which was constructed in 1990 with a design life of 50 years. There is a narrow fringing beach composed of shingle, sand and talus deposits.

WINCHELSEA BEACH

Winchelsea Beach extends from Cliff End in the south to Rye training wall in the north. The training wall was constructed to prevent sedimentation of the River Rother. The beach is shingle sand composite for the whole length with a sandstone platform foreshore capped with remnants of a Bronze Age forest in the south and extensive areas of sands and mudflats in the intertidal zone in the north. In the hinterland of this coastline lie two villages, Pett Level in the south and Winchelsea Beach in the centre. The elevation of the land behind the defence falls well below MHW.

The current defences were upgraded in 2008 where the capital scheme provided a 200-year standard of protection against breaching for the frontage. The construction of timber groynes at Cliff End and Winchelsea Beach, the construction of the secondary defence flood bund and a gabion wall to protect Haul Road, running from Nook Point to Winchelsea Beach and shingle recharge have largely improved the level of protection. The beach east of Winchelsea remains undefended and left to natural processes. To maintain the standard of protection annual recycling from the extraction pocket to the west of the Harbour arm is required.

Oblique photography of all sites can be found in Appendix A.

1-1-3 GEOLOGY

The frontage covers the western half of the Wealden anticline between the Chalk outcrops of the South and North Downs and is characterised by the relative hard points of the Chalk cliffs at the western end of Eastbourne, the Wealden Sandstone Cliffs of different elevation from Cooden to Cliff End and large Holocene intertidal embayment's of Willingdon Levels, Pevensey Levels, Pett Levels and the smaller Combe Haven.

> *"[The shoreline] has been shaped by sea level rise during the Holocene period, i.e. following the last glaciation. Flooding of the English Channel commenced from the west as sea levels rose, and by approximately 10,000 years ago had reached Beachy Head. By c.8,000 years ago the entire English Channel, including the Dover Straits, was inundated. Shortly after, the shallow land separating this water body from the North Sea was breached, initiating a strong eastward current and sediment transportation in the eastern channel. Sea level attained a level close to its present position around 5,000 years ago, and the modern hydrodynamic regime has been operating since this time. In the early stages of this period, the onshore migration of significant quantities of sediment led to major episodes of coarse sediment accumulation. This resulted in the formation of shingle barriers, that, rolled back [(Mellett et al., 2012)] to form the present shoreline position , and indeed much of the present beaches. It is probable that shingle from the South Downs (Selsey Bill to Beachy Head) coastline was once delivered onto this frontage around Beachy Head. However rising sea levels have now cut-off this source. Over the last 2,000 years sea level rise has continued, but at much lower rates resulting in on-going, but less dramatic, changes at the shoreline." (Shepway DC, 2006)*

Cliff erosion has been halted along the low sandstone cliffs at Eastbourne and along the Cooden to Hastings section. Active retreat of the chalk cliffs at Eastbourne is very slow and contributes insignificant amounts of flint. Erosion of the cliffs east of Hastings tends to occurs through land sliding and cliff fall processes but owing to the material only contributes sand and silt to the coast.

Evolution of the frontage: Cliff End to Beachy Head Strategy (Halcrow,2002)

This is a headland controlled section of coast that comprises a series of sea cliffs intersected by low-lying areas (known as Levels) that have become sealed by coarse-grained sediment moving across their mouths, which have formed barriers to normal tidal inundation. The present Willingdon Levels, Pevensey Levels and Combe Haven have all been formed by the closure of former estuaries. Over the Holocene timescale, these estuaries have been alternately sealed and re-opened, through periodic breaching and sealing of the foreshore shingle and sand ridges; they were last re-opened to tidal flow some 2,400 years ago and last became totally sealed in the 12th Century.

Rising sea levels swept material from the seabed landwards and initiated erosion of the solifluction drift deposits mantling the cliffs around Beachy Head. These sediments were transported eastwards by longshore drift across Eastbourne, causing the development and growth of a spit across the entrance to Pevensey Bay. Considerable volumes of sediment continued to be released through erosion of the solifluction drift deposits. These sediments were transported further east, first resulting in accumulation and eventual blockage of Combe Haven, and then in the feed of material to the adjacent downdrift frontage, between Cliff End and Sandgate, where it subsequently combined with local sediment sources to aid in the development and evolution of Dungeness cuspate foreland.

Continued sediment accumulation and progressive extension of the spit across Pevensey Bay led to the formation of a barrier, eventually completely cutting off the Bay from all but occasional marine inundation. As a result, the low former inter-tidal area backing the barrier began to silt up with alluvium and was reclaimed during the Middle Ages, with the formerly extensive network of tidal creeks being reduced to the embanked channels of Pevensey Haven, Old Haven and Waller's Haven. Reclamation of what is now called Pevensey Levels occurred relatively rapidly during a period of approximately 200 years and was completed by the 13th Century. In order for the former estuary mouths along this frontage to have become sealed in the 12th Century, there needed to be an influx of coarse-grained sediment into the system. The erosion of solifluction drift deposits, mantling Beachy Head, and of flint and chert, from the Chalk cliffs, and shore platform around Beachy Head provided some of this sediment, although a significant volume was also transported onshore from the sea bed. Subsequent downdrift transport of such sediment by longshore processes led to accumulation at the Crumbles. Further re-working of shingle from the Crumbles and its continued eastward transport also contributed to the processes of estuary mouth sealing.

Between the 12th and 15th Centuries, the shingle accumulation at the Crumbles grew into a cuspate foreland feature. A line of 14 Martello Towers was constructed along the Crumbles shoreline during the Napoleonic Wars (early 1800s). Five of the six towers on the south-west-facing (updrift) side have now been destroyed by marine erosion, and five of the seven on the south-east-facing (downdrift) side have now been separated from the shoreline by accumulated shingle. Over the past four Centuries, the Crumbles has experienced relatively major changes. Although the protrusion at Langley Point was not evident on late 16th Century maps, it was well developed by the 18th Century. Indeed, at this time a shingle foreland extended some 1.5km further seaward of the present position of Langley Point. Since this time, extensive erosion of the Crumbles has occurred and its plan-form area has declined markedly.

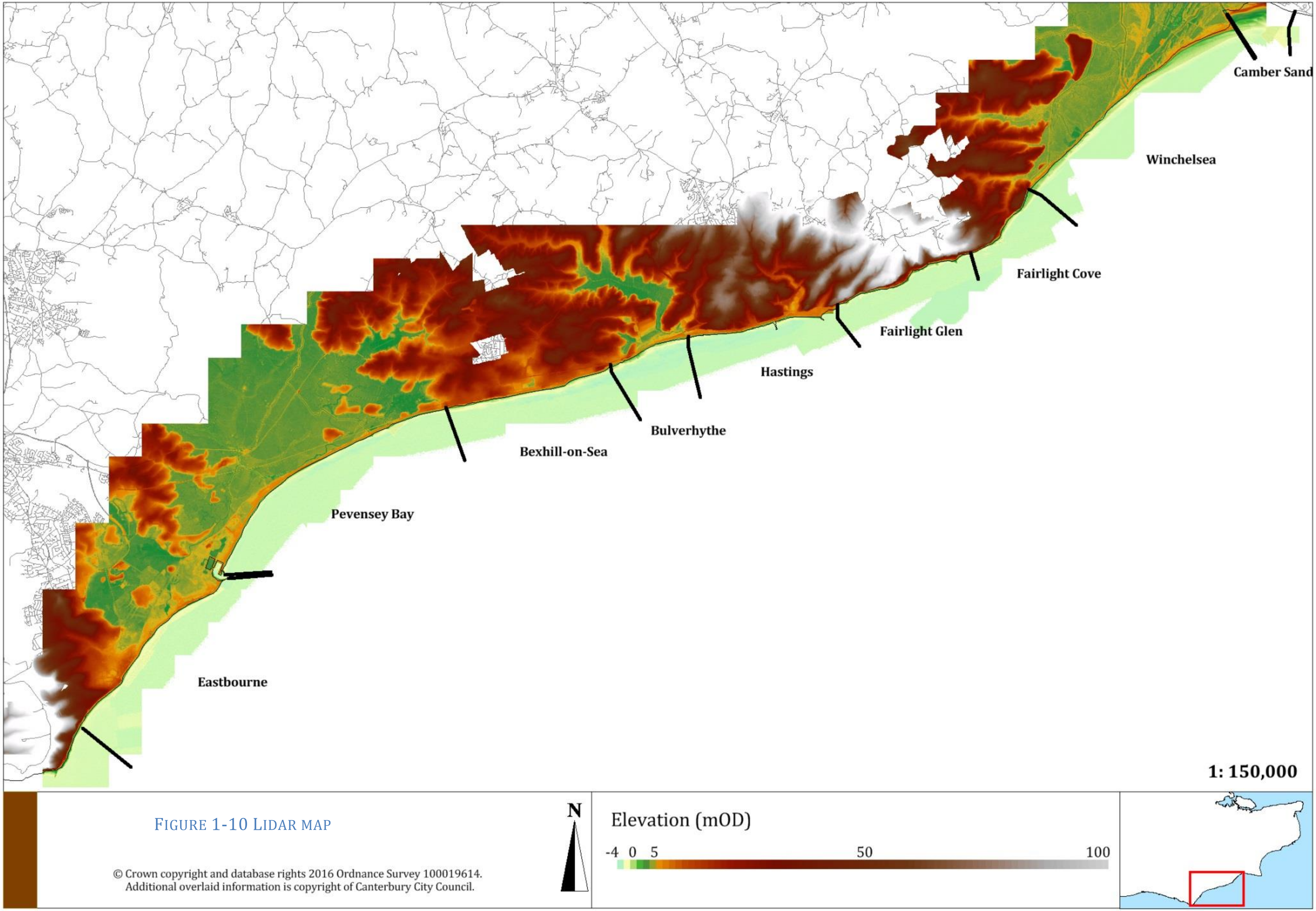

FIGURE 1-10 LIDAR MAP

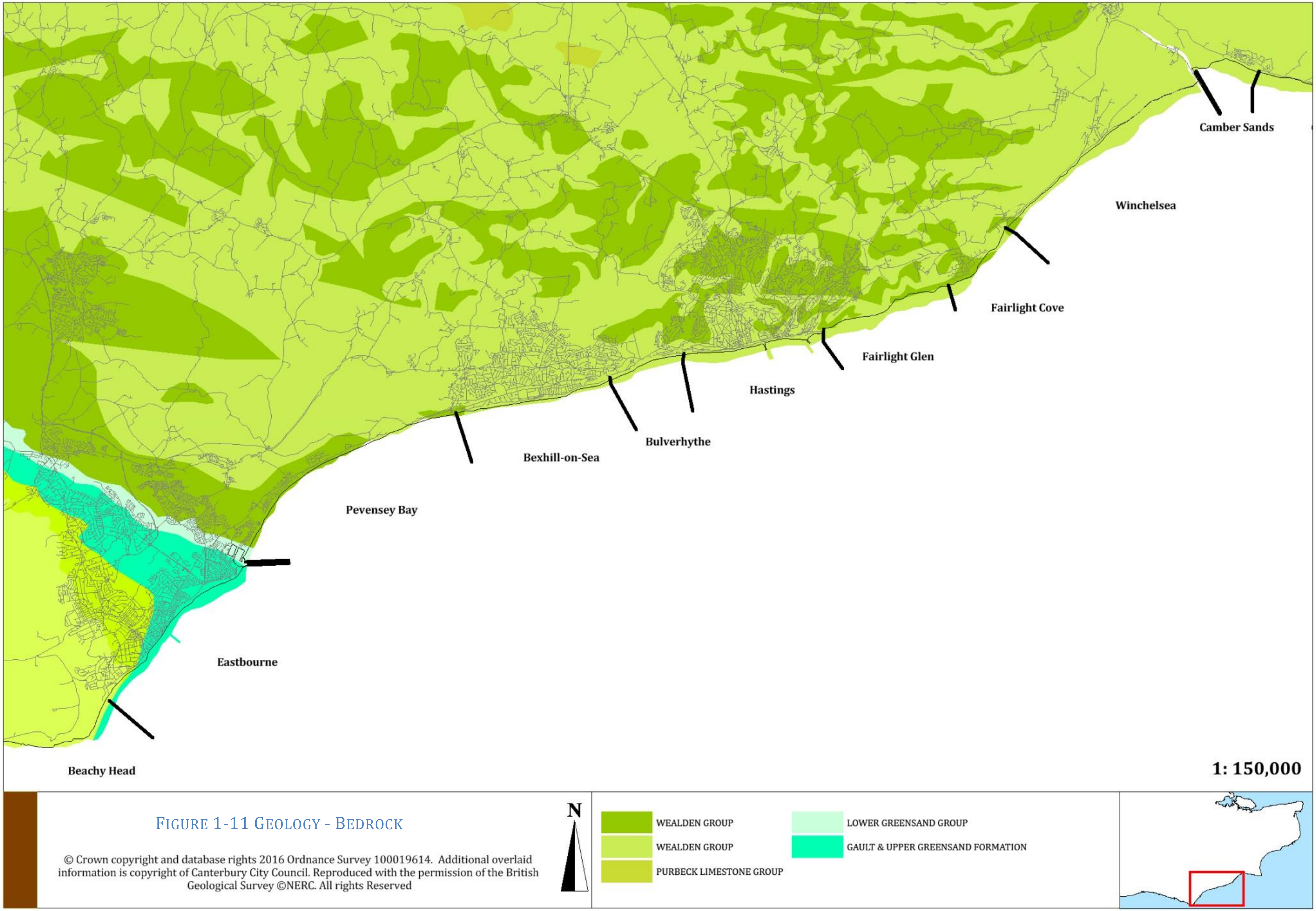

FIGURE 1-11 GEOLOGY - BEDROCK

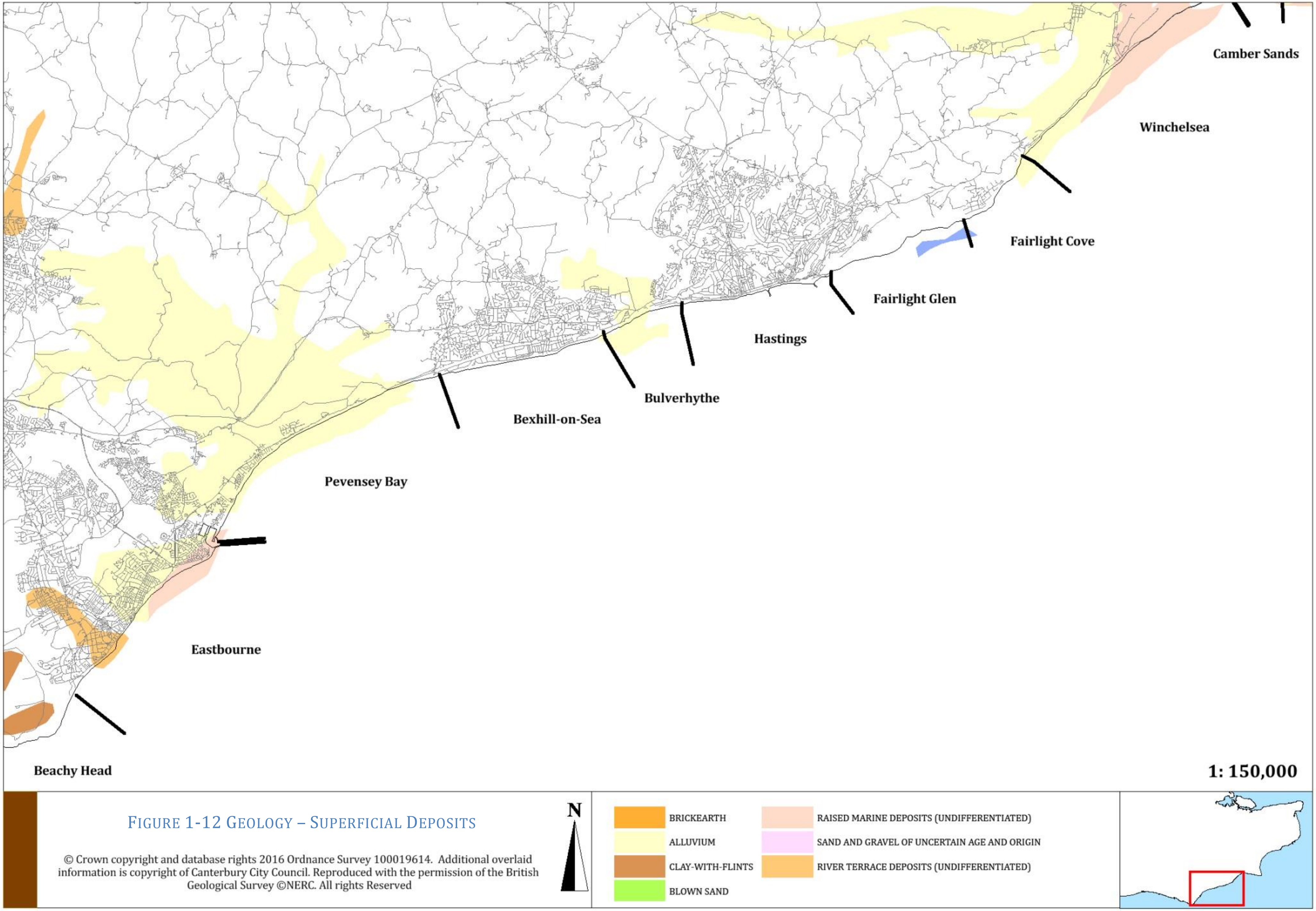

FIGURE 1-12 GEOLOGY – SUPERFICIAL DEPOSITS

1-2 HISTORY OF THE FRONTAGE

Table 1-2 lists the flooding and storm events between Eastbourne and Rye Training wall and Table 1-3 list the erosion events. 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.

1-2-1 FLOODING INCIDENTS

In Eastbourne in the late 1980s a series of storm events caused significant reduction in beach levels and wave and shingle overtopping of the defences which resulted in flooding and damage to seafront properties. The reduced beach resulted in increased loading upon the old timber groynes, resulting in failure which exacerbated the beach losses and overtopping (Halcrow, 2010). St Leonards, Hastings and Bexhill-on-Sea regularly suffered flooding which has caused a need for improvements of the defences over the years.

Recorded flood events date back to the 1800s with the earliest recorded flood in November 1875 when the sea defences were damaged and Hastings and surrounding areas flooded. Tidal surges caused flooding in 1905, 1918, 1945, 1959, 1967, 1968 and 1973. Further flood events caused by excessive rainfall at Hastings, St Leonards and Bexhill (after 1980) were recorded during 1962, 1963, 1964, 1966, 1967, 1973, 1980, 1984, 1986, 1988, 1991, 1992, 1994 and 1996 (Halcrow, 2002); however these latter events do not have any effect on the BMP or its planned activities.

1-2-2 EROSION INCIDENTS

Cliff falls along the chalk headland are a regular occurrence at Beachy Head. The AONB is not protected by sea defences due to the slow erosion rate of chalk and in attempt to maintain the whiteness of the cliffs. Historic maps indicate Beachy Head has lost between 10 and 50m of chalk cliff between 1910 and 2013, an average range of 0.09m to 0.49m per year. These figures match the most recent SMP guidance of 0.1m/yr to 0.5m/yr for the next 100 years (Shepway District Council, 2006).

Landslides have been fairly common at Fairlight Cove and Fairlight Glen with up to 110m retreat of the cliff top in front of the village Fairlight since 1910. Remedial action was undertaken in 2007 to reduce the erosion rate and protect the village from falling into the sea. The cliffs have become more stable as a result of the construction of the rock revetment and land drains in the slip face to remove water from the cliffs.

TABLE 1-2 COASTAL FLOODING AND STORM INCIDENTS

DATE	LOCATION	DAMAGE	REPAIR WORKS	SOURCE
SEPTEMBER 1932	WINCHELSEA	BUNGALOWS FLOODED FOLLOWING ~70M BREACH OF SEA DEFENCES	BREACH REPAIRED	*EUROPENANA 1932*
WINTER 1989/1990	EASTBOURNE	"HUGE DAMAGES TO DEFENCES, SHINGLE WASHED AWAY"		*THE ARGUS 12-05-1999*

1990	WINCHELSEA	WAVES IMPACTED ON THE FRONT FACE OF THE WALL AT DOG'S HILL WHICH STRIPPED AWAY THE CONCRETE BLOCK REVETMENT		
1990	HASTINGS	DAMAGE TO HASTINGS PIER		*COODEN TO CLIFF END STRATEGY*
1992	BEXHILL-ON-SEA	DAMAGE TO BEACH HUTS		*COODEN TO CLIFF END STRATEGY*
1998	WINCHELSEA	OVERTOPPING OF THE FLOOD DEFENCES AND DAMAGE TO GRASSED BACK FACE		
28TH OCTOBER 1999	HASTINGS	DAMAGE TO COUNCIL PROPERTY. PEBBLES THROWN ONTO THE PROMENADE		
OCTOBER 1999	PEVENSEY	OVERTOPPING OF DEFENCES CAUSED DAMAGE TO SOME OF THE CREST TOP PROPERTIES		*THE ARGUS 19.06.2009*
DECEMBER 1999	PEVENSEY	RESIDENTS EVACUATED DUE TO STORM FEARS		*THE ARGUS 19.06.2009*
DECEMBER 2013	RYE	SAILING CLUB BOATHOUSE AND NATURE RESERVE VISITOR CENTRE DAMAGES AND ROAD WASHED AWAY		*RYE NEWS 11.02.2015*
JANUARY 2014	BULVERHYTHE	SMALL AMOUNTS OF SHINGLE WASHED ONTO THE RAILWAY LINE; DAMAGE TO FOOTPATH		EA INTERNAL 08.01.2014

Table 1-3 Erosion Incidents

Date	Location	Damage	Repair Works	Source
1974-1975	Normans Bay, Bexhill	30,000-35,000 m^3 losses from 200m long sections reported by the beach monitoring survey		*East Sussex County Council Report (Thorburn, 1977)*
December 1979	Fairlight Cove	66m in length of cliff face lost in a single night by landslides		*Waugh, D., (2000) Geography, an integrated approach. 3rd Ed. pp.172*
Winter 1980-81	Fairlight Glen, Fairlight Cove	Scar more than 30m in height caused by a major landslip and rock fall		*Robinson, D.A., and Williams, R.B.G, (1984) The High Weald coast from Hastings to Pett. Classic Landforms of the Weald. Landform Guide No. 4.*
May 1997	St Leonards, Hastings	Landslip tore away foundations of a bungalow		*The Argus 14-05-1987*
January 1999	Beachy Head	Thousands of tons of chalk fell from cliff. Estimated that 50ft of cliff face along a 150-200 yard stretch was lost. Filled in channel between beach and lighthouse.		*The Argus 11-01-1999*
		Volume of landslide estimated at between 100-150000 m3		*British Geological Survey*
May 2001	Beachy Head	Loss of "Devil's Chimney" - 200ft high chalk tower. Thousands of tons of rubble.		*The Independent 04-05-2001*

1-3 HISTORY OF COASTAL MANAGEMENT

Figure 1-13, at the end of this section of text, is a summary timeline of these activities.

EASTBOURNE

Eastbourne was first recorded as a settlement preceding Roman times; however the first defences were not constructed until the 1800s. In 1883, the promenade at the eastern end of Eastbourne was completed. As with many Victorian developments, the promenade was built on top of the shingle beach (Halcrow, 2010). This fixed the shoreline in a position it would not naturally stay at, causing a need for timber groynes.

HASTINGS

The first breakwaters were constructed at Hastings in the early 1800s, and have been extended and reinforced throughout the early part of the 20th century.

During the 1930s, the first concrete seawalls were constructed, which were then upgraded during the 1980s/1990s. After WWII, Hastings harbour works were constructed on the eastern and downdrift end of the Hastings' frontage. This further restricted the natural supply of shingle moving to Winchelsea. In the 1950s/60s, the timber groyne fields were constructed, and these were encased/ reconstructed at the same time as the seawalls in the 1980s/1990s. In addition, beach renourishment was also undertaken between 1980/1990 in West Hastings and a renourishment was also undertaken in 1992 to East Hastings.

WINCHELSEA

Since the 14th century the Rye area has been accretive and successive ridges have been formed in a more progressively south-facing alignment, resulting in a fan-like ridge complex (Halcrow, 2000). On the Cliff End frontage, the width of the shingle beach experienced significant cut back between 1872 and 1950 (up to 200m immediately down drift of Cliff End), possibly due to the defence works updrift at Hastings. To combat this, between 1933 and 1936 a timber breastwork (6.5km in length) was built to form a solid crest to the beach. Timber groynes and wave screens were also installed to encourage beach build up and to reduce the effect of waves on the shingle beach and excess shingle at Rye Harbour was transported to Cliff End using a railway running along the beach crest.

Between 1947 and 1952 the Pett Seawall was constructed: a concrete revetment and timber groynes placed at 30-50m intervals. Since 1952 shingle has been recycled from Nook Point to the western half of the beach to compensate for the longshore drift in an attempt to maintain the beach in front of the seawall. The Pett Seawall reached the end of its design life at the beginning of the 21st century.

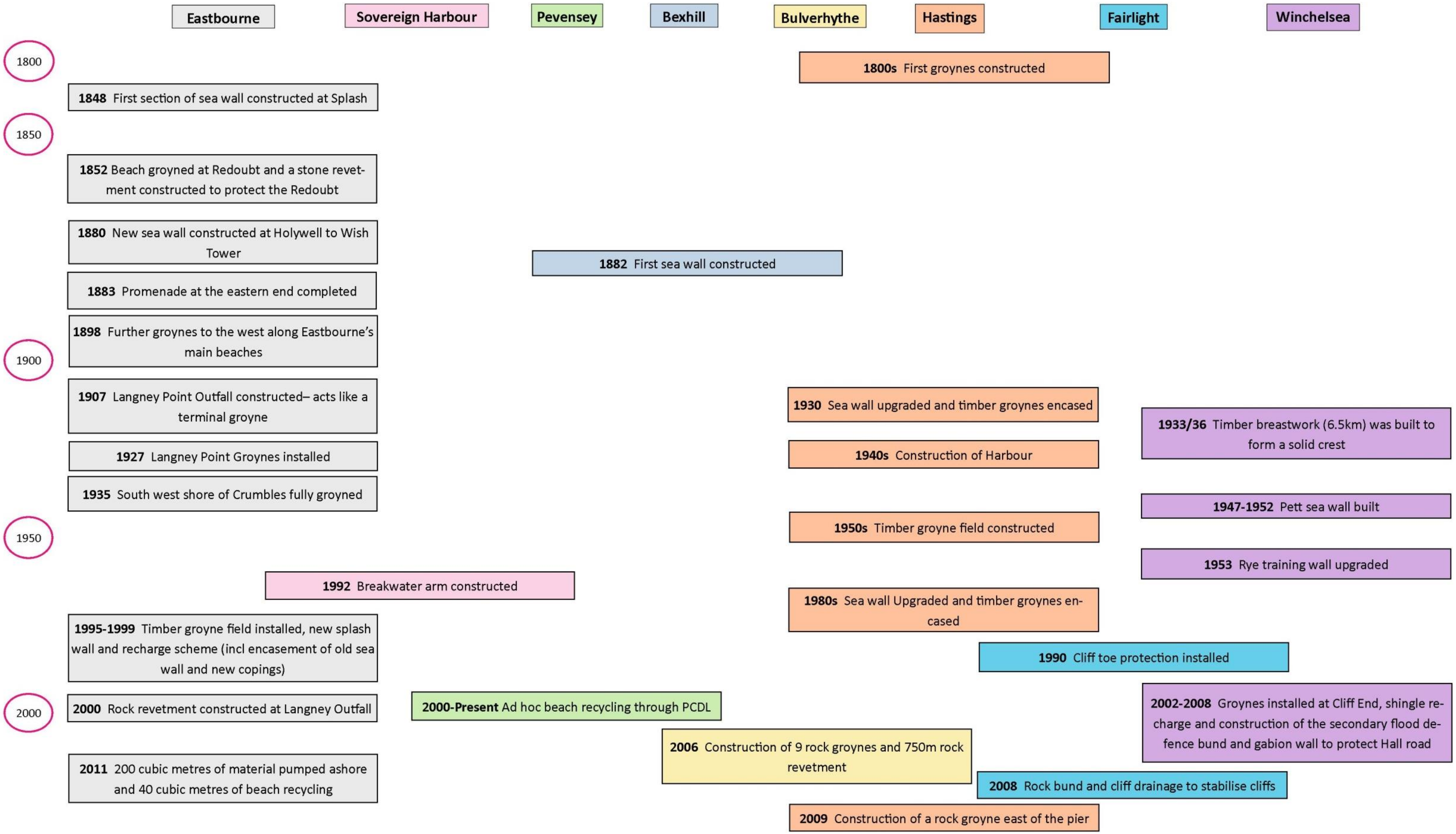

FIGURE 1-13 OVERVIEW OF COASTAL MANAGEMENT ACTIVITIES IN THE BMP AREA

1-4 ENVIRONMENTAL OPPORTUNITIES AND CONSTRAINTS

The issues relating to the local environment are fully described in the Environmental Assessment in Appendix B of this report. The following 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 1-14 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:

- Seaford to Beachy Head SSSI
- Beachy Head East RMCZ
- Pevensey Levels SSSI
- Hastings Cliff to Pett Beach SSSI
- Hastings Cliff to Pett Beach SAC
- Dungeness Romney Marsh and Rye Bay SSSI
- Dungeness to Pett Levels SPA
- Dungeness SAC

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 (for more details see Appendix B).

The following activities within Table 1-4, 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 1-4 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)

Non Statutory Designations

Sites with no legal protection in the study area:

- Dungeness LNR

It is important to consider those sites of local significance, i.e. LWS and LNR, by consulting with the land manager, e.g. Romney Marsh Countryside Partnership.

ENVIRONMENTAL OPPORTUNITIES

Four Biodiversity Opportunity Areas exist within the study area. No statutory protection is afforded to these sites however it is in the best interest of sustainable development that these opportunities are considered and, potentially, integrated into any proposed scheme. Figure 1-15 outlines these areas. More detail is given within Appendix B.

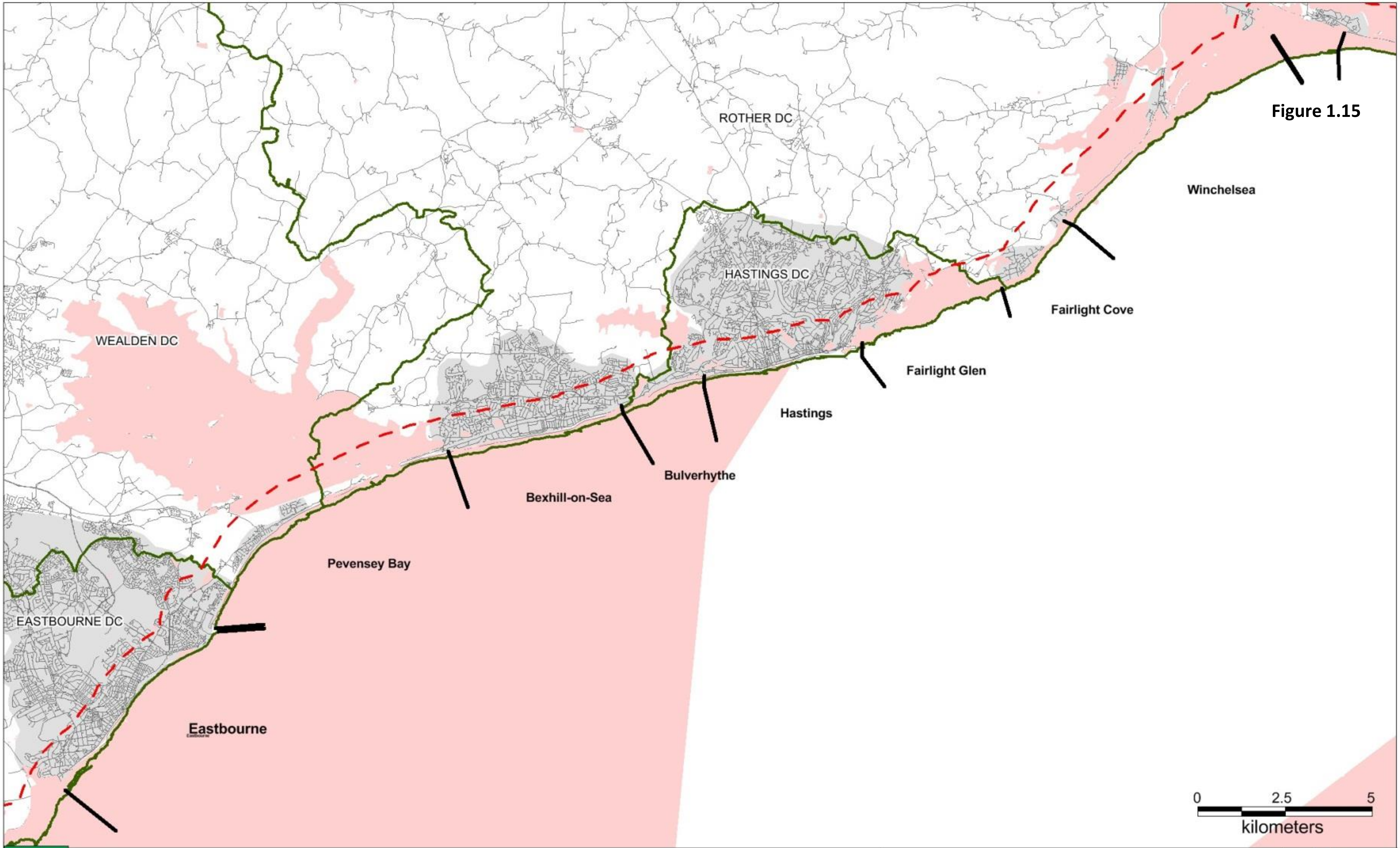

FIGURE 1-14 ENVIRONMENTAL RESTRICTIONS OVERVIEW MAP

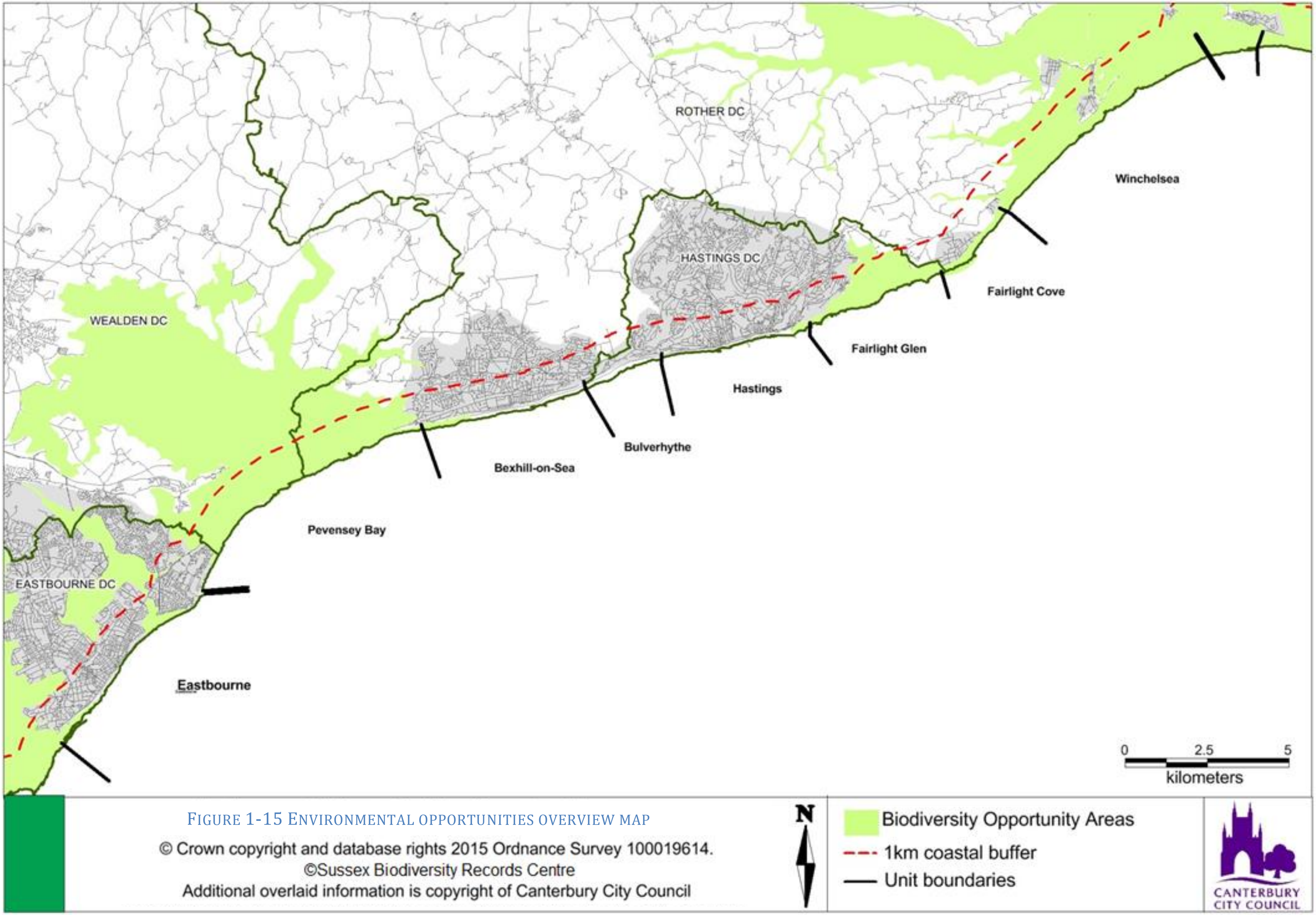

FIGURE 1-15 ENVIRONMENTAL OPPORTUNITIES OVERVIEW MAP

1-4-1 AGRICULTURE

The main areas of farmland are on the Pevensey and Pett Levels. Due to their elevation, the soils are poorly drained with a high water table. This restricts the use of arable farming, and much of the land is given over to permanent pasture. There are also a number of fields in arable and pastoral use to the east of Bexhill where woodland gives way to open, more level countryside. There are also patches of farmland located on the eastern side of Hastings following the coast towards the Pett Levels. The steeply undulating landscape here contains large open fields of low/average quality agricultural land. The remainder of this area is interspersed with ancient, semi-natural woodland above the cliffs at Fairlight, and woodland of more recent origin in the surrounding vicinity.

1-4-2 INFRASTRUCTURE

There are a number of main roads running through the study area. These include the A259 (the main Rye to Eastbourne road), the road from Hastings to Winchelsea via Pett Level, and the various coast roads in Eastbourne, Bexhill-on-Sea, Hastings and Fairlight. There are also a number of minor coast roads, including Pevensey Bay to Cooden, and a private single track road from Nook Point to Winchelsea Beach.

The Brighton to Ashford railway line runs through the study area at varying distances from the coast. At its closest it runs along the back of the beach from St Leonards to Galley Hill, and again from Cooden to Norman’s Bay. An embankment at the back of the shingle beach protects the railway line from the sea.

Both Sovereign Harbour and Rye Harbour are used by commercial fishing vessels and private yachts. There is also a beach-launched fishing fleet at Hastings. In addition, the RNLI operates a lifeboat from its stations at Eastbourne (located in Sovereign Harbour), Hastings (beach-launched) and Rye Harbour (at high tide, or from the beach at Nook Point at low tide). A second inshore lifeboat is operated by the Pett Level Rescue Association from the concrete slipway at Cliff End.

1-4-3 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.*

There are a number of archaeologically sensitive areas that have been designated along the study area. These include an area around Eastbourne Pier, the remains of a deserted medieval village at Glyne Gap, Hastings Old Town and the coastline between Hastings and Fairlight. Features of archaeological importance are also found offshore. The shipwrecks shown in Appendix B and a 75-100m radius of the surrounding area of seabed are protected from unauthorised interference. Some of the notable wrecks include "*HMS Anne*", a third rate ship-of-the-line lost near Fairlight, the "*Amsterdam*", a Dutch East Indiaman lost off Bulverhythe, and four Spitfires and two bombers downed in the Second World War. There is also a submerged Bronze Age oak and hazel forest can also be found off Little Galley Hill which is visible at low tide.

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 assessed against the four hazards 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. Eastbourne, Bexhill and Hastings could be affected by over wash as they all have properties in close proximity to the seawalls. There is potential for ponding between Hastings and Bexhill in the Combe Valley. Partial breach and full breach would affect a large number of properties in both the Pevensey Levels and the Pett levels (Appendix C).

2-2 OVERTOPPING

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. Eastbourne, Pevensey, Bexhill, Bulverhythe, Hastings and Winchelsea have potential for overtopping, with the impact dependent on the topography and infrastructure behind the defence (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. Beachy Head has endured several cliff falls over the recent decades, adding chalk material to the sediment budget. Fairlight Cliffs were, until recently, prone to landslides due to the soft clay sediment with some gardens and houses being lost to the sea (Appendix C).

2-4 STRUCTURES

The beach reduces damage to structures preventing undermining 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. Extensive networks of coastal defences protect Eastbourne to Winchelsea, with a short undefended section at Fairlight (Appendix C).

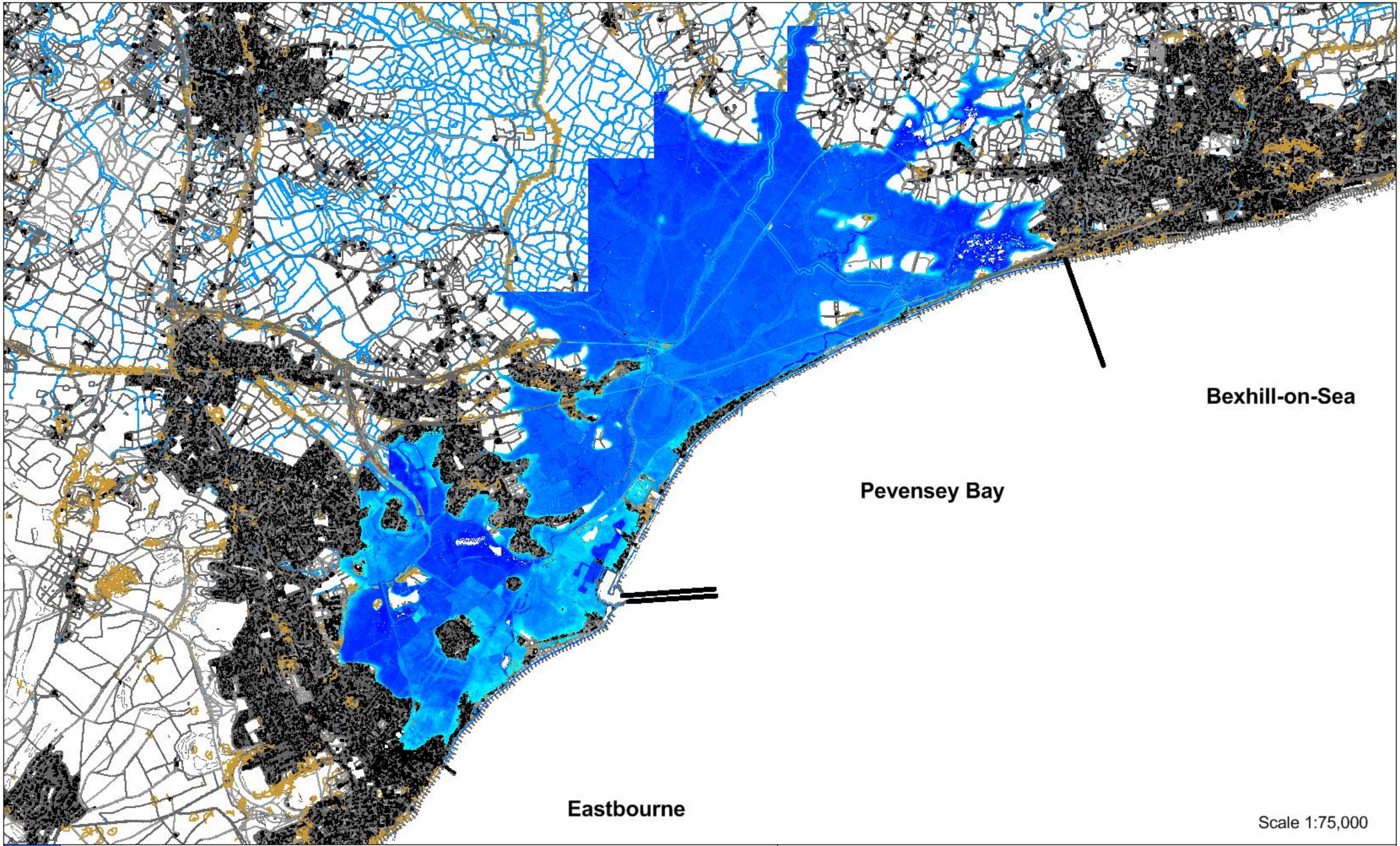

FIGURE 2-1 PEVENSEY AND EASTBOURNE FLOOD DEPTH AT 1 IN 200 YEAR STILL WATER LEVEL. PLANAR FLOOD MAP, NO DEFENCES

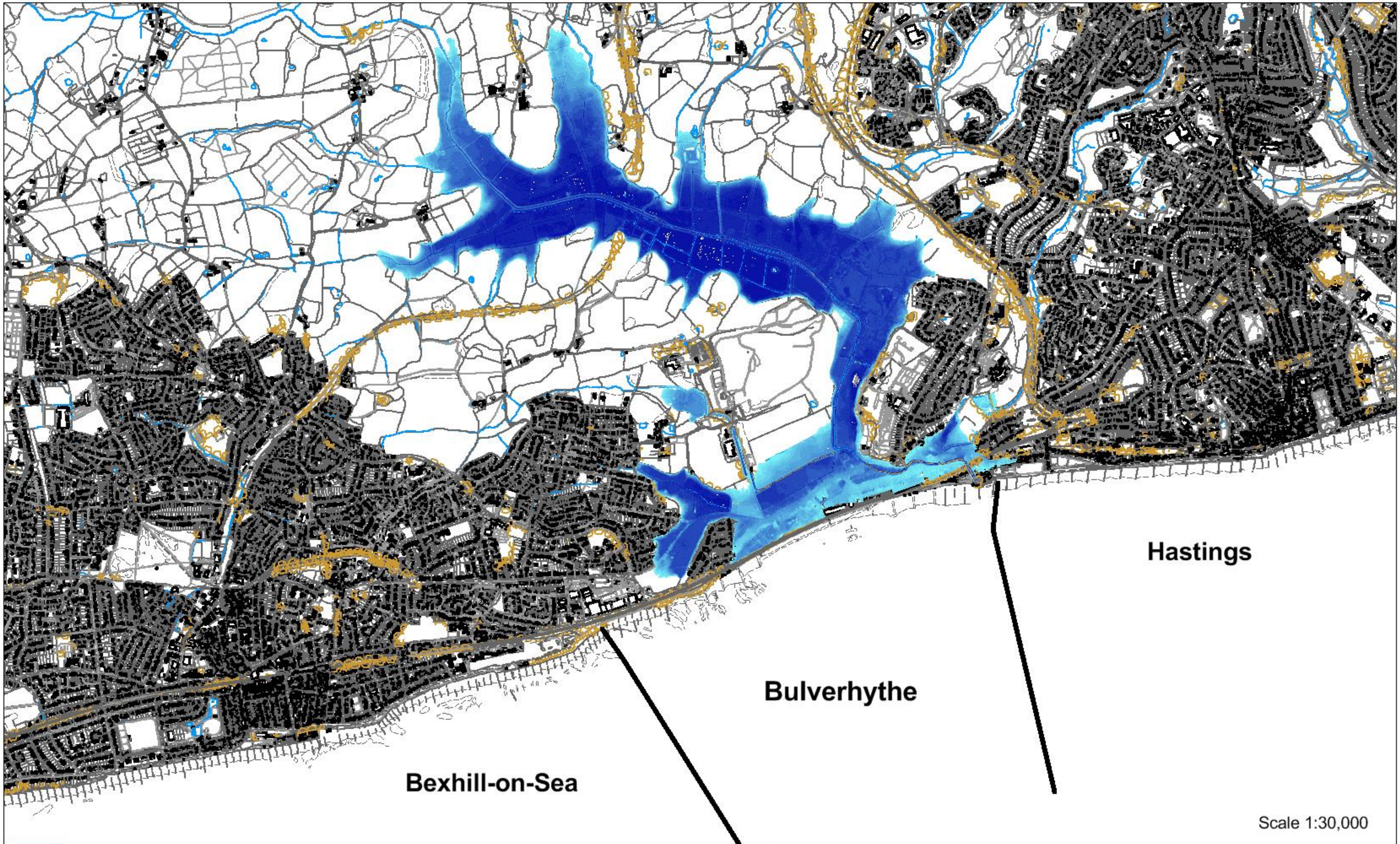

FIGURE 2-2 BULVERHYTHE FLOOD DEPTH AT 1 IN 200 YEAR STILL WATER LEVEL. PLANAR FLOOD MAP, NO DEFENCES

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Figure 2-3 Winchelsea flood depth at 1 in 200 year still water level . planar flood map, no defences

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
EASTBOURNE	HOLYWELL TO WISH TOWER	46
EASTBOURNE	WISH TOWER TO REDOUBT FORTRESS	83.5
EASTBOURNE	REDOUBT FORTRESS TO SOVEREIGN HARBOUR	56.5
PEVENSEY	SOVEREIGN HARBOUR TO SAILING CLUB	30.5
PEVENSEY	SAILING CLUB TO COODEN	32.5
BEXHILL	COODEN TO WEST PARADE	25
BEXHILL	WEST PARADE TO BEXHILL SAILING CLUB	47
BEXHILL	BEXHILL SAILING CLUB TO GALEY HILL	39.5
BULVERHYTHE		27.5
HASTINGS	GROSVENOR GARDENS TO THE PIER	51.5
HASTINGS	PIER TO HARBOUR ARM	77.5
HASTINGS	FISHERMAN'S BEACH	49.5
FAIRLIGHT		8
WINCHESLEA	PETT LEVELS TO RYE BAY CARAVAN PARK	22.5
WINCHESLEA	RYE BAY CARAVAN SITE TO RYE HARBOUR	21.5

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3 PHYSICAL INPUTS

3-1 WATER LEVELS

3-1-1 TIDAL WATER LEVELS

This frontage has a tidal range of 3.6m during a mean neap and 6.9m during a mean spring tide (Admiralty Tide Tables).

3-1-2 EXTREME WATER LEVELS

Extreme water levels were derived from the results of *Coastal flood boundary conditions for UK mainland and islands* (Environment Agency, 2011). Results for four locations along the study area, as depicted in Figure 3-1, are provided in Table 3-1.

TABLE 3-1 EXTREME WATER LEVELS (+MODN) AND RETURN PERIODS

RETURN PERIOD (1 IN X YEARS)	A EASTBOURNE	B BEXHILL	C HASTINGS	D WINCHELSEA	UNCERTAINTY VALUES A-C	UNCERTAINTY VALUES D
1 IN 1	4.22	4.26	4.29	4.35	0.1	0.2
1 IN 5	4.38	4.44	4.48	4.54	0.1	0.2
1 IN 10	4.46	4.52	4.55	4.61	0.1	0.2
1 IN 25	4.55	4.61	4.64	4.71	0.1	0.2
1 IN 50	4.62	4.67	4.71	4.78	0.1	0.2
1 IN 100	4.69	4.75	4.79	4.86	0.2	0.3
1 IN 200	4.77	4.81	4.85	4.92	0.2	0.3

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

It should be noted that there are no primary data sites within the study area and historical secondary tide data is extremely limited. As a result the outputs are heavily reliant on the modelling and interpolation between nodes. 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.

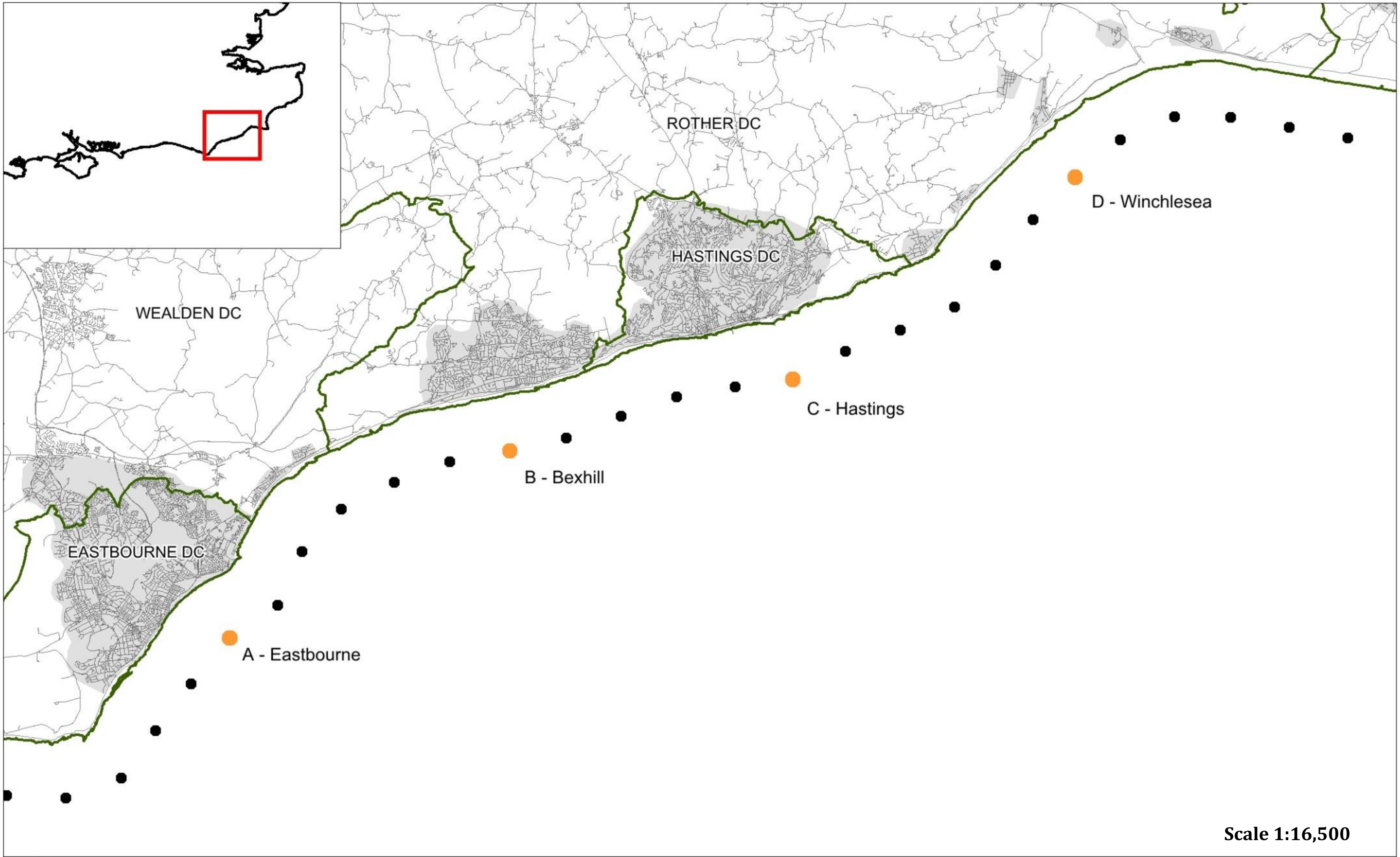

FIGURE 3-1 LOCATION OF EXTREME WATER LEVELS (EWL) AND EXAMPLE POINTS

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Comparison with other studies 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. It is however recommended that consideration should be given to installing a permanent tide gauge within the study area. Water levels increase as you move from west to east along the frontage with a typical difference in the region of 150mm between Eastbourne and Winchelsea.

3-1-3 WAVES

The wave climate is dominated by waves from the south west, resulting in a west to east drift of beach material along the whole frontage. Waves from the south west are more frequent and typically larger in magnitude, but it should be recognised that periods of waves from the east can result in a temporary reversal in the sediment drift direction.

Two sources of data have been used for this study, measured data from local wave buoys and Met Office Hindcast data that models 33 years of predicted wave conditions.

3-1-4 WAVE RECORDER

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

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

Directional Waverider buoys applicable to this study were Rye Bay, which was deployed for four years from 2008 – 2012, and Pevensey Bay deployed from 2003 to present day. Both buoys are located along the 10m CD contour and a summary of collected data is presented in the following wave roses (Figures 3-3 and 3-4).

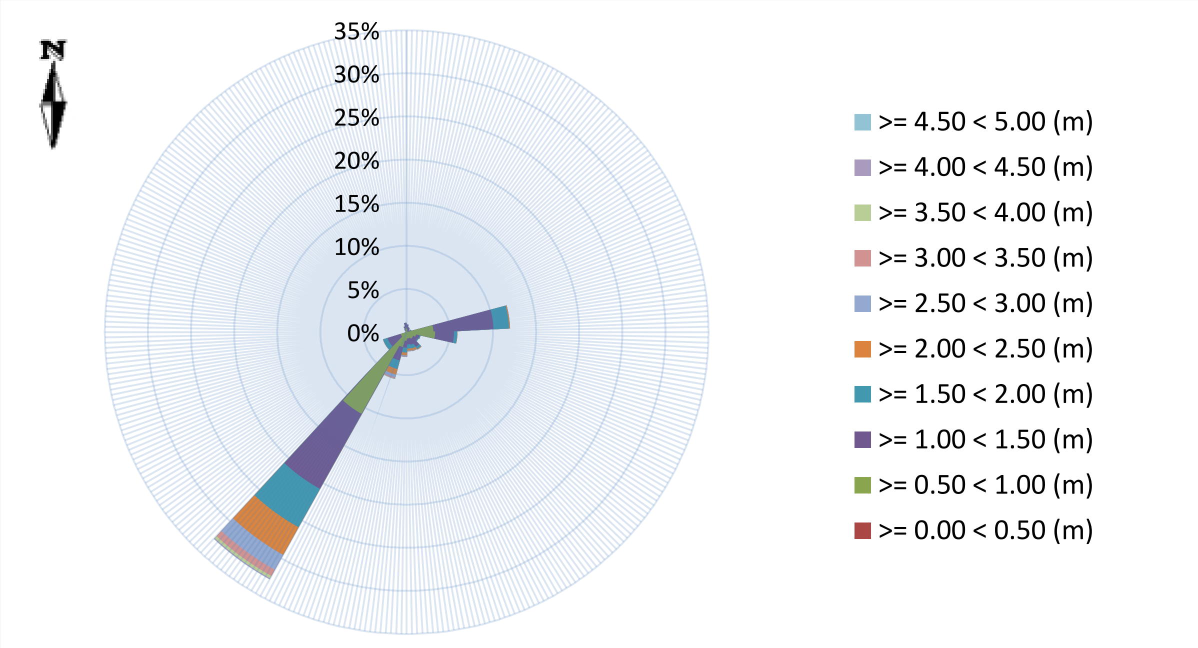

FIGURE 3-3 RYE BAY DIRECTIONAL WAVERIDER BUOY, SIGNIFICANT WAVE HEIGHT AND DIRECTION (JULY 2008 - JULY 2012*) *DECOMMISSIONED IN 2012

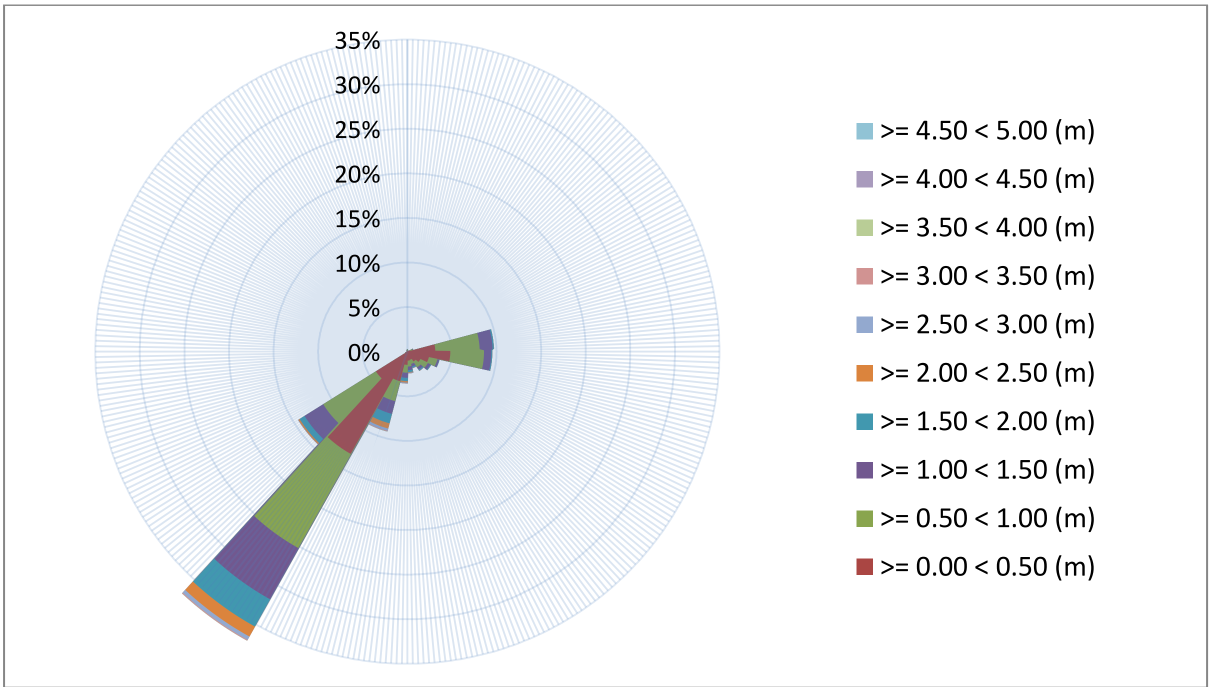

FIGURE 3-4 PEVENSEY BAY DIRECTIONAL WAVERIDER BUOY, SIGNIFICANT WAVE HEIGHT AND DIRECTION (JULY 2003 - JULY 2013)

3-1-5 MET OFFICE HINDCAST

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

FIGURE 3-5 LOCATION OF MET OFFICE HINDCAST POINTS

Significant wave height return periods for Met Office points MO444, MO445, MO446 and MO461 are included for reference in Table 3-2. 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)	MO444 (7m)	MO445 (9m)	MO446 (12m)	MO461 (10m)
1 in 1	4.23	3.77	3.94	3.38
1 in 2	4.42	3.96	4.14	3.58
1 in 5	4.67	4.20	4.39	3.84
1 in 10	4.85	4.38	4.57	4.03
1 in 20	5.02	4.55	4.75	4.22
1 in 50	5.24	4.77	4.98	4.46
1 in 100	5.40	4.94	5.15	4.64
1 in 200	5.56	5.09	5.31	4.81

Contours of the annual 0.05% wave height exceedance are illustrated in Figure 3-6 and show the geographical variability within the study area suggesting very little variation in conditions between Rye Training Wall and Beachy Head.

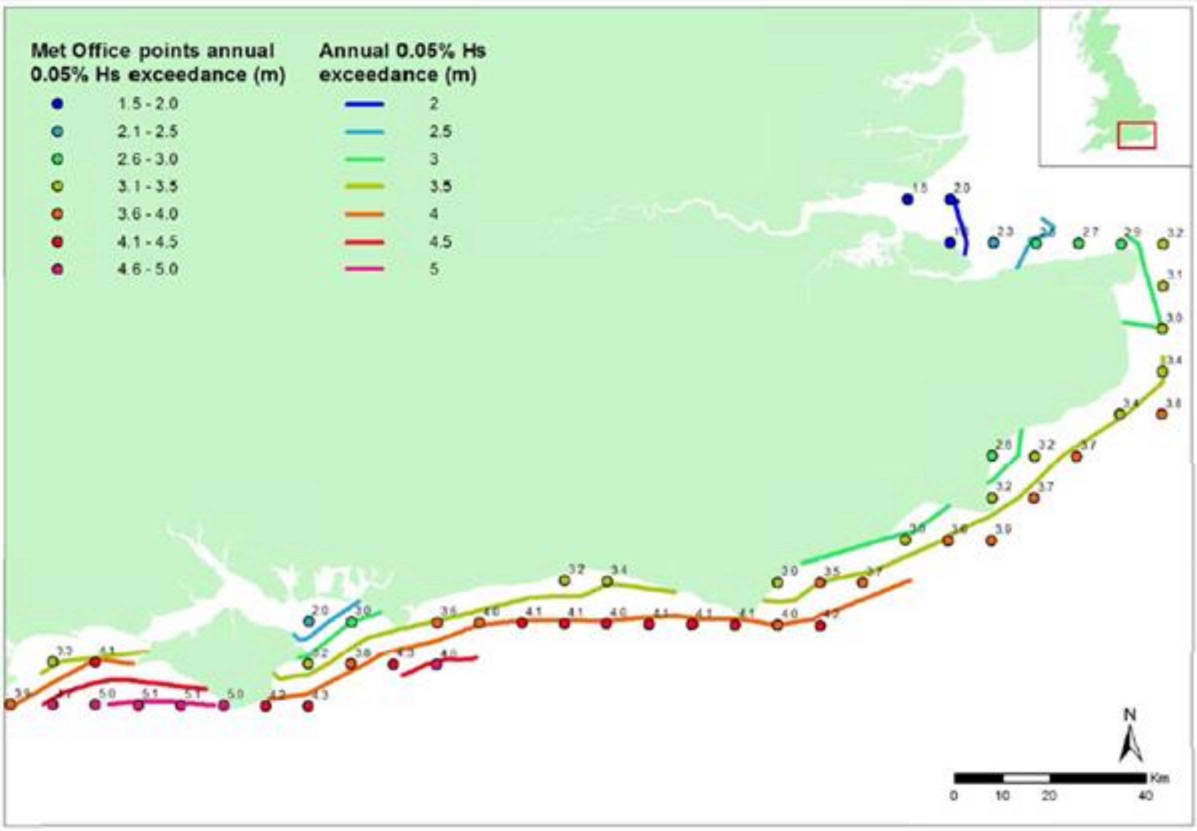

Figure 3-6 Annual significant wave height (Hs [m]) 0.05% exceedance joint return probability for beach management (Mason, 2014)

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 MO445, MO446 and MO461 are presented graphically in Figures 3-7 to 3-10. 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.

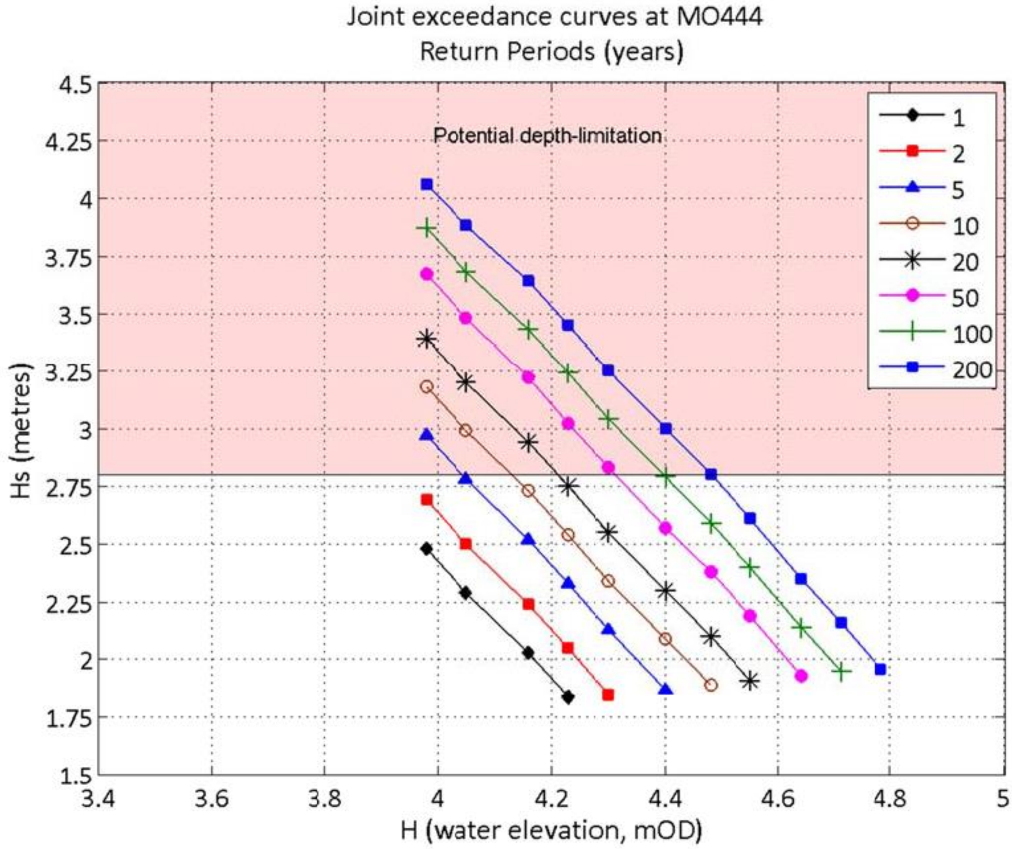

FIGURE 3-7 JOINT PROBABILITY EXCEEDANCE CURVES AT MO444, RETURN PERIOD (YEARS)

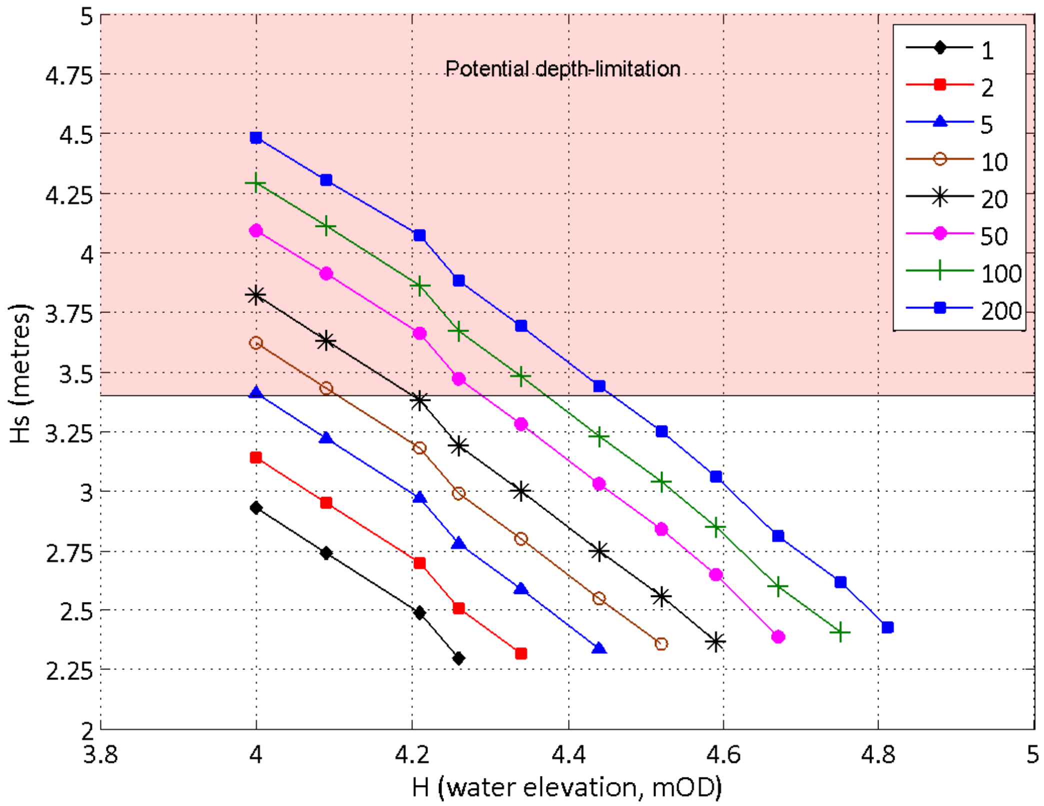

FIGURE 3-8 JOINT PROBABILITY EXCEEDANCE CURVES AT MO445, RETURN PERIOD (YEARS)

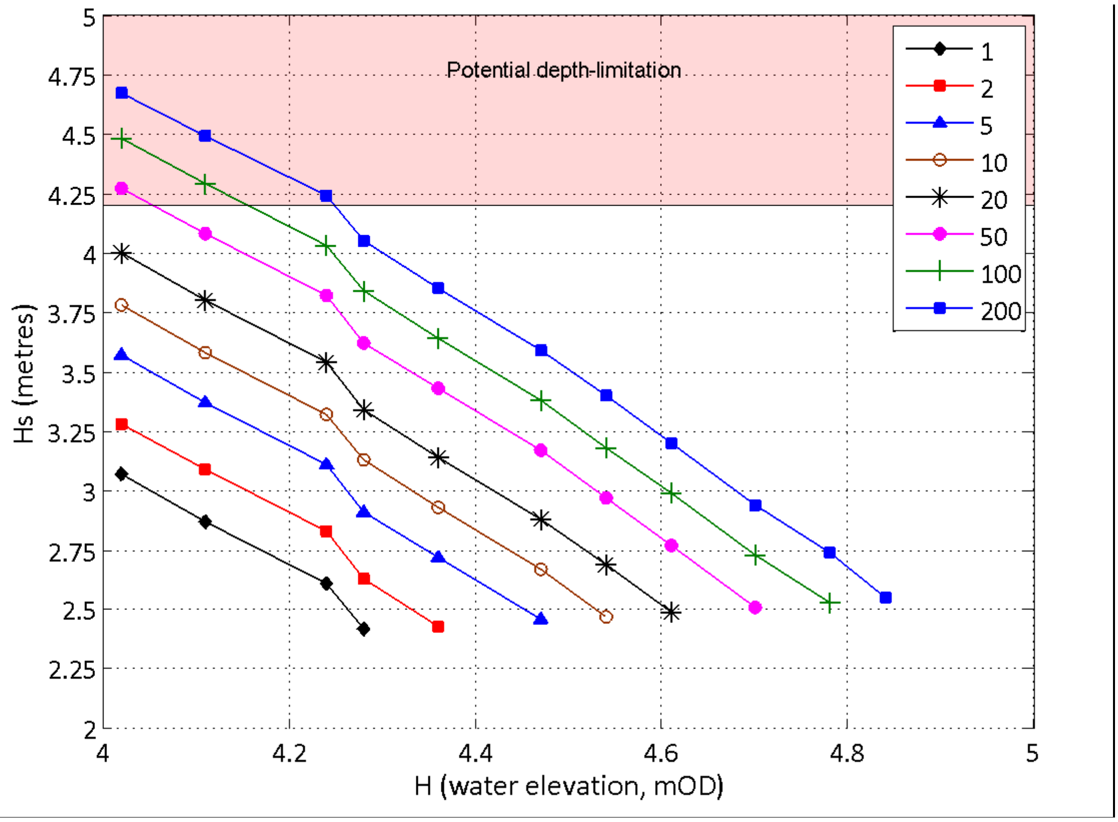

FIGURE 3-9 JOINT PROBABILITY EXCEEDANCE CURVES AT MO446, RETURN PERIOD (YEARS)

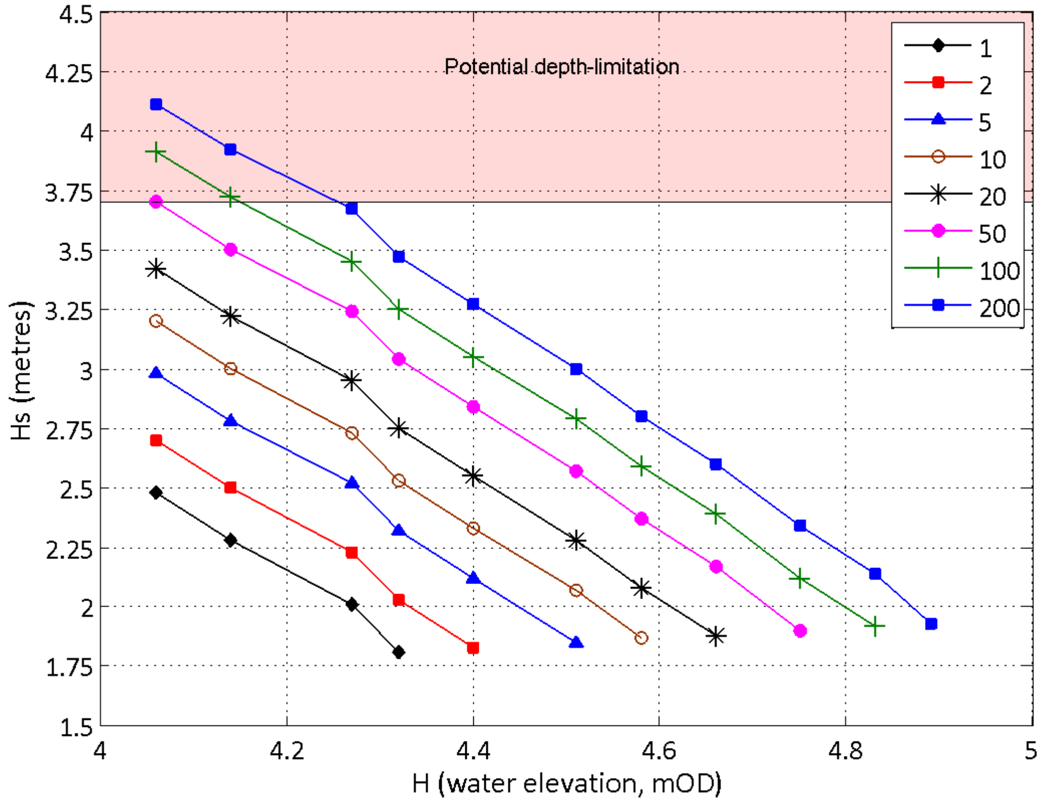

FIGURE 3-10 JOINT PROBABILITY EXCEEDANCE CURVES AT MO461, RETURN PERIOD (YEARS)

3-3 SEDIMENT CHARACTERISTICS

Beaches within the study area are typical of those found throughout the Southeast of England, comprising mixed sand and shingle sediment.

TABLE 3-3 PREDOMINANT SEDIMENT COMPOSITION OF BEACHES

LOCATION	BEACH SEDIMENT	FORESHORE
EASTBOURNE	SHINGLE	CHALK PLATFORM/SAND
PEVENSEY BAY	SHINGLE	SAND
BEXHILL	SHINGLE	SAND
BULVERHYTHE	SAND/SHINGLE	SAND/CHALK PLATFORM
HASTINGS	SHINGLE	SAND
FAIRLIGHT	SAND/SHINGLE	SAND/ROCK PLATFORM
WINCHELSEA	SAND/SHINGLE	SAND/ROCK PLATFORM

Sediment grading curves are not readily available for this stretch of coastline, but visual observations would suggest the beaches are similar to other beaches within the southeast of England with a D_{50} of 10-14 mm.

The only relevant research available at the time of writing is the *BAR Phase I final report: Beach Material Properties* (Dornbusch, 2005). This contained study on the properties of the beach material across several sites along the south and south east coastline. Three sites along the Pevensey to Bexhill stretch and a further three sites between Fairlight Cove and Rye Harbour. The results are summarised in Figures 3-11 to 3-13, which have been adapted from the Beach Material Properties Report.

It is good practice to ensure that the grading envelope of the replenished material is as close to the natural beach material as possible. Therefore it is recommended that a contract grading envelope is used for all works and that the delivered material is monitored to ensure it meets the specification and avoids performance issues associated with sub-standard finer material.

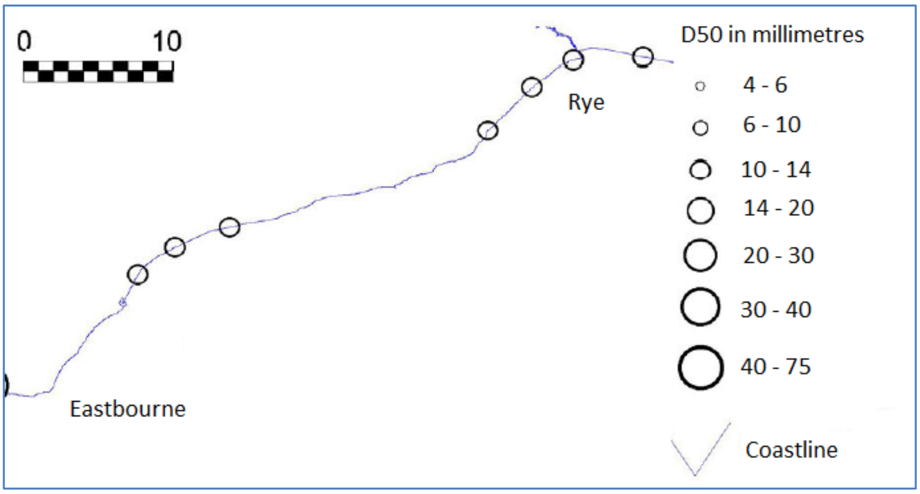

FIGURE 3-11 D50 GRAIN SIZE OF SAMPLES FROM THE TOP OF THE BEACH

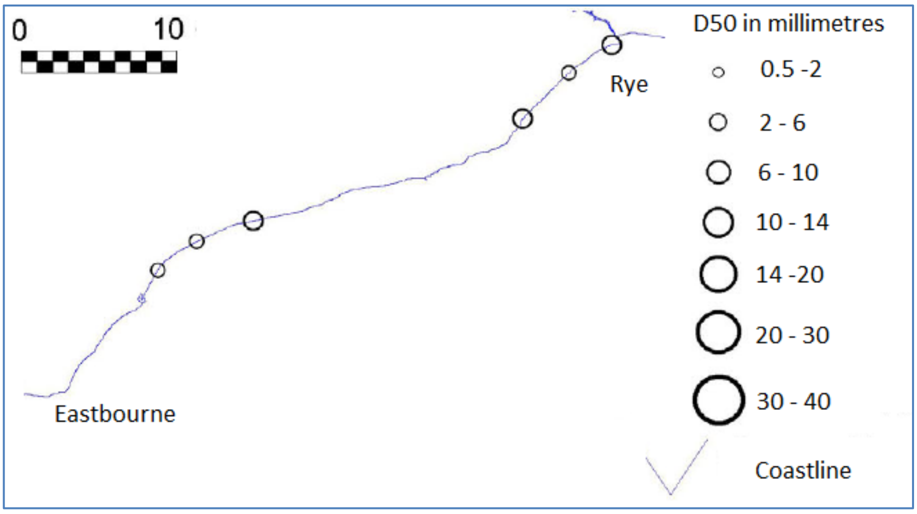

FIGURE 3-12 D50 GRAIN SIZE AVERAGED OVER ALL SAMPLES IN A PROFILE

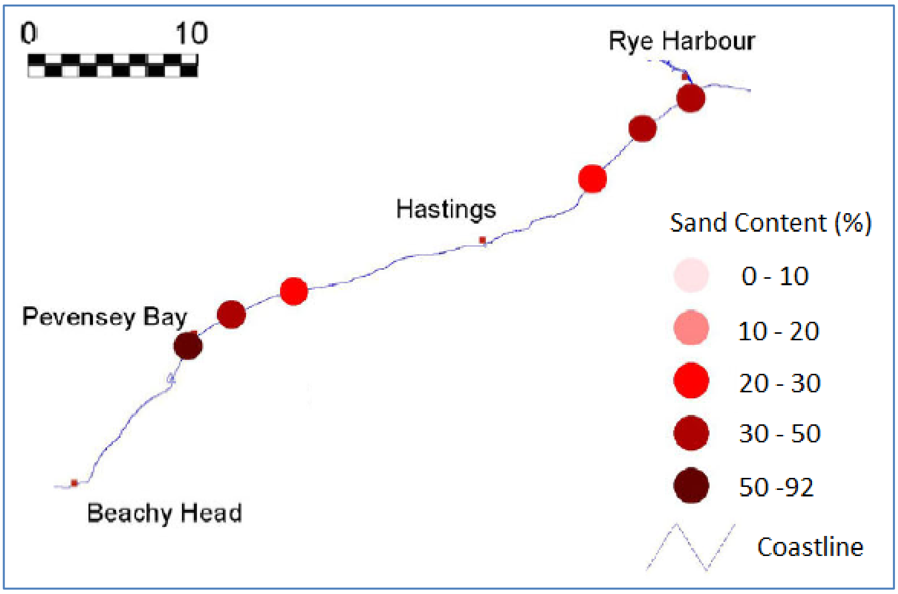

FIGURE 3-13 AVERAGE SAND CONTENT OF EACH PROFILE

3-4 BEACH GEOMETRY

The coastline between Eastbourne and Rye Harbour is defined by several headlands and terminal structures. The orientation varies throughout and frequently within each sub-cell. For example, the western side of Pevensey is 19^{o} off due North compared to 55^{o} at the eastern end.

Orientation is one of the factors which affect the rate of longshore transport as the dominant waves approaching from the south west tend to strike the coast at a more acute angle promoting west to east drift. Conversely, waves from the East attack the coast in amore perpendicular fashion reducing the amount of material that is transported back in a westerly direction.

The following figure identifies the orientation of the coastline in relation to due north.

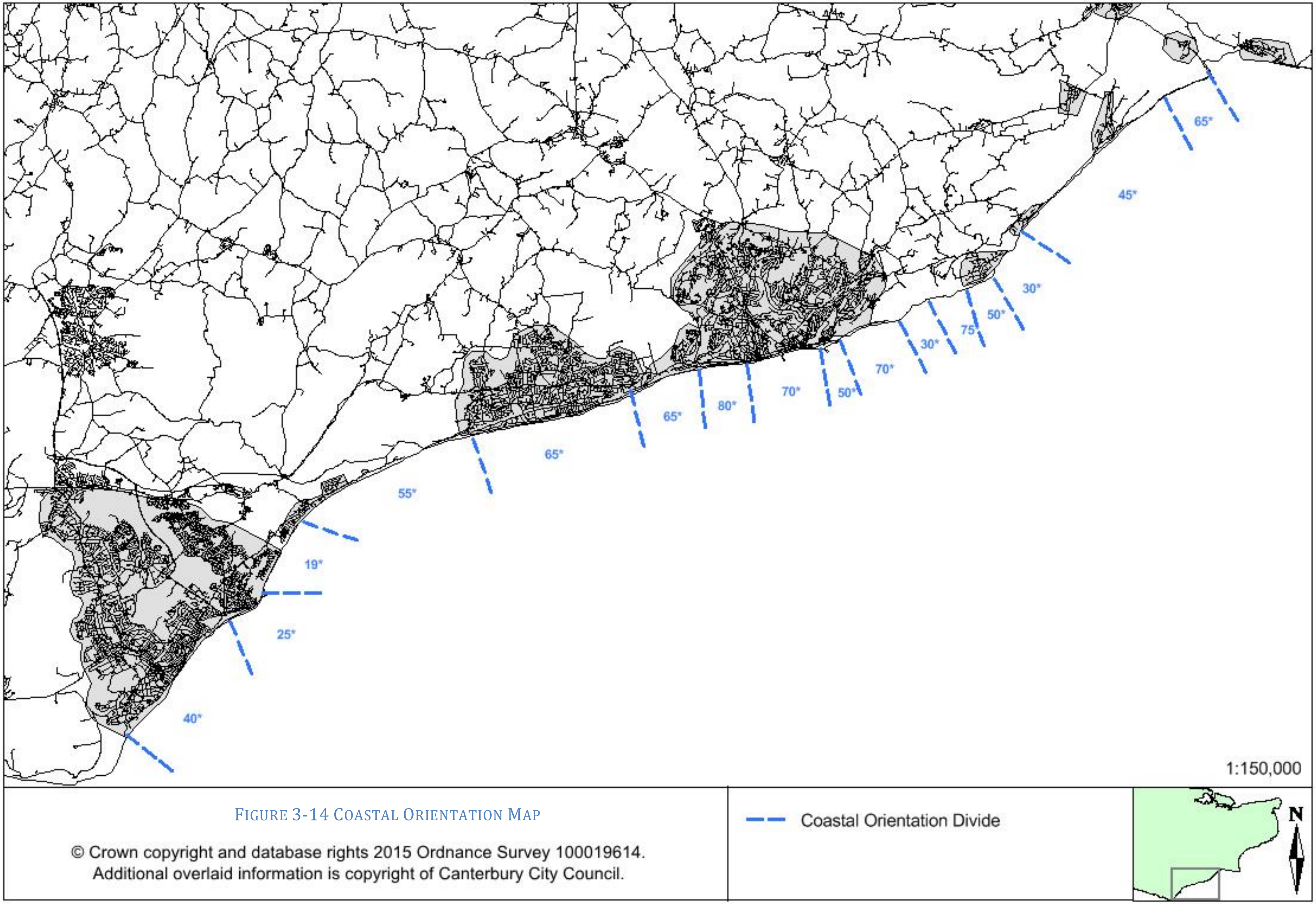

FIGURE 3-14 COASTAL ORIENTATION MAP

4 HISTORICAL MONITORING

4-1 CONTROL NETWORK

A control network was set up by Longdin and Browning for the Regional Coastal Monitoring Programme (RCMP) in 2003, covering the coastline between Eastbourne and Rye Harbour. It includes several E1 and E2 pins (As defined by the EA Survey Specification) which are both suitable for levelling and GPS surveys; their location is shown in Figure 3-1. GPS equipment has an accuracy of +/- 30mm in the vertical and +/- 20mm in the horizontal.

More recently in 2012 a Rinex base station (NetR9) was installed on the roof of the Hastings Borough Council building which has a live feed streamed to the Channel Coast Observatory website.
In addition to the RCMP surveys, the Environment Agency has undertaken annual photogrammetry surveys in the form of the ABMS (Annual Beach Management Surveys) since 1973.

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

Prior to 2012 the topographic beaches data between Eastbourne and Rye Harbour were surveyed with GPS equipment. GPS RTK methods are used to collect 2-D (profile method) or quasi 3-D (continuous method) representations of the volume 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. Profiles are categorised as designated and intermediate; designated profiles are positioned to represent similar stretches of coast and the intermediates close the gaps.

SPRING & AUTUMN SURVEYS

Designated profile data was collected during 2003 and 2012 for the spring and autumn surveys. Analysis is available for all profiles and is used to monitor beach response to wave conditions or replenishment schemes.

SUMMER SURVEYS

A full set of designated and intermediate profile data and a 3D elevation model of the beaches was undertaken annually between 2003 and 2012; data collected using a detail pole and walking/quad respectively.

POST STORM SURVEYS

Following a series of storm waves which exceed the storm threshold as set by Channel Coastal Observatory, post storm surveys may have be conducted as an additional set of data, if deemed necessary by the individual Risk Management Authority (Local Authority or Environment Agency) managers i.e. large losses or severe drawdown of material which will not recover over the course of the next few tidal cycles.

Profiles will be concentrated in the areas of concern with a light coverage of the whole unit as these can inform emergency repair works.

IN/OUT SURVEYS

In and Out surveys refer to the pre and post work surveys respectively. The profiles and/or 3D model is concentrated on those areas specified by the Local Authority or Environment Agency manager, typically the extraction and deposition sites.

4-2-1 LASER SCANNING

Since spring 2012 a mobile laser scanner mounted on an ATV replaced the GPS profile surveys and the walking/quad to create the 3D beach model. The mobile laser scanner covers up to 10km per tidal window. The scanner is a dual antenna system and has a 500m range, collecting 36,000 points per second.

This method of surveying collects data across whole beach face from the vegetated back beach to MLW. The designated and intermediate profiles are cut out of the 3D terrain model. Naturally occurring changes, arising from wave and tidal conditions, are put in context by comparing the data with other surveys following beach management operations. Plan shape changes of beach contours are used for validation of numerical models of sediment transport.

4-3 BATHYMETRIC SURVEYS

The most recent bathymetry data is a 2013 multi-beam survey extending approximately 1kmoffshore, prior to this single beam surveys were undertaken in 2007 and 2004.

4-4 BMP SITES

Eastbourne, Pevensey Bay, Bexhill, Bulverhythe, Hastings and Winchelsea are beach management plan sites. Topographic surveys are currently undertaken at these sites three times 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 must have a minimum of two months between each survey.

To ensure the method is repeatable a series of profile lines are surveyed every time and the extents of each site are maintained. Profile Lines are named consecutively within Coastal Cell 4c (South Foreland to Eastbourne). There are approximately 800 profiles between Eastbourne and Winchelsea named 4c01859 to 4c01061 with GPS data dating back to 2003 (Profile Location Maps are included in Appendix D).

A full survey review will be undertaken prior to Phase IV, where consideration to reduce the number of surveys per unit is being given.

TABLE 4-1 SURVEYING SCHEDULE

SITE	SPRING	SUMMER		AUTUMN
	ANNUALLY	5 YEARLY	ANNUALLY	ANNUALLY

EASTBOURNE	✓		✓	✓
SOVEREIGN HARBOUR	✓		✓	✓
PEVENSEY BAY	✓		✓	✓
BEXHILL	✓		✓	✓
BULVERHYTHE	✓		✓	✓
HASTINGS	✓		✓	✓
FAIRLIGHT		✓		
WINCHELSEA	✓		✓	✓

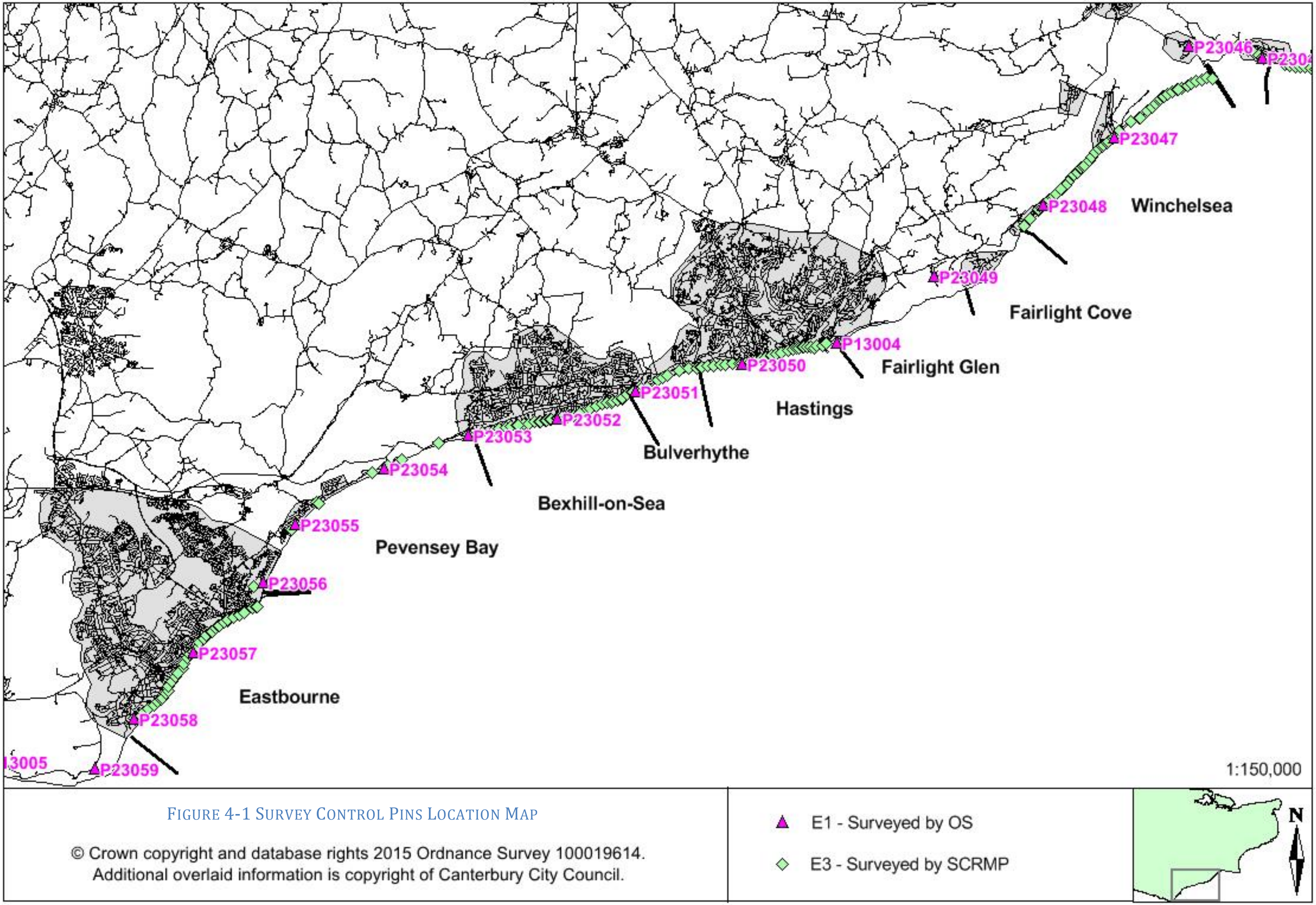

FIGURE 4-1 SURVEY CONTROL PINS LOCATION MAP

4-5 AERIAL SURVEYS

4-5-1 AERIAL PHOTOGRAPHY

As part of the RCMP ortho-rectified aerial photography is flown every 5 years. The most recent available photography was flown in 2013 and prior to that 2008 and 2003. This is available to download from the Channel Coast Observatory website. The next set of ortho-rectified photography should be available winter 2016/17.

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 soft cliff or few coastal defences would be a high priority, with heavily managed beaches that are regularly surveyed by other means low priority.

4-6 STRUCTURES

4-6-1 GPS

The exposed defence structures are surveyed every five years as part of the Regional Coastal Monitoring Programme. 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. In addition to this coastal monitoring teams survey the beach three times per year and report any major defaults to the local authorities.

4-7 HYDROLOGICAL MONITORING

4-7-1 WAVE RECORD

A wave buoy is located offshore at Pevensey Bay. A wave buoy was also deployed in Rye Bay for four years from 2008 – 2012. Real time data for the significant and maximum wave height are freely available via the Channel Coastal Observatory website. Wave parameters at Pevensey Bay are recorded using a Datawell Directional WaveRider Mk III buoy. The Pevensey Bay buoy was deployed on 08 July 2003 and is still in operation.

4-8 ECOLOGICAL MONITORING

4-8-1 HABITIAT 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 and laser scan data each point is coded with the material underfoot. In cases of vegetation “vg” or “dv” or “gr” are used to note vegetated gravel, 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.

5 SEDIMENT BUDGET

5-1 METHOD

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 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, Eastbourne to Rye Training Wall. 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 between Eastbourne and Rye Training Wall are heavily managed and mask the natural changes. The sediment budget uses Equation 1 to calculate the sediment transport rate leaving the cell, accounting for measured volume change, management activities and anticipated losses within a cell.

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

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 updrift 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 spreadsheets 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, individual units and a regional summary are provided in this report.

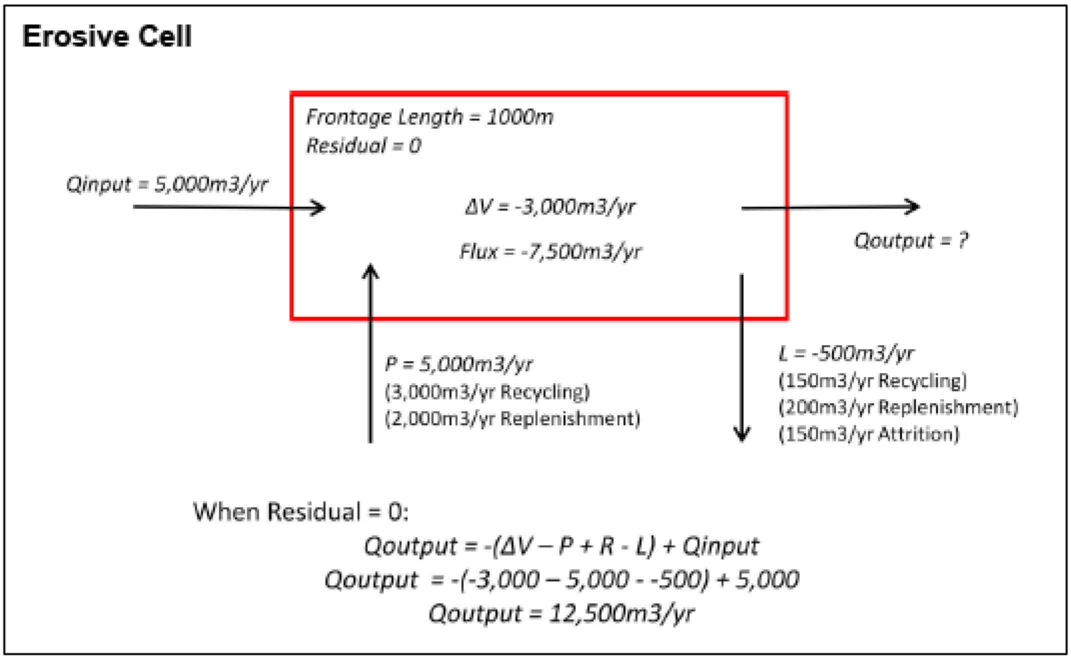

FIGURE 5-1 EXAMPLE OF AN EROSIVE CELL CALCULATED THROUGH THE SEDIMENT BUDGET

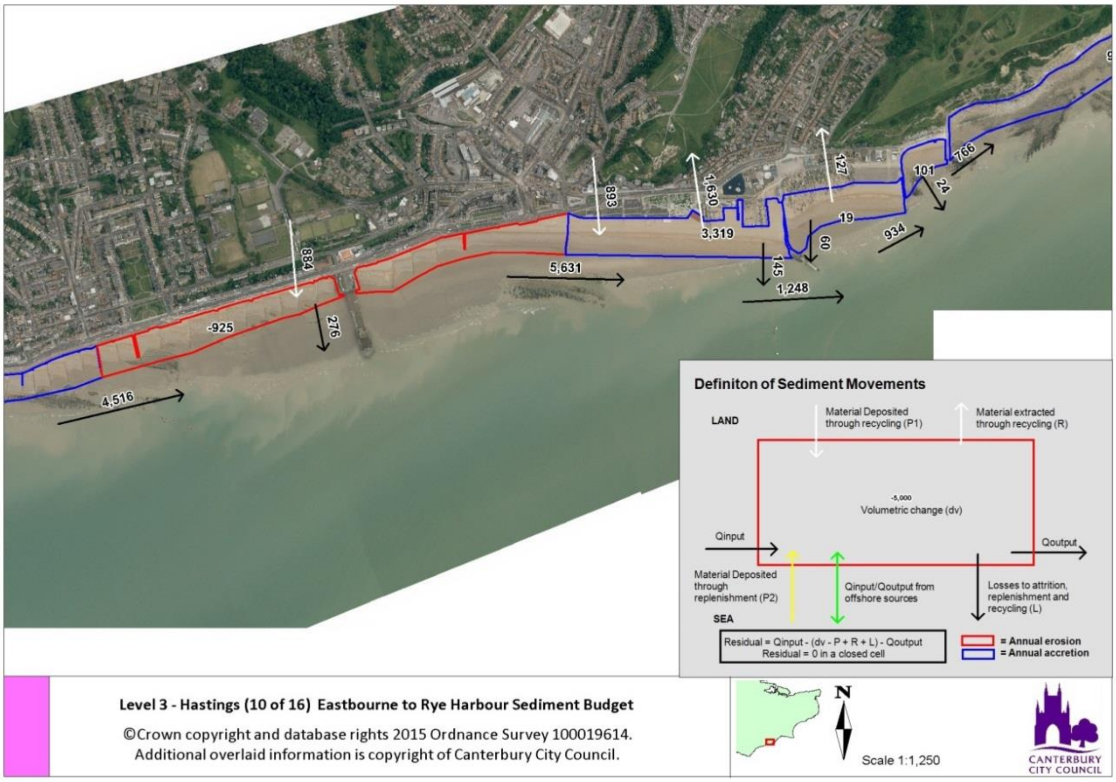

FIGURE 5-2 EXAMPLE OF DETAILED SEDIMENT BUDGET OUTPUTS (APPENDIX E)

5-2 BEACH MANAGEMENT ACTIVITIES

Current management of the beaches within the study area relies heavily on artificial transport of shingle, either through recycling along the coast or shingle replenishment (typically marine aggregate sourced offshore). 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
EASTBOURNE	194,800	16,200	194,700	16,200
PEVENSEY BAY	1,003,200	83,600	220,500	18,400
BEXHILL	N/A	N/A	N/A	N/A
BULVERHYTHE	N/A	N/A	84,500	7,000
HASTINGS	19,500	1,600	N/A	N/A
FAIRLIGHT	N/A	N/A	N/A	N/A
WINCHELSEA	292,500	24,400	N/A	N/A
NET	1,510,000	125,800	499,700	41,600

(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 a great deal of variability throughout the frontage. There is no natural feed from Beachy Head to the Eastbourne frontage, with over 10,000m^3 being transported west out of Eastbourne. Pevensey Bay has the largest transport rates peaking at 50,000m^3 year; these reduce through Bexhill, Bulverhythe and Hastings, with 12,000m^3 being transported into Fairlight cove. With no controlling structures rates increase from Fairlight cove into Winchelsea and along the open beach to Rye Harbour.

The following figures 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 7.

FIGURE 5-3 SEDIMENT BUDGET - EASTBOURNE

Estimated annual sediment transport in cubic meters.

Unit boundaries

N

0 - 2,500

2,500 - 5,000

5,000 - 10,000

10,000 - 30,000

30,000 - 75,000

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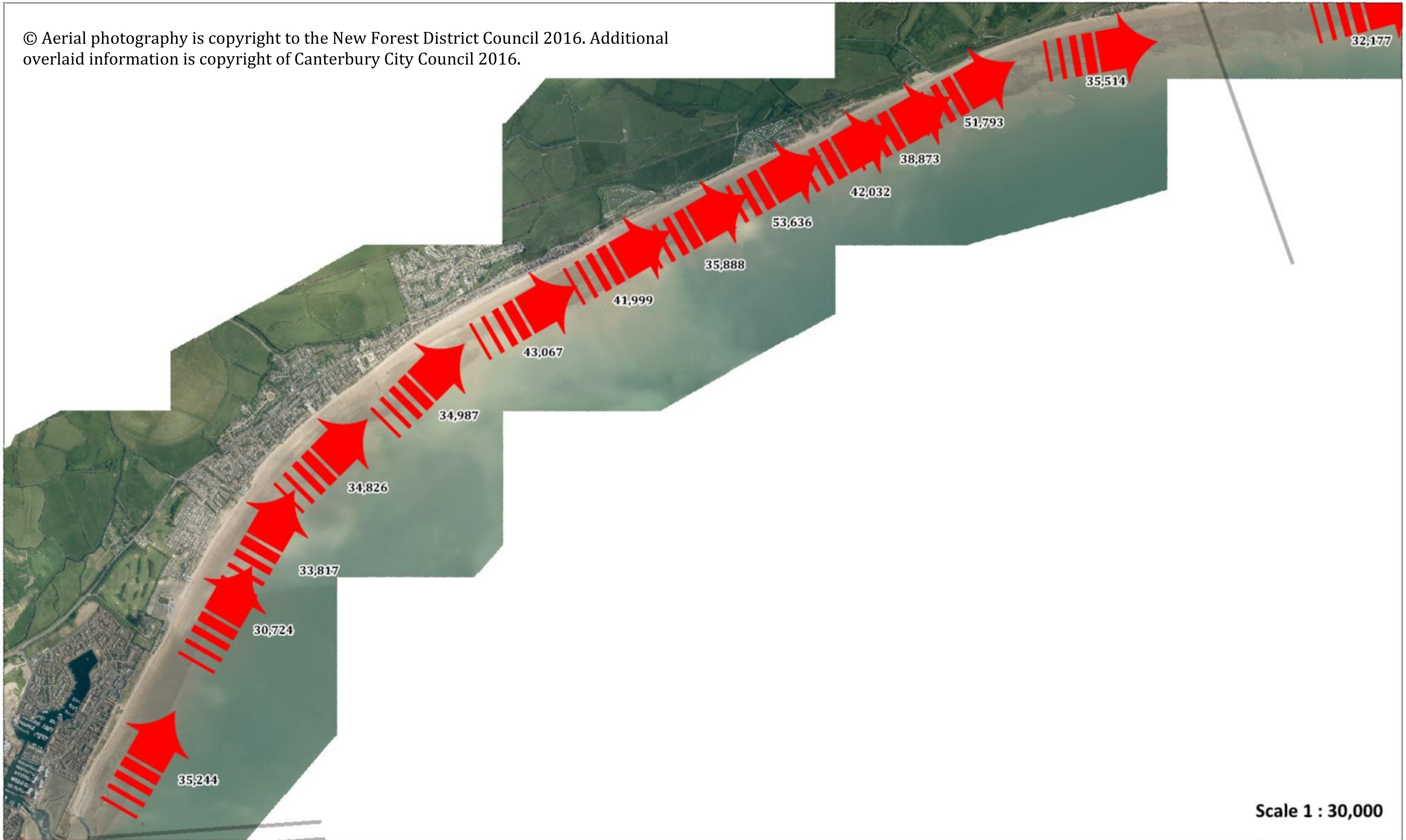

FIGURE 5-4 SEDIMENT BUDGET - PEVENSEY

Estimated annual sediment transport in cubic meters.

— Unit boundaries

N

0 - 2,500 | 2,500 - 5,000 | 5,000 - 10,000 | 10,000 - 30,000 | 30,000 - 75,000

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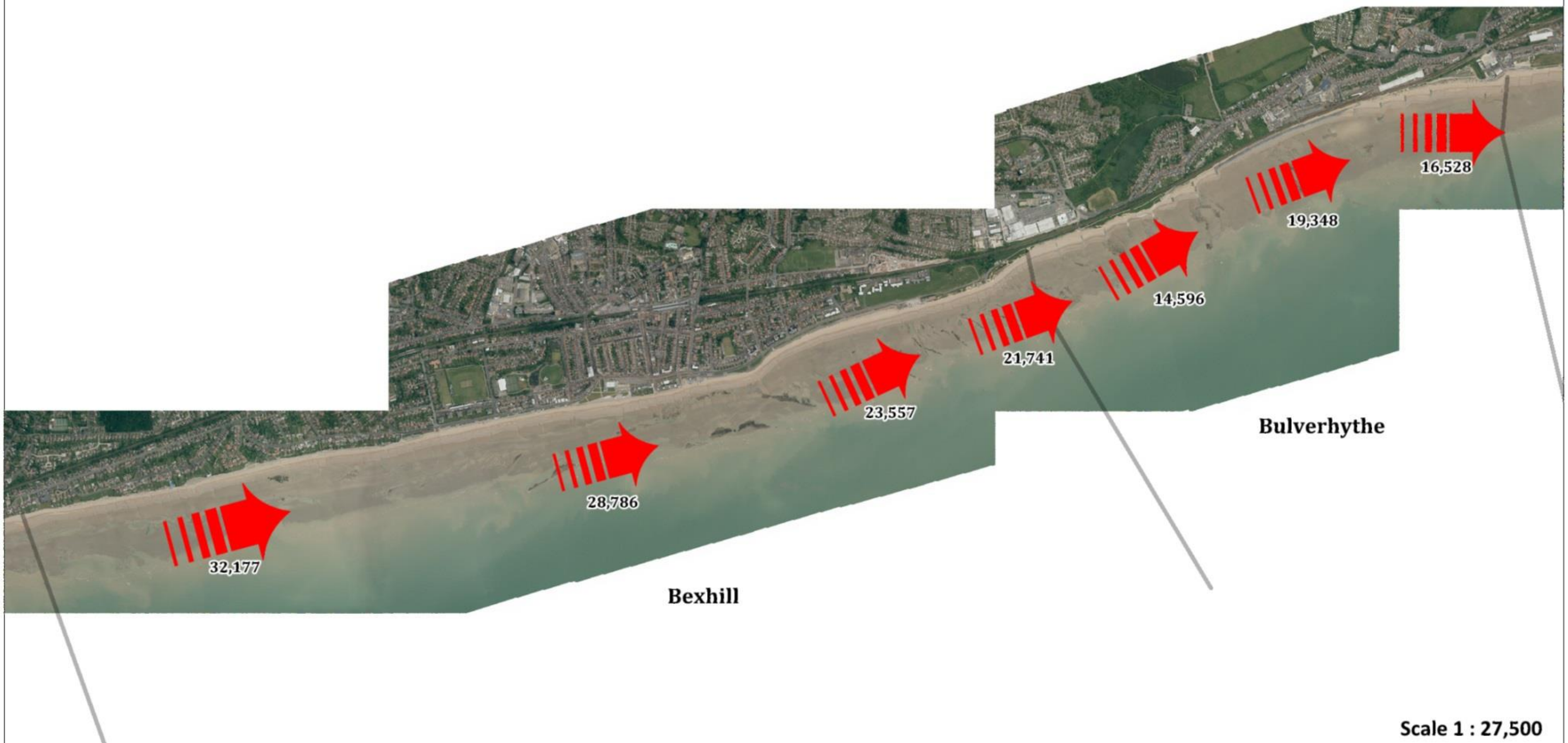

FIGURE 5-5 SEDIMENT BUDGET – BEXHILL AND BULVERHYTHE

Unit boundaries

N

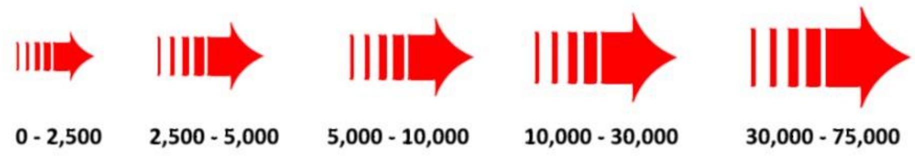

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FIGURE 5-6 SEDIMENT BUDGET - HASTINGS

Estimated annual sediment transport in cubic meters.

Unit boundaries

0 - 2,500 | 2,500 - 5,000 | 5,000 - 10,000 | 10,000 - 30,000 | 30,000 - 75,000

N

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FIGURE 5-7 SEDIMENT BUDGET - FAIRLIGHT

Estimated annual sediment transport in cubic meters.

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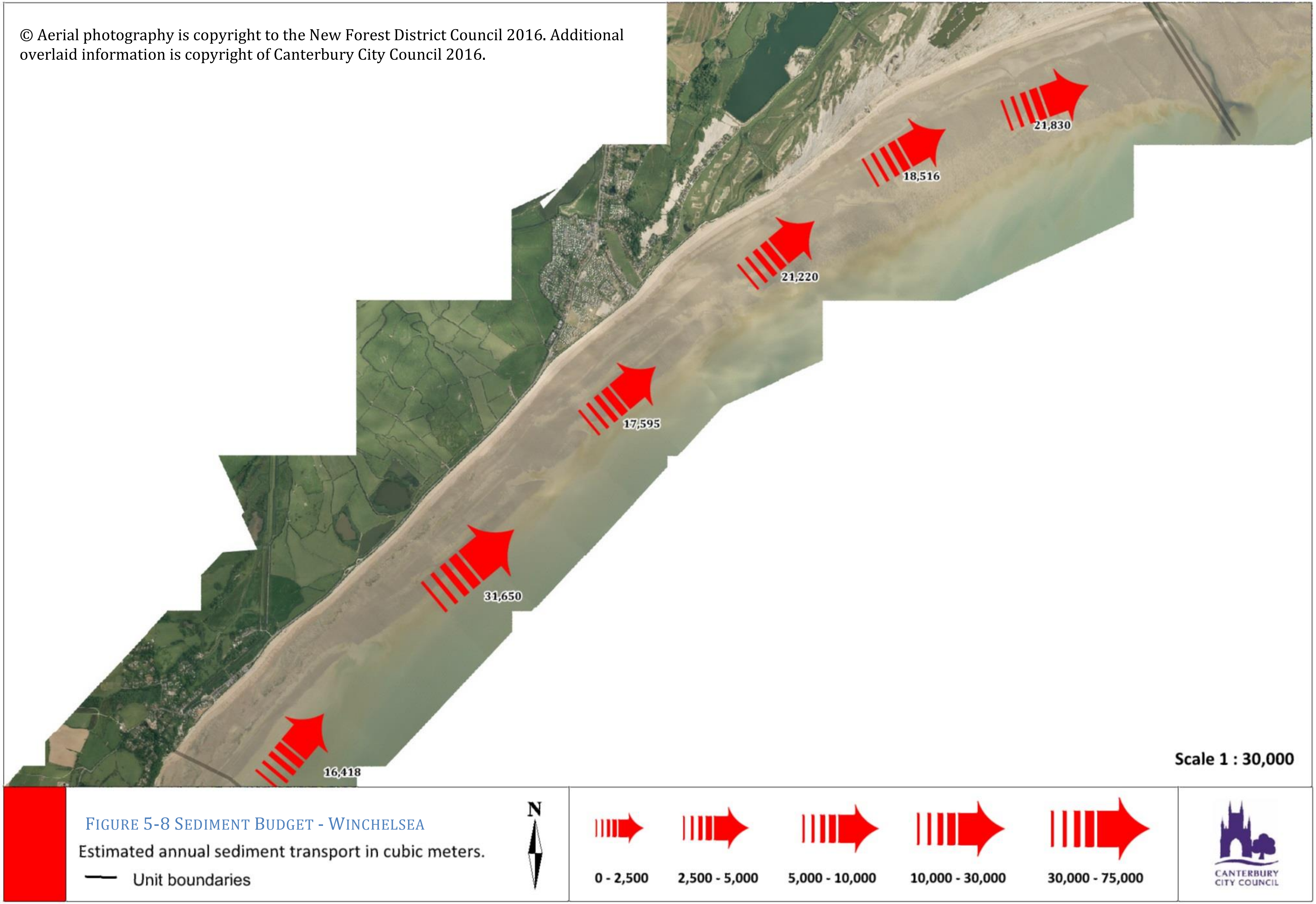

FIGURE 5-8 SEDIMENT BUDGET - WINCHELSEA

Estimated annual sediment transport in cubic meters.

Unit boundaries

5-4 EROSION/ACCRETION

With twelve 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: $$Net\ Erosion/Acretion = \Delta V - P + R$$

The following figures illustrate the average annual erosion/accretion across the study area. Again, it should be stressed that these figures represent the average figure 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.

FIGURE 5-9 NET ANNUAL EROSION/ACCRETION - EASTBOURNE

(Influence of beach recycling and replenishment discounted)

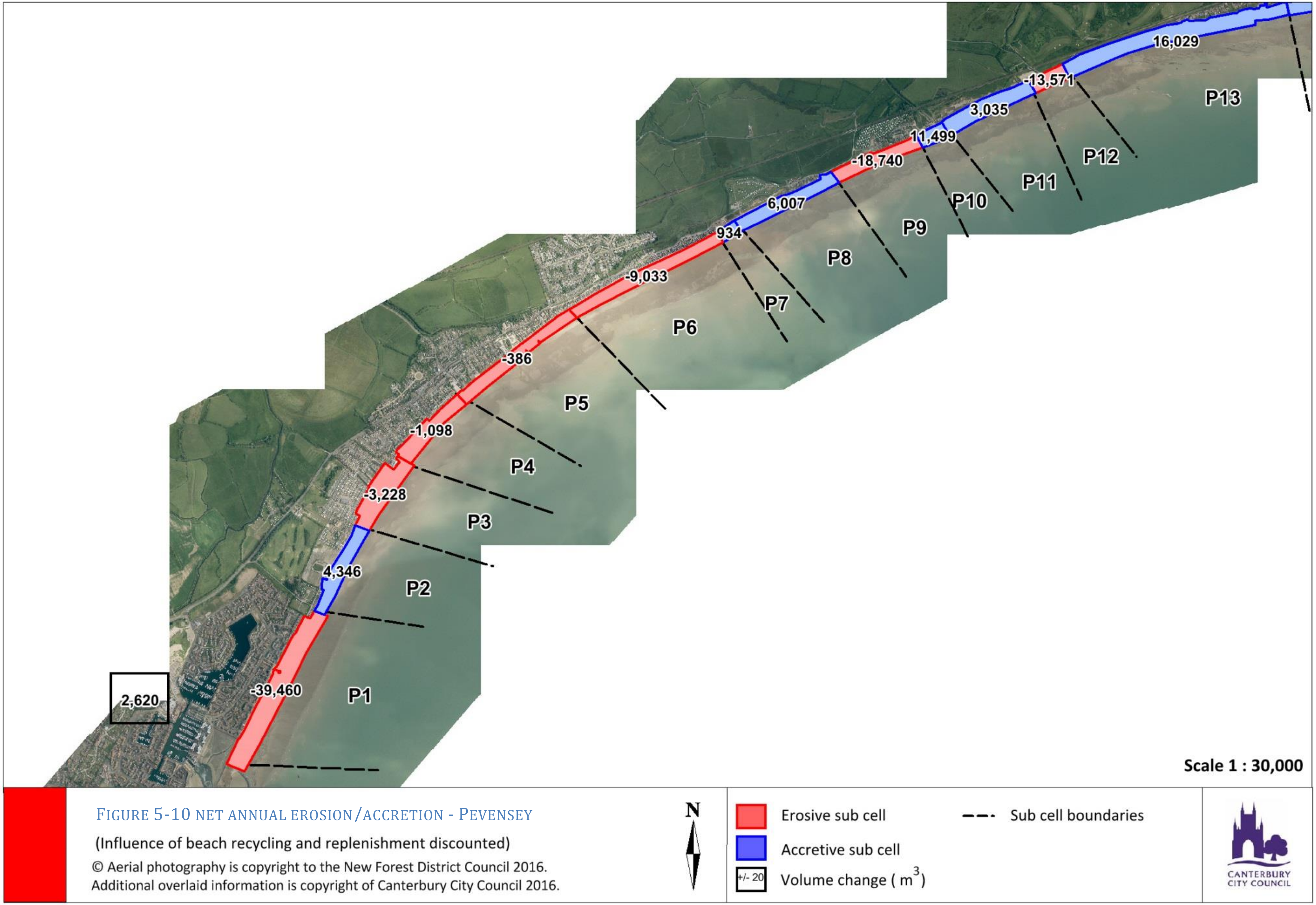

FIGURE 5-10 NET ANNUAL EROSION/ACCRETION - PEVENSEY

(Influence of beach recycling and replenishment discounted)

FIGURE 5-11 NET ANNUAL EROSION/ACCRETION – BEXHILL AND BULVERHYTHE

(Influence of beach recycling and replenishment discounted)

N

Erosive sub cell

Accretive sub cell

+/- 20 Volume change (m^3)

Sub cell boundaries

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Scale 1 : 20,000

FIGURE 5-12 NET ANNUAL EROSION/ACCRETION - HASTINGS

(Influence of beach recycling and replenishment discounted)

N

Erosive sub cell

Accretive sub cell

+/- 20 Volume change (m^3)

Sub cell boundaries

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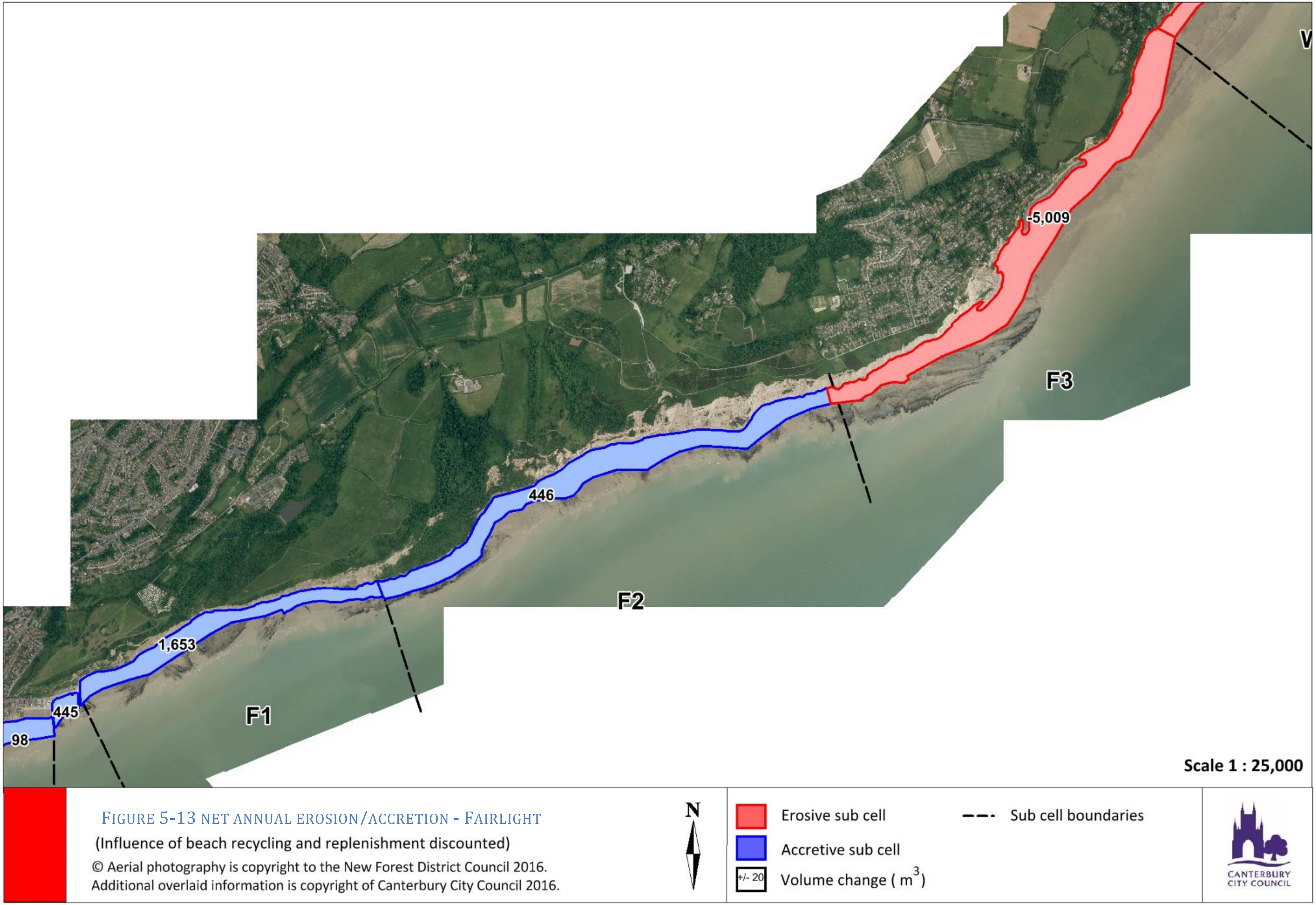

Figure 5-13 net annual erosion/accretion - Fairlight

(Influence of beach recycling and replenishment discounted)

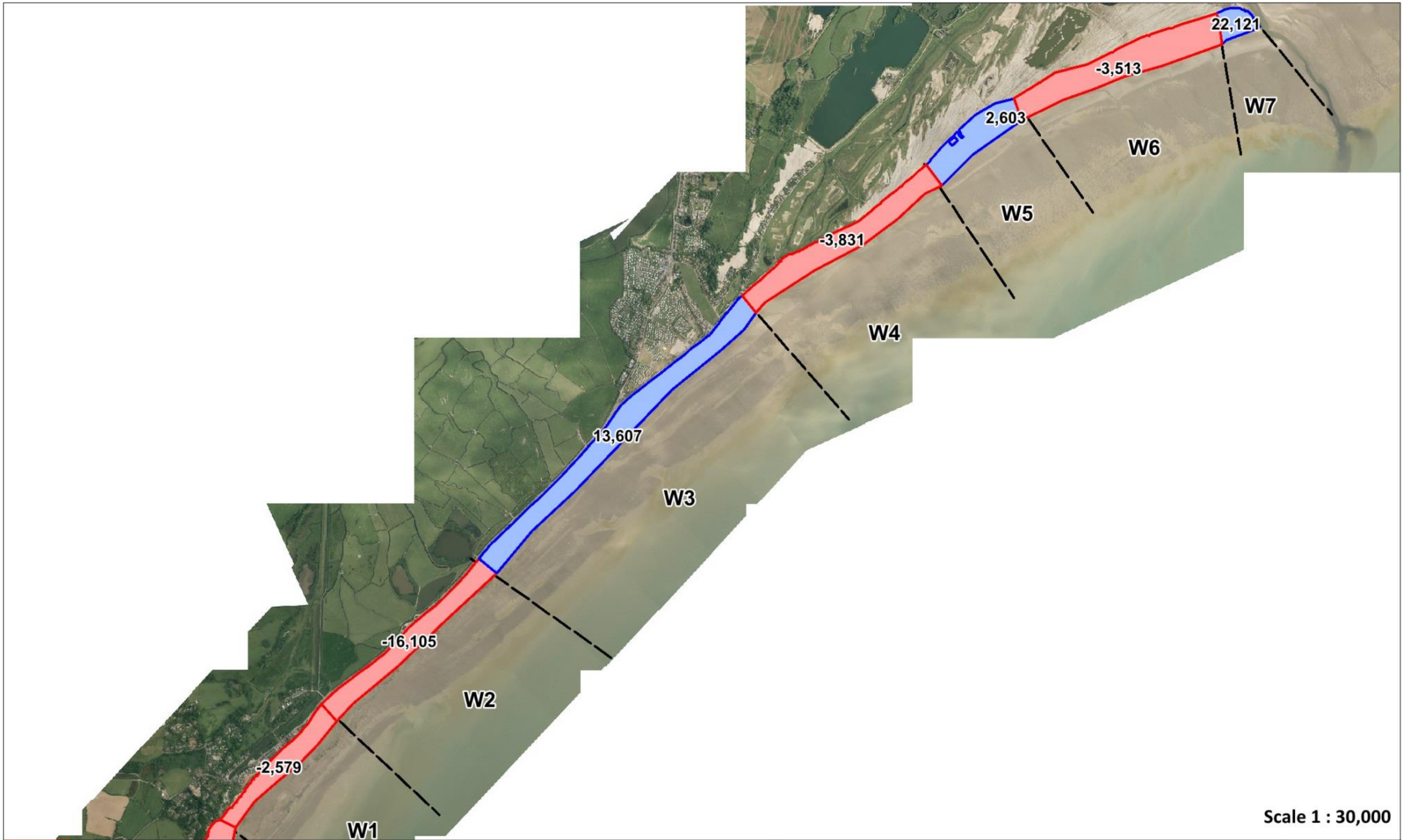

FIGURE 5-14 NET ANNUAL EROSION/ACCRETION - WINCHELSEA

(Influence of beach recycling and replenishment discounted)

Erosive sub cell

Accretive sub cell

+/- 20 Volume change (m^3)

Sub cell boundaries

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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.

5-5-1 EASTBOURNE

With virtually no input of sediment from Beachy Head and very little lost past Sovereign Harbour, Eastbourne is essentially a self-contained unit. Shingle recycling operations effectively counteract the movement of material from west to east and losses through attrition, and those associated with management activities, are only in the region of 5,000m^3 per year. An additional volume (c. 8,000m^3) is bypassed around sovereign harbour, resulting in an average annual loss of around 13,000m^3.

In order to compensate for this drain on beach material Eastbourne has conducted periodic beach replenishments, the most recent in 2015. The following chart illustrates the gradual impact of this beach loss and the influx of material from the replenishment operation.

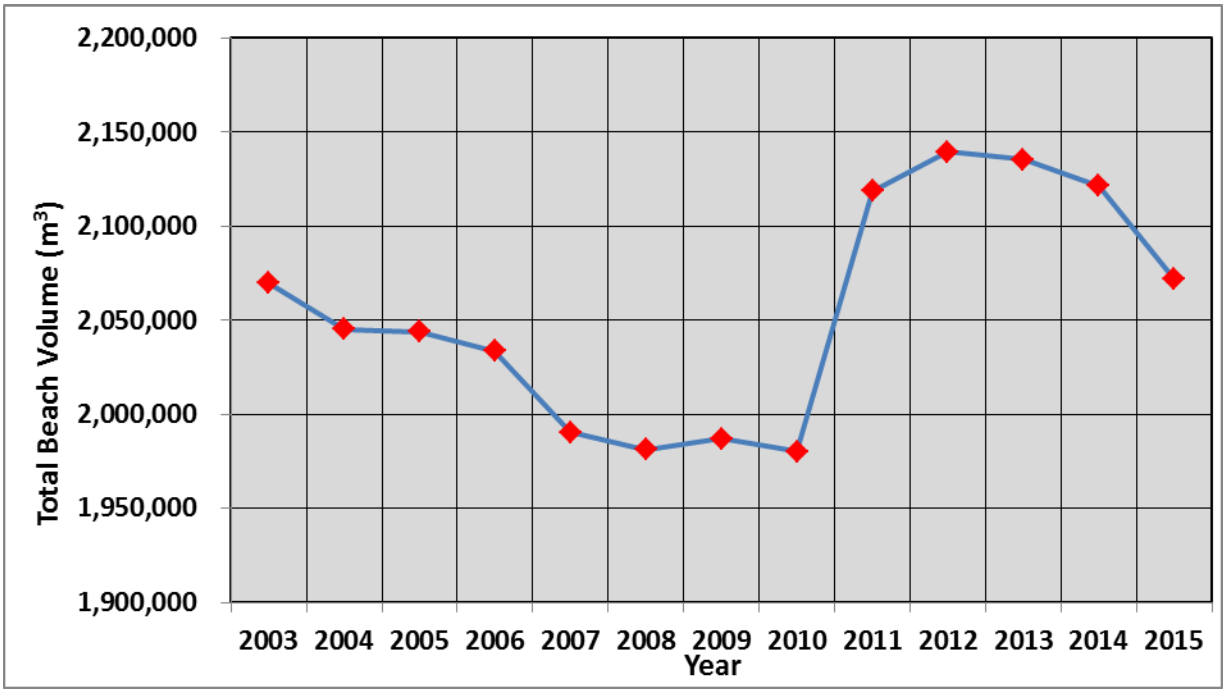

FIGURE 5-15 EASTBOURNE TOTAL BEACH VOLUME (2003-2015)

5-5-2 PEVENSEY BAY

Pevensey Bay is one of the most actively managed beaches in the UK, with annual beach recharge averaging 20,000m^3 (plus 8,000m^3 bypassed around Sovereign Harbour) in addition to a shingle recycling operation that moves on average over 70,000m^3 of material a year, as part of the PFI contract. This is a consequence of the open beaches and highest sediment transport rates in the study area.

From 2003-2015 the frontage has lost an average of 12,000m^3/year, but this figure is somewhat deceptive in that the management activities have kept the beach level stable since 2007. The exception was the year 2013/14, which had an unprecedented number of storms leading to bigger losses.

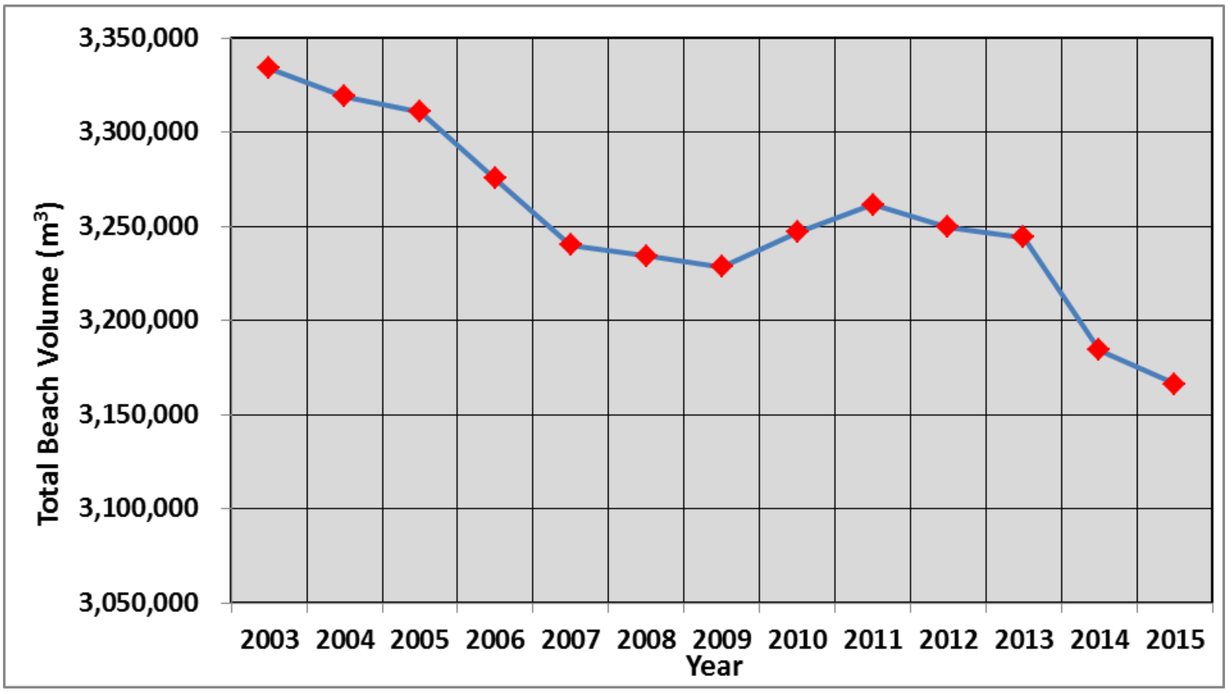

FIGURE 5-16 PEVENSEY BAY TOTAL BEACH VOLUME (2003-2015)

5-5-3 BEXHILL

Since the coastal monitoring project began in 2003 Bexhill has been one of the main beneficiaries of material passed through from Pevensey Bay. In 2003 groyne bay volumes were depleted, over time the input of sediment has filled the groyne field to near capacity with the frontage gaining upwards of 150,000m^3 in the process. It is anticipated that the fact the beach levels are approaching the capacity of the groyne field that sediment transport rates may increase, this will result in more material being passed through to Bulverhythe and Hastings.

There have been virtually no shingle beach management activities over the reporting period as a consequence of this influx.

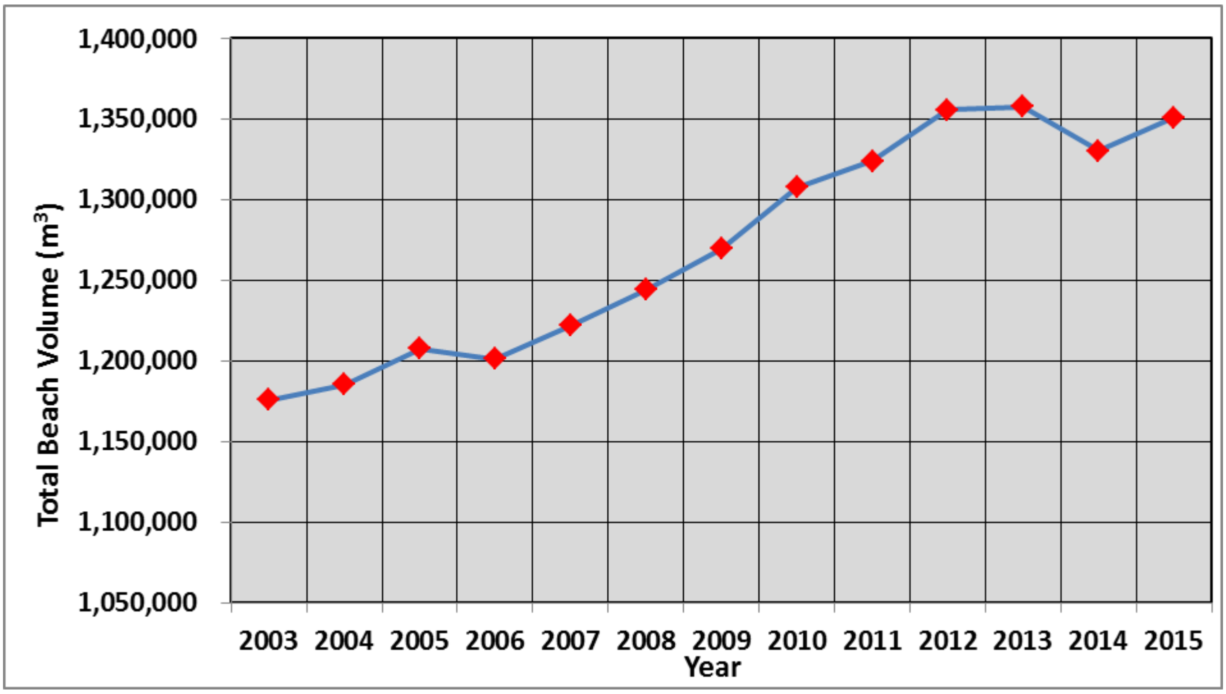

FIGURE 5-17 BEXHILL TOTAL BEACH VOLUME (2003-2015)

5-5-4 BULVERHYTHE

A number of coastal works have been carried out along this frontage to install rock groynes a revetment and subsequently to change the rock configuration. In addition there has been a beach replenishment of c 60,000m³ in 2005/2006, there have also been some minor replenishment activity in other years.

Despite the large influx of material from Bexhill, Bulverhythe does not have a configuration of coastal defences that will readily retain material. Although the works and some natural accretion have increased the total volume by over 100,000m³, since 2003, this material is largely at the western end towards Glyne Gap. In contrast the central section in front of the revetment is losing material.

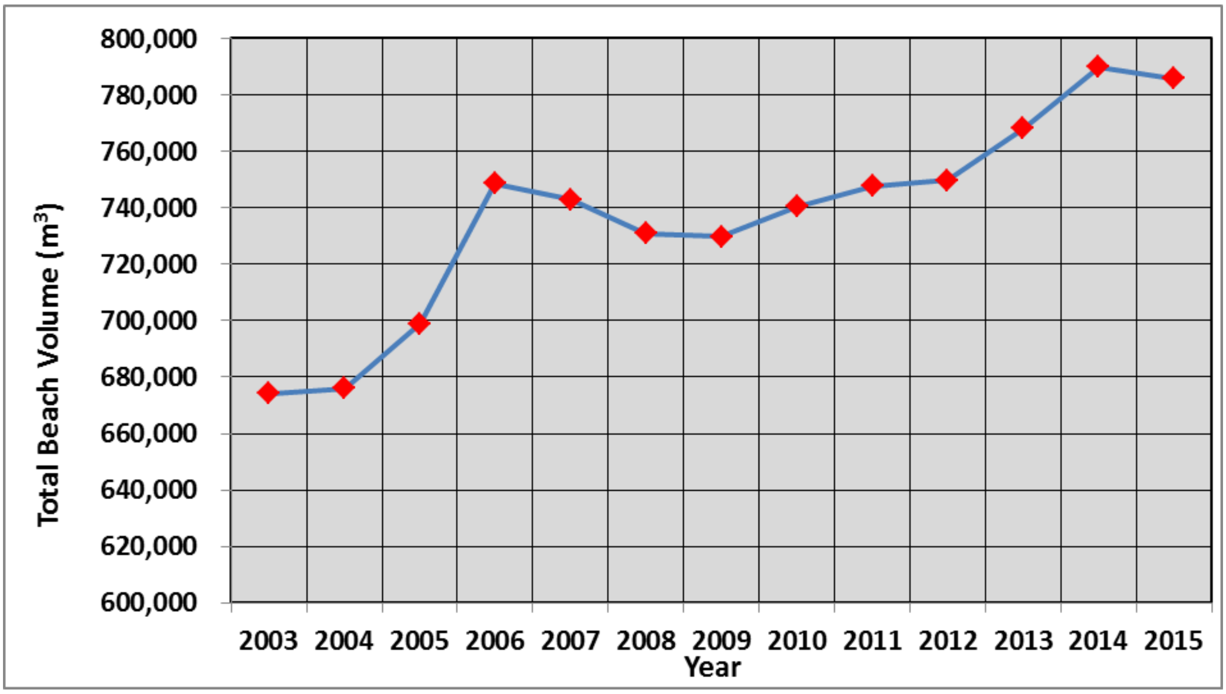

FIGURE 5-18 BULVERHYTHE TOTAL BEACH VOLUME (2003-2015)

5-5-5 HASTINGS

No beach material has been artificially introduced to the Hastings frontage over the reporting period 2003-2015. A large recycling operation was conducted in 2009 to accompany the installation of a new rock groyne, this utilised material that had accreted at the Harbour arm and moved it back towards the Pier. A much smaller operation was also carried out the following year.

Hastings is the beneficiary of a regular influx of material from Bexhill, due to the fact most groyne compartments are full this moves readily along the frontage and accretes updrift of the Harbour Arm which acts as a terminal structure letting very little material past. The net effect has resulted in the total beach volume steadily accreting.

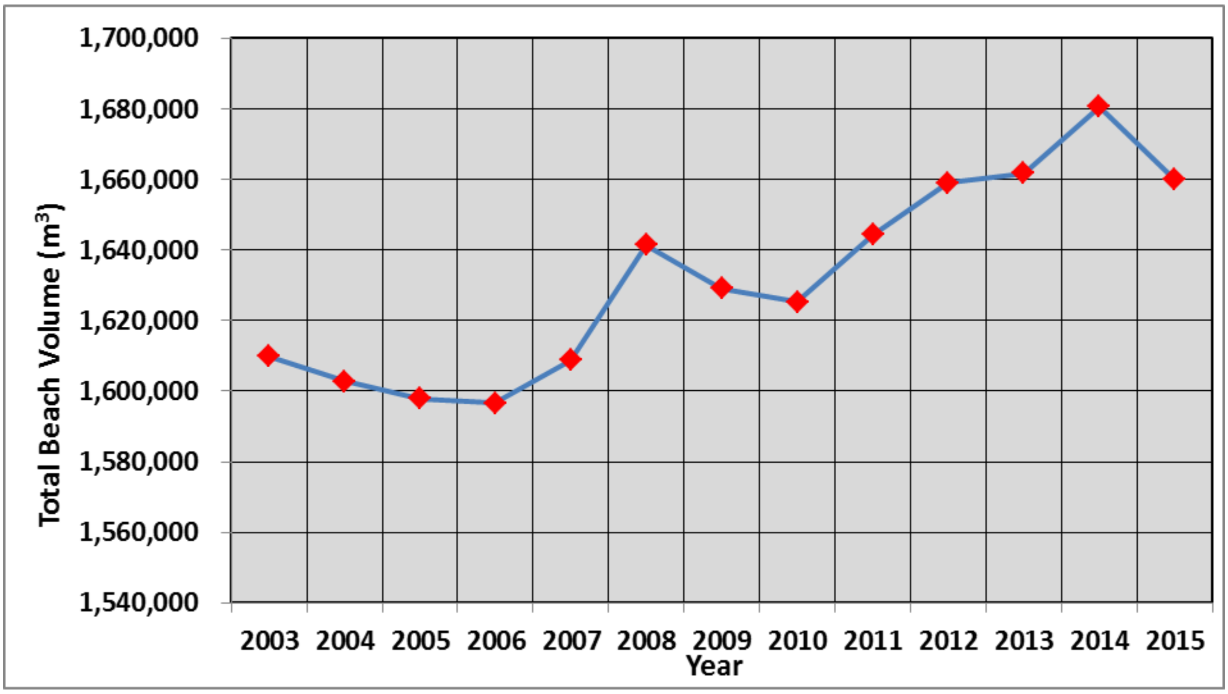

FIGURE 5-19 HASTINGS TOTAL BEACH VOLUME (2003-2015)

5-5-6 FAIRLIGHT

A reasonably large volume of shingle is now present at the eastern end of Fairlight cove. Although cliff erosion has taken place, with cliff tops receding by up to 3m a year in places, the sand and mudstone contains next to no gravel size material and so it is not expected that this contributes much quantity of shingle.

FIGURE 5-20 SHINGLE DEPOSITS AND ERODING CLIFFS AT FAIRLIGHT COVE

Beach material has moved through and into the rock structures, effectively being taken out of the active beach. In addition beaches have accumulated updrift of the revetments. With no controlling structures in place large quantities of shingle move eastwards into the Winchelsea frontage.

5-5-7 WINCHELSEA

The large quantity and supply of beach grade shingle at Fairlight cove has contributed to a steady increase in total beach volume at Winchelsea. Shingle moves readily through the frontage and heavily accretes alongside the Rye Harbour training wall. This material has historically been used for annual recycling operations.

Despite the steady supply of shingle the western end is still highly erosive, a fact which may be masked when looking at the total beach volumes.

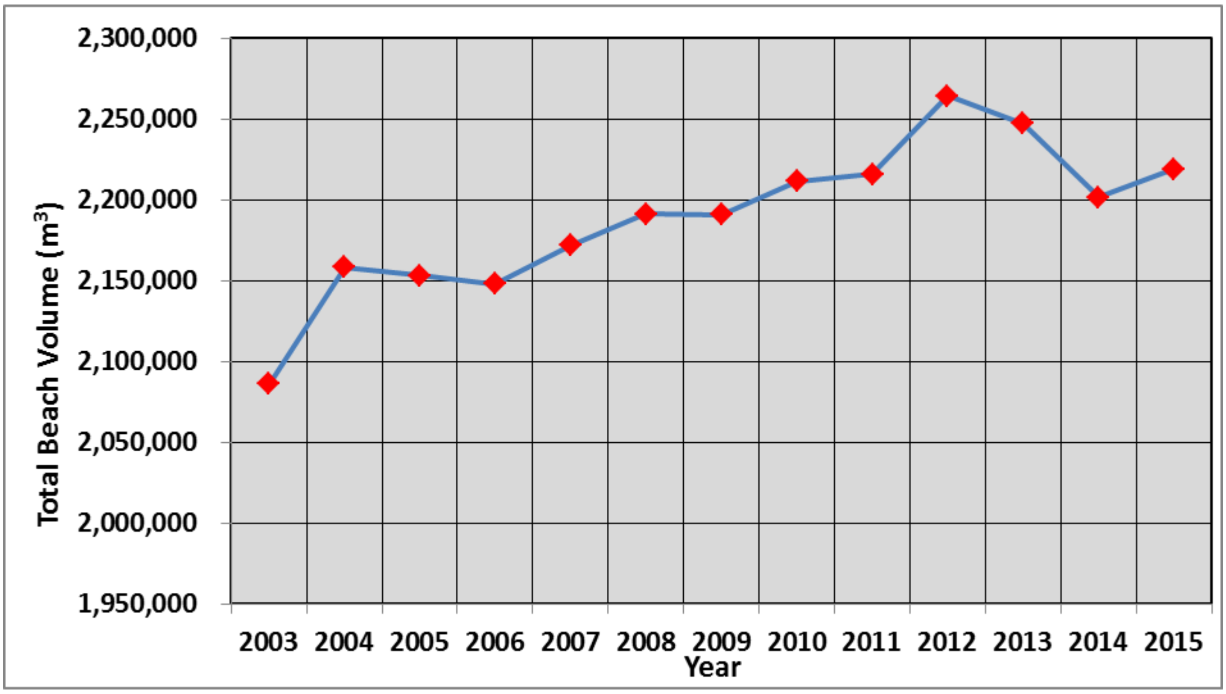

FIGURE 5-21 WINCHELSEA TOTAL BEACH VOLUME (2003-2015)

5-6 REGIONAL OVERVIEW

In order to look broadly at the regional picture the sediment budget figures are presented on a management unit basis with beach management activities discounted. This gives an overview of the expected natural changes along the frontage as an annual average.

Results are illustrated in Figure 5-22 and clearly show the losses at Eastbourne and Pevensey and the gains along the Bexhill, Bulverhythe and Hastings coastline.

The figures show a regional loss of sediment of -+1,185m^3/year, which is the best estimate of what would occur naturally[1]. The as surveyed changes show a gain of 30,000 m^3 along the frontage, due to the input of replenished shingle.

[1] In areas where management has taken place a fully 'natural' change can never be calculated .In practice beach management activities may increase or decrease net longshore or cross shore movement, so the 'natural annual change' may not equal what would have occurred had no management taken place.

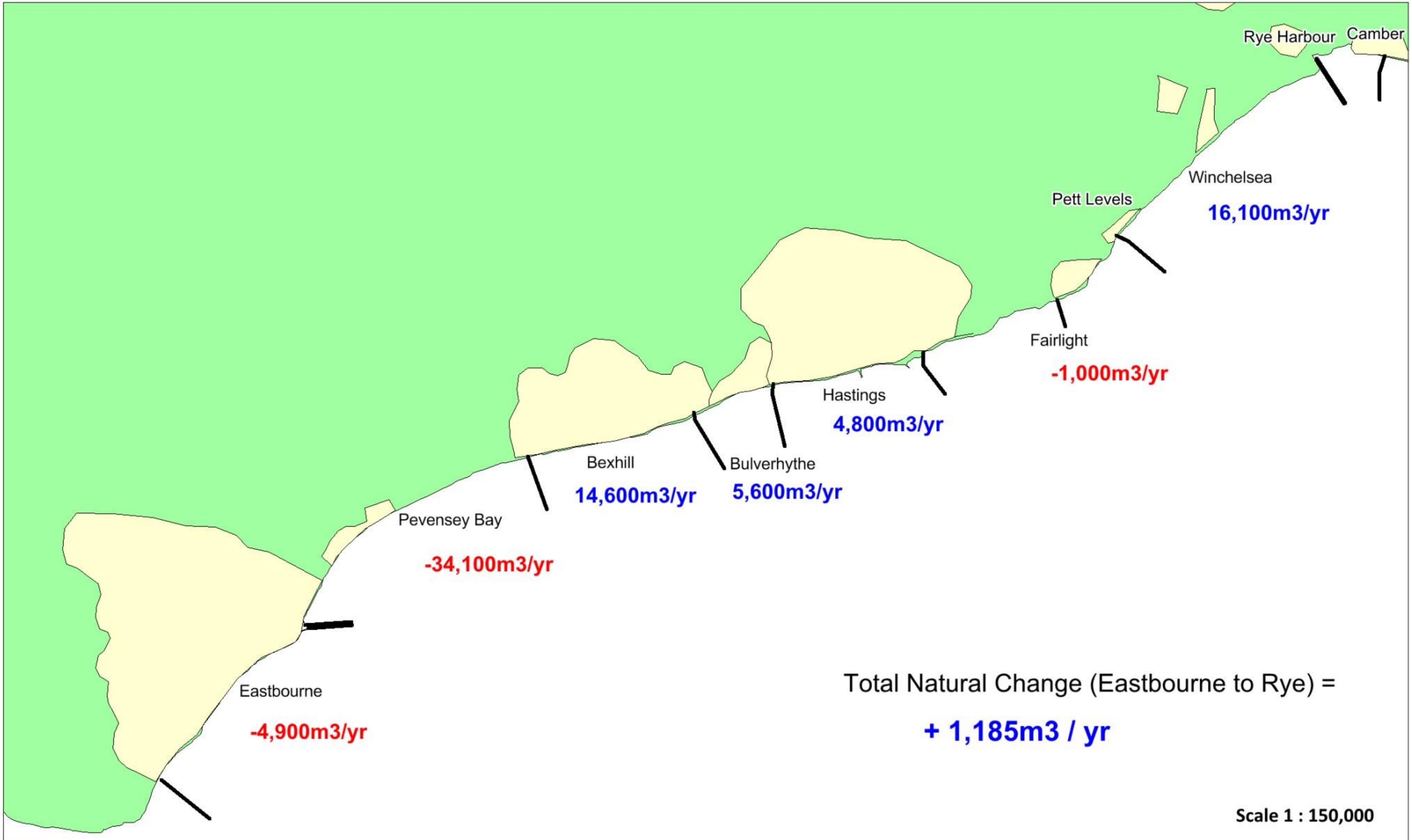

FIGURE 5-22 SEDIMENT BUDGET REGIONAL EROSION/ACCRETION SUMMARY

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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.

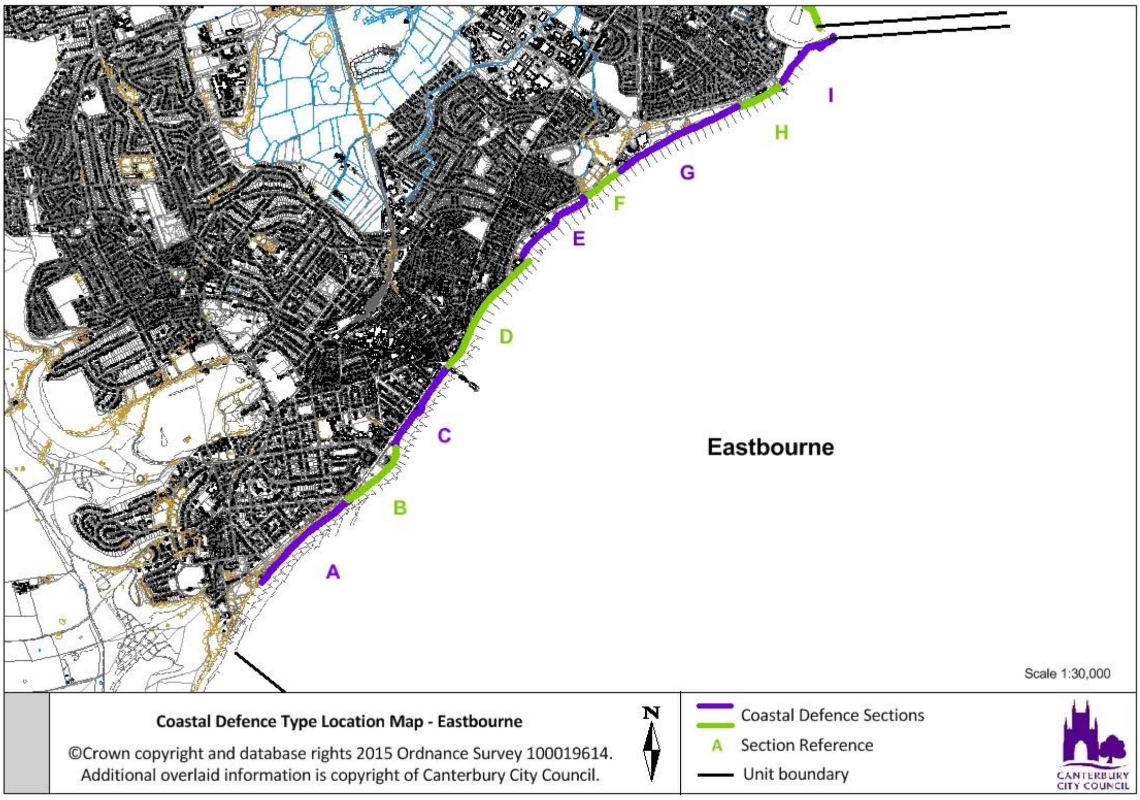

FIGURE 6-1-1 EXAMPLE OF DEFENCE SECTIONS FOR EASTBOURNE

6-2 METHOD

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)

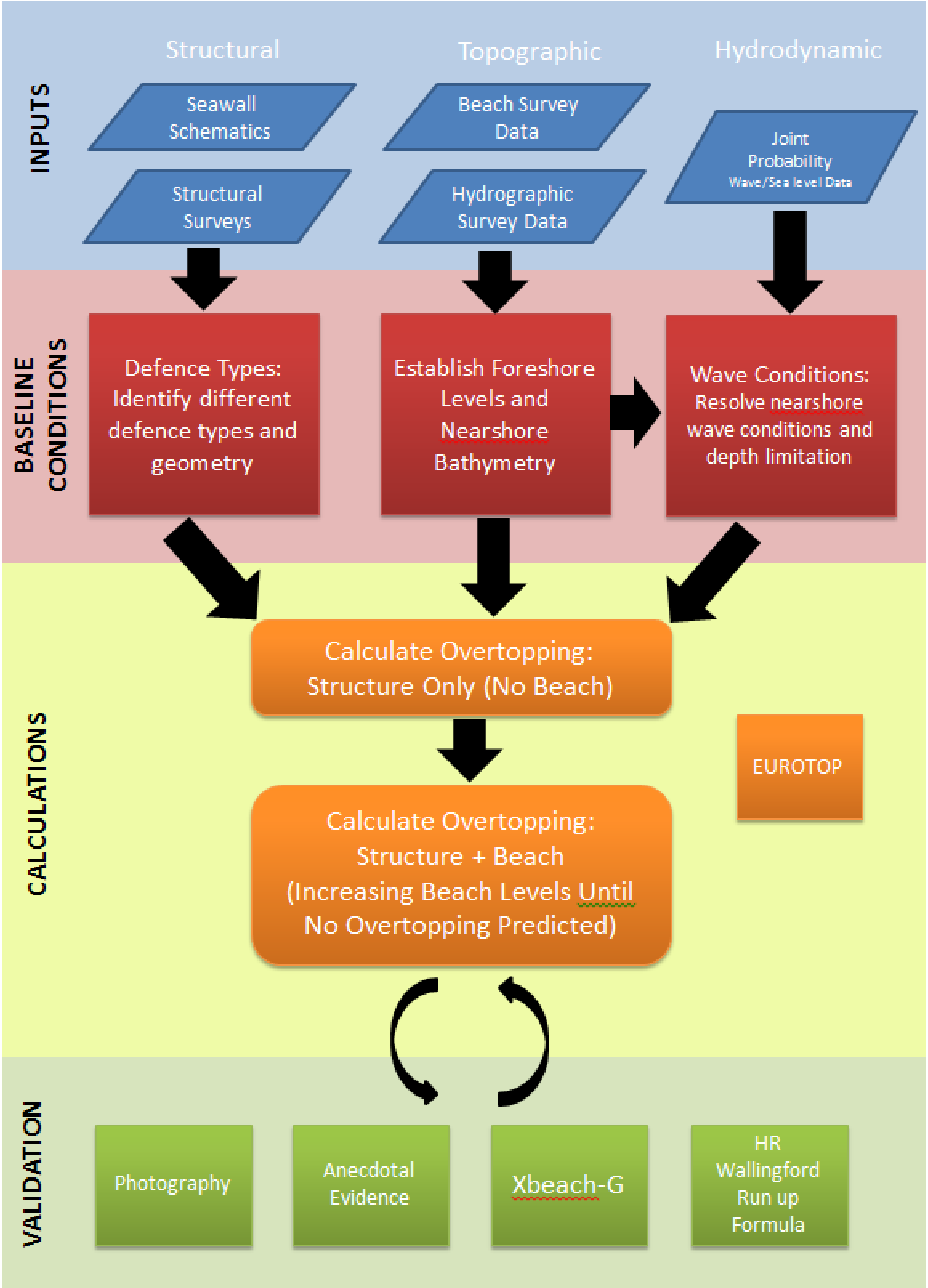

FIGURE 6-2-2 SUMMARY OF OVERTOPPING METHODOLOGY DEVELOPED FOR THIS REPORT

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 Coastal Monitoring Project. 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 breakdown each management unit into frontage lengths with different defence sections. 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. 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 are dependent upon the foreshore level in each location, which are presented in Appendix G.

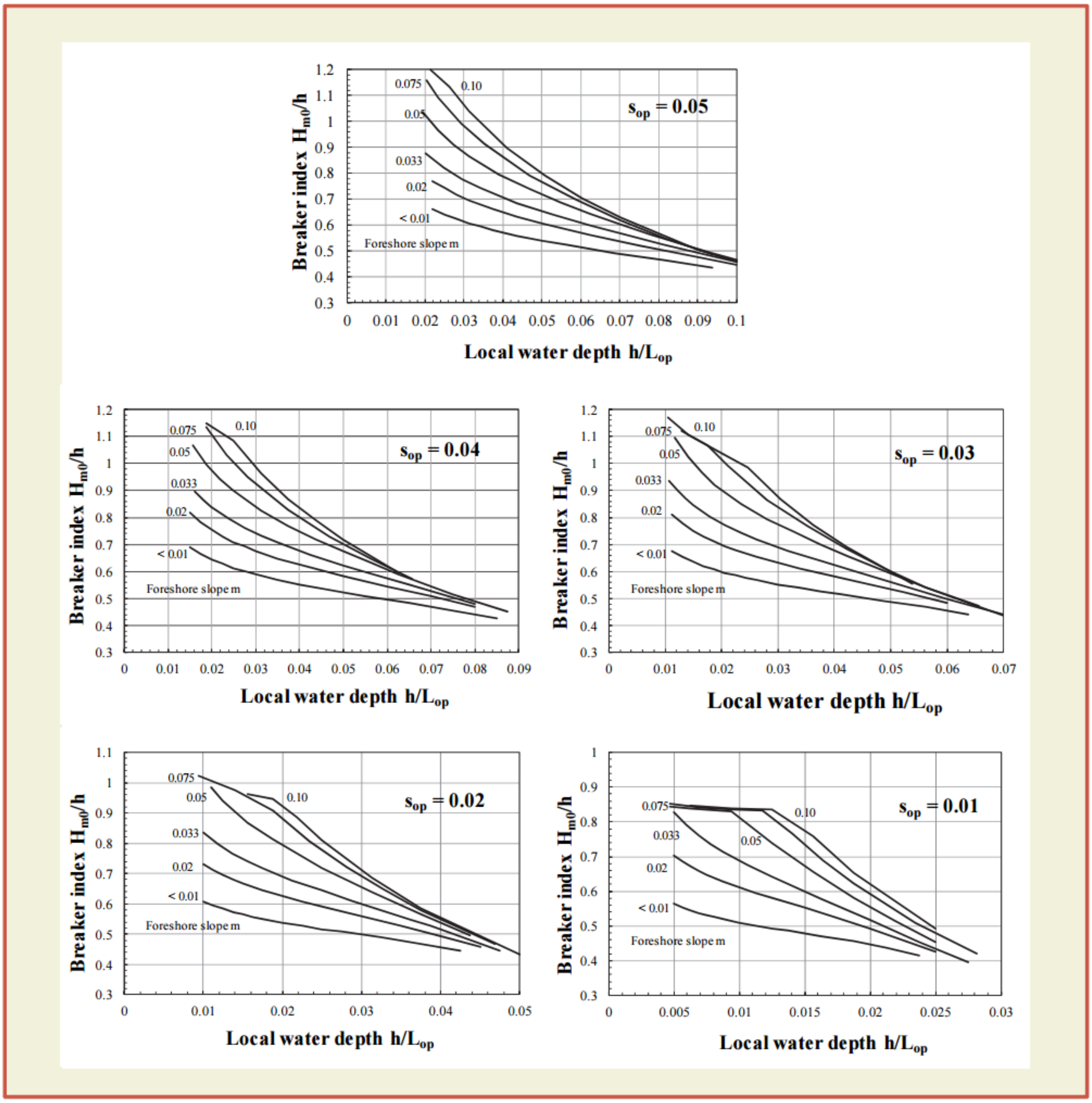

FIGURE 6-2-3 CALCULATION OF DEPTH LIMITATION USING THE BREAKER INDEX

CALCULATIONS

For most calculations the EUROTOP research was used (HRW, 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.

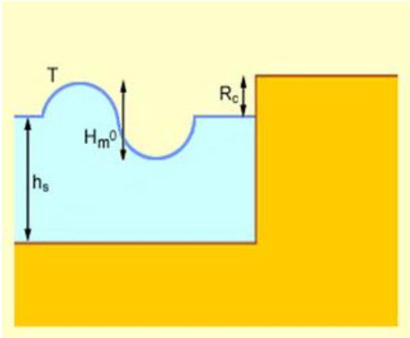

FIGURE 6-2-4 EUROTOP - CALCULATION OF OVERTOPPING AT A SIMPLE VERTICAL SEAWALL

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.

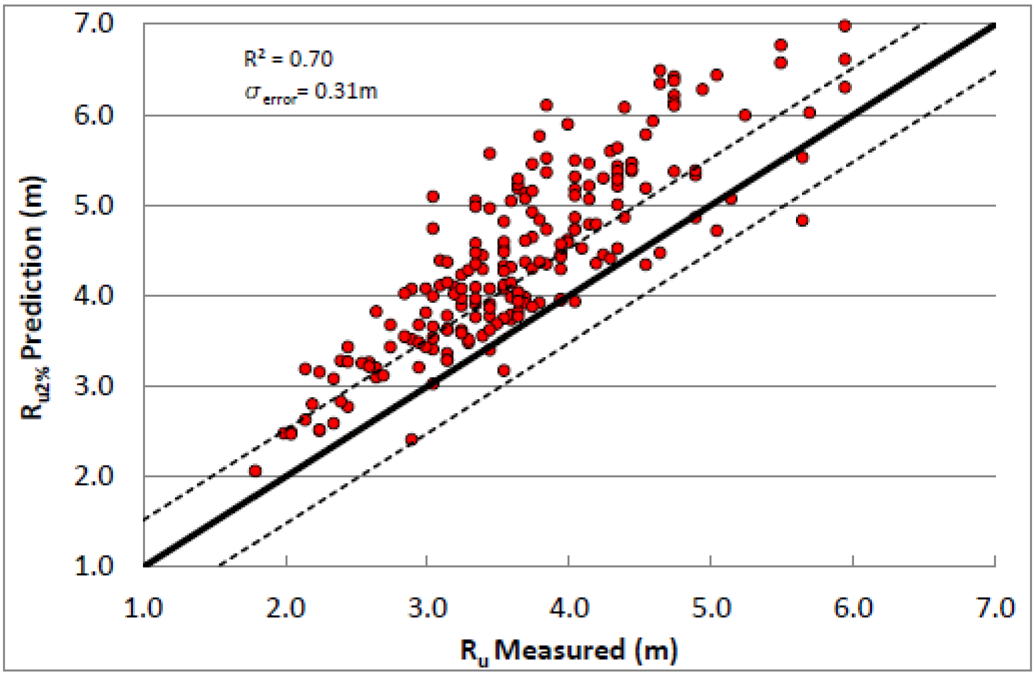

FIGURE 6-2-5 SIMPLISTIC EUROTOP METHOD VS ACTUAL MEASURED DATA AT WORTHING (HRW, 2014)

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. 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. 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).

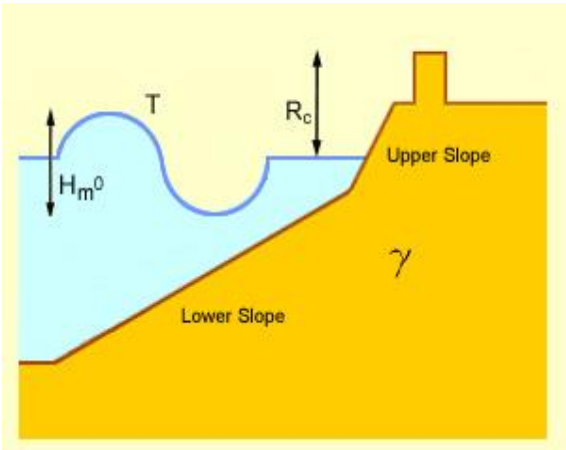

FIGURE 6-2-6 EUROTOP - CALCULATION USING MORE COMPLEX STRUCTURES

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. There were several instances where this was possible, examples shown below.

FIGURE 6-2-7 SEVERE OVERTOPPING AT HASTINGS AS A CONSEQUENCE OF LOW BEACH LEVELS (2009)

FIGURE 6-2-8 OVERTOPPING AT EASTBOURNE IN THE 1990S (BEACH LEVELS LOWER THAN PRESENT DAY)

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 6-2-9). 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 6-2-9 SHINGLE WASHED ON TO THE PROMENADE AT BEXHILL (2015)

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.

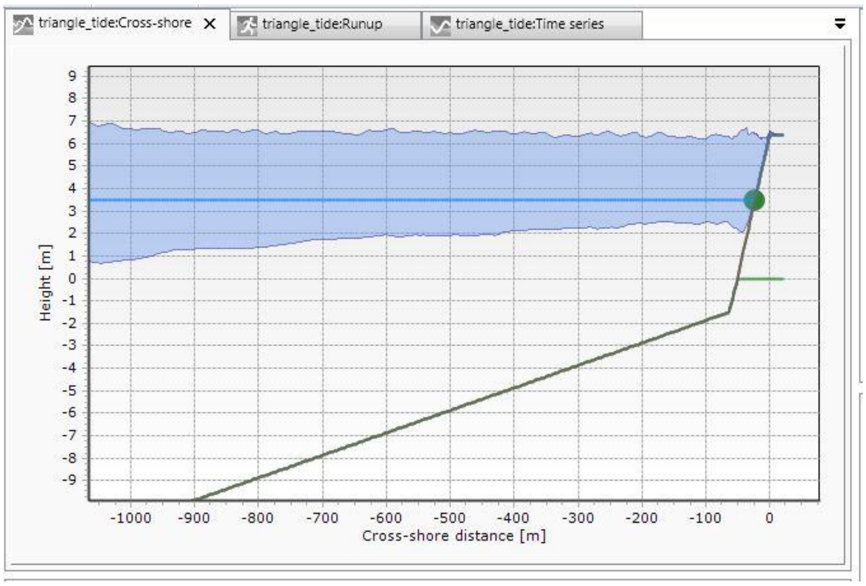

FIGURE 6-2-10 XBEACH-G SAMPLE SCREENSHOT

4. The improved formula presented in Wave run-up on shingle beaches: a new method (HRW, 2014) 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.

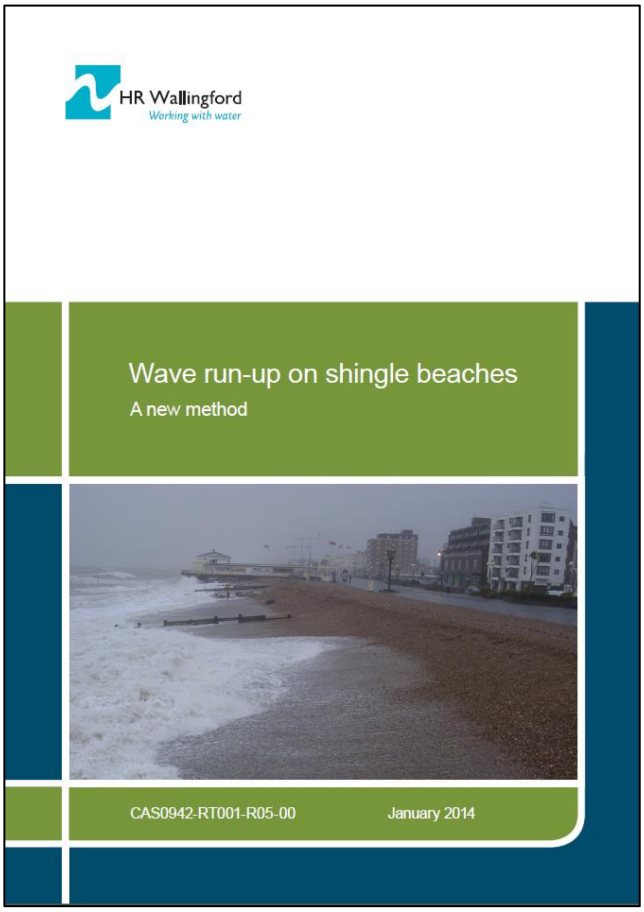

FIGURE 6-2-11 SUB-PROJECT RESEARCH AND DEVELOPMENT OF IMPROVED RUN-UP FORMULA.

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 steady 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 6-2-12 DILAPIDATED GROYNES LOW BEACH AND SEAWALL FAILURE AT KINGSDOWN

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 6-2-12 and 6-2-13). 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 6-2-14).

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 6-2-13 EXAMPLES OF UNDERMINING AT TANKERTON (LEFT) AND RECULVER (RIGHT)

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 6-2-14 FAILURE OF A SEAWALL AT ALL HALLOWS DUE TO SLIDING/TOPPLING OF DEFENCE SECTIONS

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 6-2-15). The full methodology is provided in Appendix G.

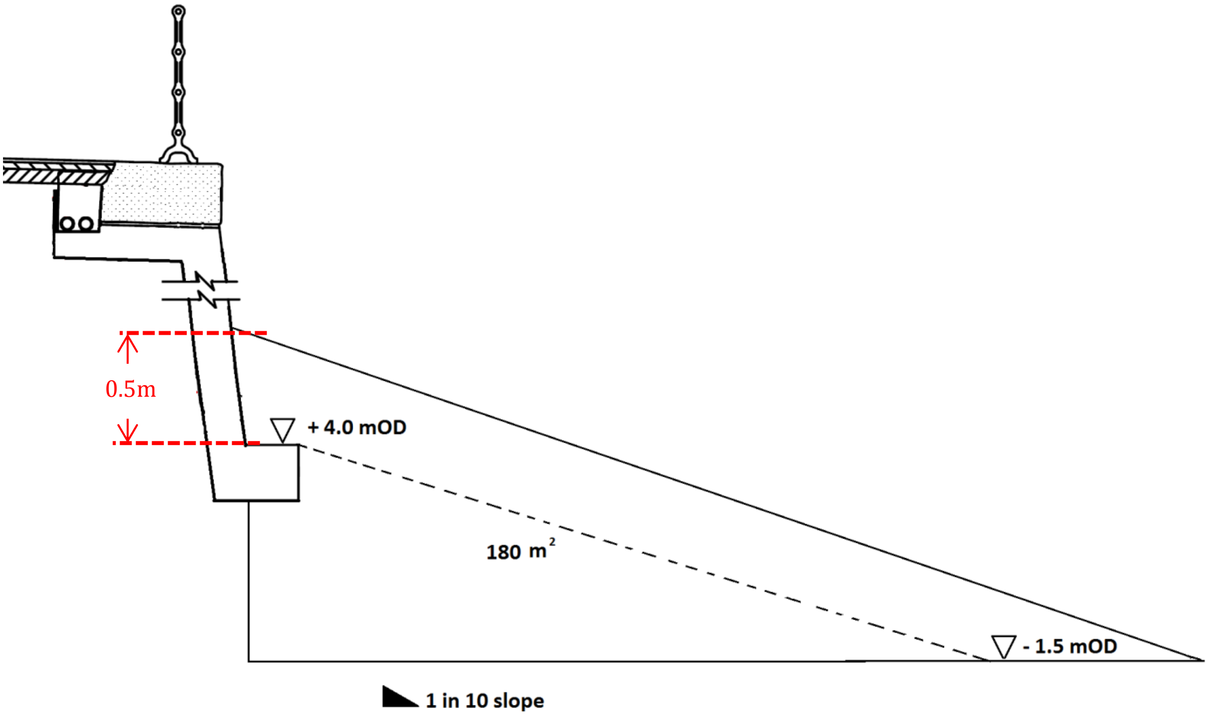

FIGURE 6-2-15 CRITICAL BEACH LEVEL TO PREVENT UNDERMINING OF THE DEFENCE FOUNDATIONS INCLUDING A 50CM ALLOWANCE FOR SCOUR

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.

There are four main flood basins within the frontage, at Eastbourne, Pevensey, Bulverhythe and Pett Levels/Winchelsea/Rye. In order to calculate the number of properties at risk extreme water levels for a 1:200 year event were plotted at each location, in conjunction with LiDAR data, to calculate the potential inundation and properties that would be affected.

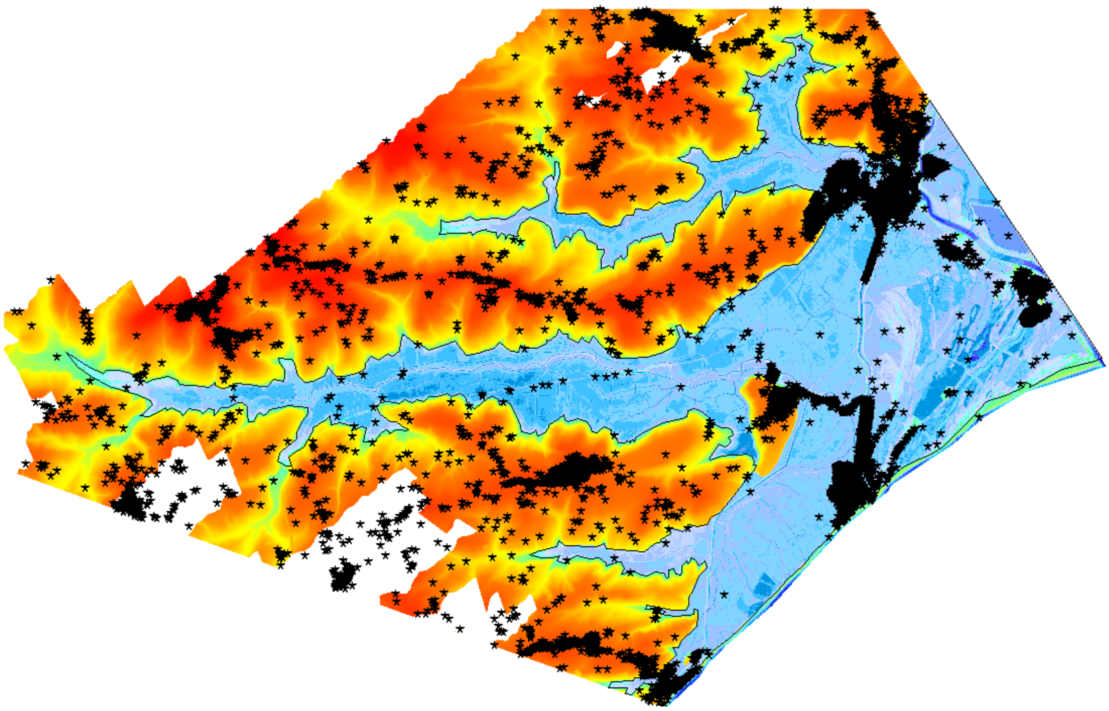

FIGURE 6-2-16 EXAMPLE OF PROPERTIES (STARS) AT RISK FROM A MAJOR FLOODING EVENT

Utilising the LLPG (local land property gazetteer) address layer this highlights the properties that would be flooded above the threshold level, this produces a database of properties 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), and those that would be cut off and possible lose access and utilities (Table 6-2). For comparison purposes Table 6-3 provides the results from previous Project Appraisal Reports (PARs) alongside those from this study.

TABLE 6-1 PROPERTIES AT RISK FROM FLOODING

LOCATION	1:200 YEAR FLOOD LEVEL (M ODN)	NUMBER OF PROPERTIES FLOODED	2014 PROPERTY VALUE (£ K)
WINCHELSEA	4.9	4,790	£1,195,595
BULVERHYTHE	4.8	772	£120,462
PEVENSEY	4.8	6,004	£1,406,993
EASTBOURNE	4.8	14,212	£2,597,926
		TOTAL	£5,320,977

TABLE 6-2 PROPERTIES ISOLATED BY FLOODING

LOCATION	1:200 YEAR FLOOD LEVEL (M ODN)	NUMBER OF PROPERTIES CUT OFF	2014 PROPERTY VALUE (£ K)
WINCHELSEA	4.9	1,333	£533,267
BULVERHYTHE	4.8	0	-
PEVENSEY	4.8	1,739	£482,613

EASTBOURNE	4.8	1,894	£336,895
		TOTAL	£1,352,776

TABLE 6-3 COMPARISON OF RESULTS FROM PREVIOUS STUDIES

LOCATION	NUMBER OF PROPERTIES IN FLOOD BASIN	NUMBER OF PROPERTIES PROPOSED IN PREVIOUS PARS
WINCHELSEA*	6,123	1,500
BULVERHYTHE	772	770
PEVENSEY	7,743	11,000
EASTBOURNE	16,106	17,130

**The flood basin for this report includes properties towards Rye, the previous PAR only considered those in Winchelsea and Pett Levels, which are at a higher risk of flooding.*

In total this equates to over £6 billion of property that is reliant on the sea defences along this frontage. In reality, the most likely flooding events would result in only a partial inundation of the flood plain; however modelling numerous individual breaches and overtopping scenarios is outside the scope of this report. As with most coastal settlements infrastructure is densely concentrated near the coastline, as such any flooding or breaching scenario immediately impacts large numbers of properties.

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.

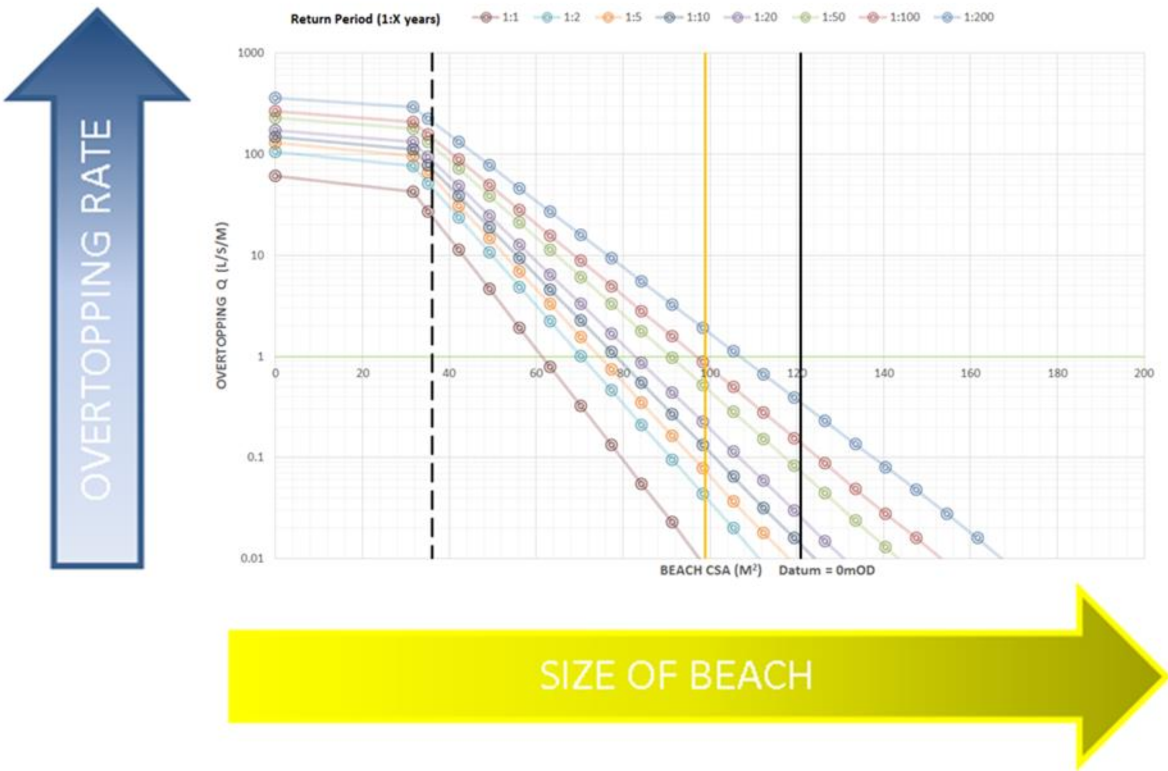

FIGURE 6-3-1 EXAMPLE OF OVERTOPPING RESULTS CHART

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 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 Chapter 7.

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.

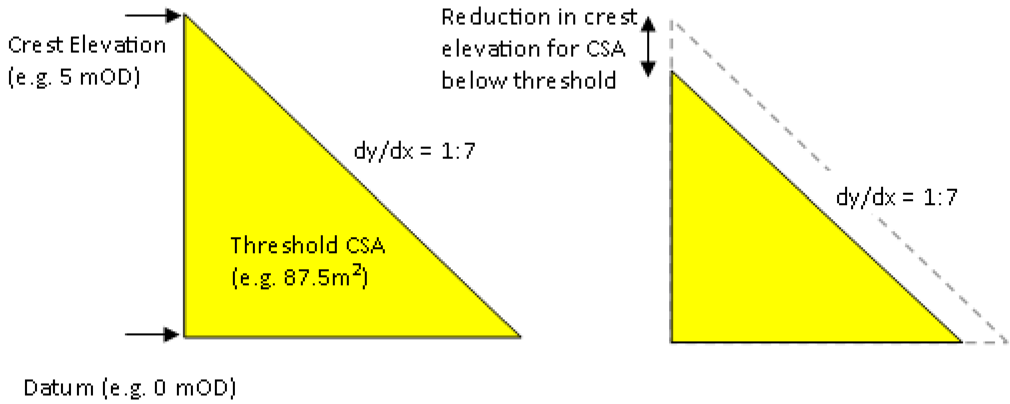

FIGURE 6-3-2 REDUCTION IN CREST HEIGHT FOR PROFILES BELOW A THRESHOLD CSA

7 STANDARD OF PROTECTION

7-1 BASELINE CRITERIA

This report 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).

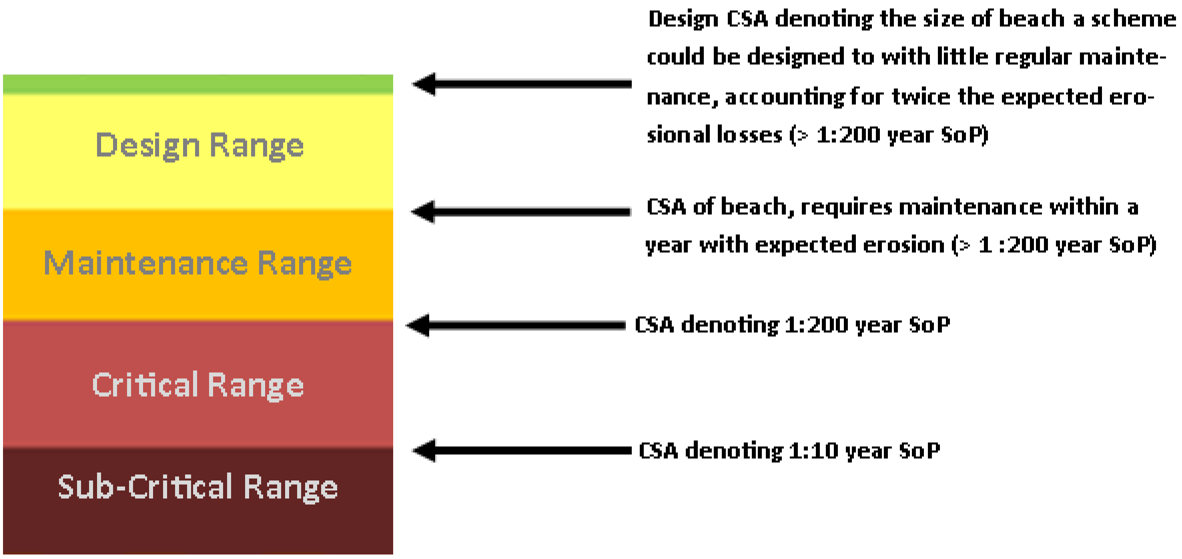

FIGURE 7-1 DESIGN, MAINTENANCE, CRITICAL AND SUB CRITICAL RANGES BASED ON TRIGGER LEVELS

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), these can 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 as an overview of each management unit it is necessary to summarise the data for each profile as shown in Figure 7-2.

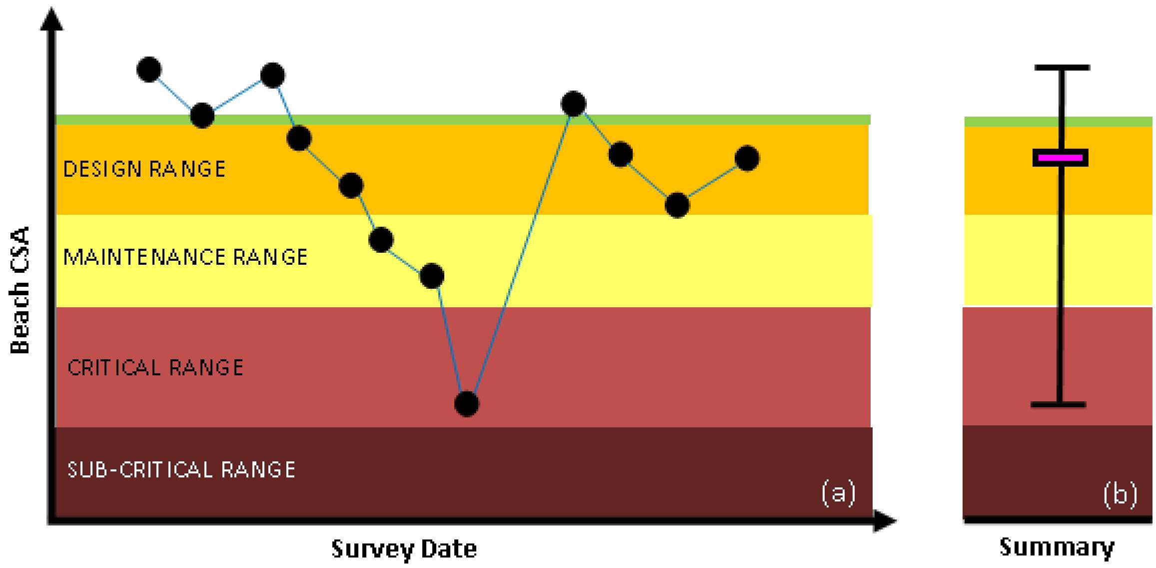

FIGURE 7-2 PRESENTATION OF STANDARD OF PROTECTION AND TRIGGER LEVELS
(A) HISTORIC VARIATION OF BEACH LEVELS (CSA)

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.

7-3-1 EASTBOURNE

Eastbourne is erosive in the west and accretive in the east; with beach CSA typically exceeding 200m^2 in the west and up to 600m^2 in the east. Please refer to the sediment budget for Eastbourne for more information.

The beaches along section A and B, approximately 1,500m long, are typically larger in the west and smaller in the east. Parts of the beaches here are on the threshold of critical failure through undermining, although the sediment transport rates here are low at the west they increase towards the East and so the problem is likely to worsen without intervention. Sections C and D are currently above Critical levels; however it is important to note that the beach here is regularly managed to retain the beach levels within the design and maintenance boundaries. Sections E to F are mostly above the design level however there are points where the beach levels are below the critical level. Sections G to I are at or above the design requirements., and the frontage here is accretive and so levels are not likely to reduce. The individual overtopping charts for each defence section are provided in Appendix G.

The potential impact throughout this unit covers the spectrum of low to high due to the varying nature of the hinterland and the purpose of the beach. The centre of the unit, Sections C and D have the highest potential impact due to the large flood plain and dense urban areas directly behind the line of defence. There is a Wastewater Treatment Works on the beach front in Section G. Elsewhere the main impacts are overtopping damages to properties and amenity (see Appendix C for an assessment of current risk).

TABLE 7-1 EASTBOURNE 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) $L\ M^{-1}S^{-1}$	NO. OF PROPERTIES IN FLOOD PLAIN	HINTERLAND	NOTES
CLIFFS	EASTBOURNE BC	-	-	CLIFF EROSION	50	5	-	RESIDENTIAL	
A		SEA WALL	-	UNDERMINING	180	2	-		
B		SEA WALL	REAR WALL	UNDERMINING	180	2	-		
C		SEA WALL	REAR WALL	OVERTOPPING	200	1	-		
D		SEA WALL	REAR WALL	OVERTOPPING	200	1	14,212		REGULAR RECYCLING UNDERTAKEN TO MAINTAIN BEACH LEVELS
E		PROM	-	OVERTOPPING	340	1			
F		PROM	-	OVERTOPPING	340	1			
G		PROM	-	OVERTOPPING	295	1			
H		PROM	-	OVERTOPPING	310	1			
I		ROCK REVETMENT	-	OVERTOPPING		10			ACCRETION POCKET

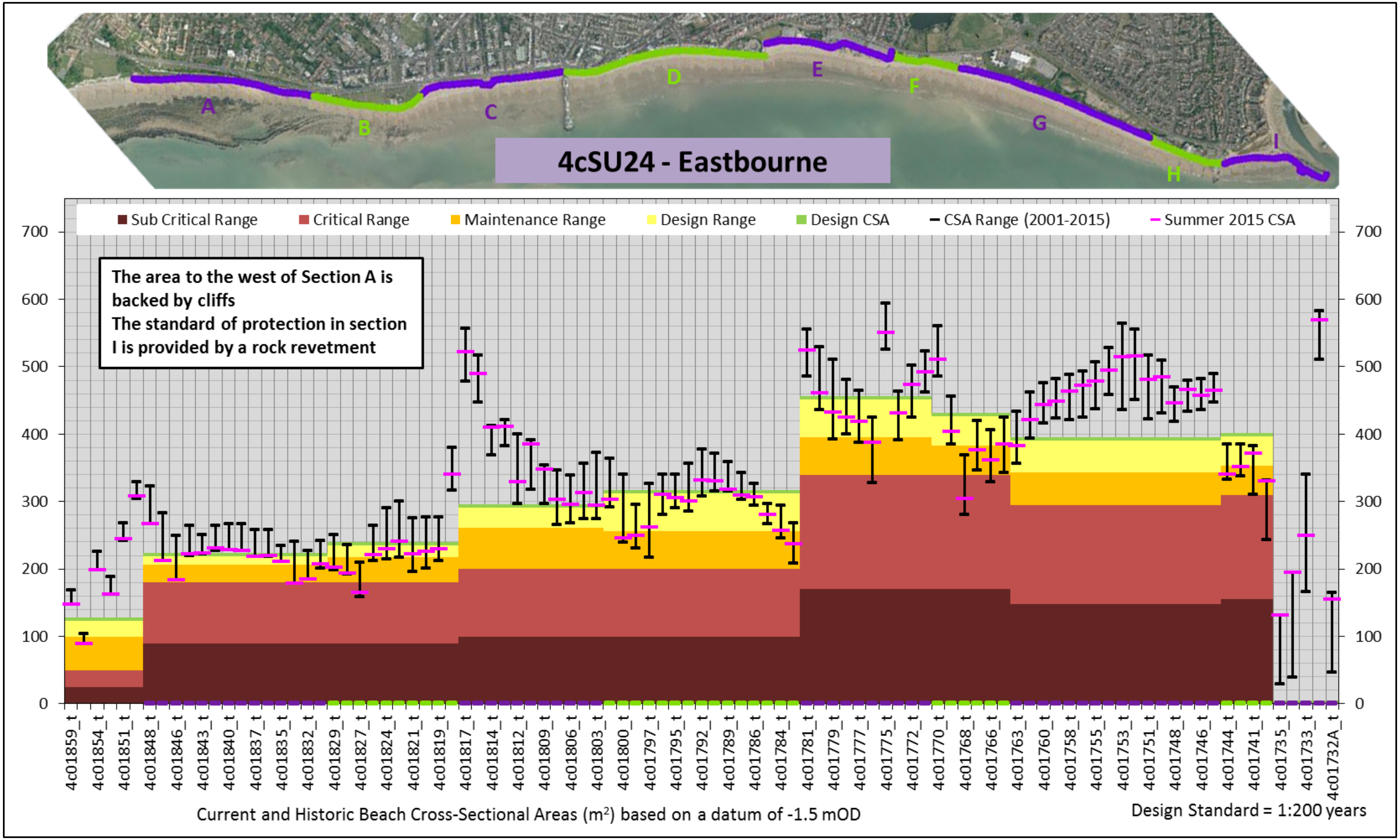

FIGURE 7-3 OBSERVED CSA CHANGES IN EASTBOURNE (4CSU24) WITHIN THE CONTEXT OF BEACH TRIGGER LEVELS

7-3-2 PEVENSEY BAY

Pevensey is currently managed by Pevensey Coastal Defence Limited (PCDL) on a 25 year management contract on behalf of the Environment Agency. The design levels from the PCDL/Environment Agency contract are shown in Figure 7-4. The PCDL designs are based on a combination of factors including maintaining a design berm width and having a large enough design to maintain updrift beaches, which require more detailed calculations than are conducted as part of this BMP.

The design values based upon overtopping calculations, calculated for this BMP, are shown in Figure 7-5. The individual overtopping charts for each defence section are provided in Appendix G.

TABLE 7-2 PEVENSEY BAY 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) L $M^{-1}S^{-1}$	NO. OF PROPERTIES IN FLOOD PLAIN	HINTERLAND	NOTES
A	ENVIRONMENT AGENCY (PCDL)	ROCK REVETMENT	SHINGLE BUND	OVERTOPPING	-	-	7,743	RESIDENTIAL, SOME AGRICULTURAL TOWARDS EAST	
B (6.5M CREST)		BIG BEACH	-	OVERTOPPING	250	10			SECTIONS B-E ARE REPRESENTATIVE OF DIFFERENT CREST HEIGHTS, SEE FIGURE 7-5 FOR LOCATIONS
C (6M CREST)		BIG BEACH	-	OVERTOPPING	290	10			
D (5.5M CREST)		BIG BEACH	-	OVERTOPPING	350	10			
E (5M CREST)		BIG BEACH	-	OVERTOPPING	500	10			

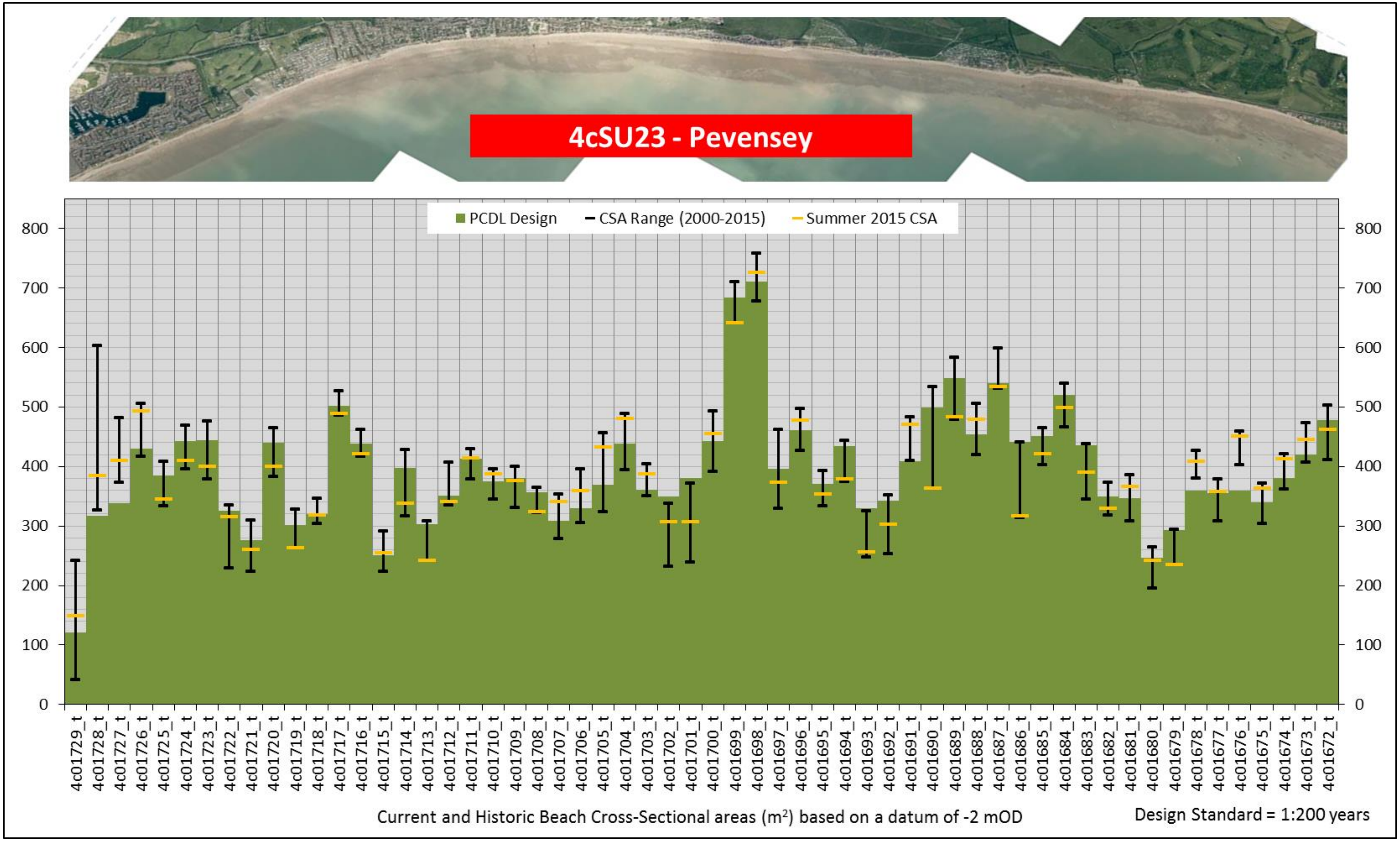

FIGURE 7-4 PEVENSEY BAY PCDL DESIGN LEVELS (BEACH CROSS SECTIONAL AREA (M2) VS PROFILE LOCATION)

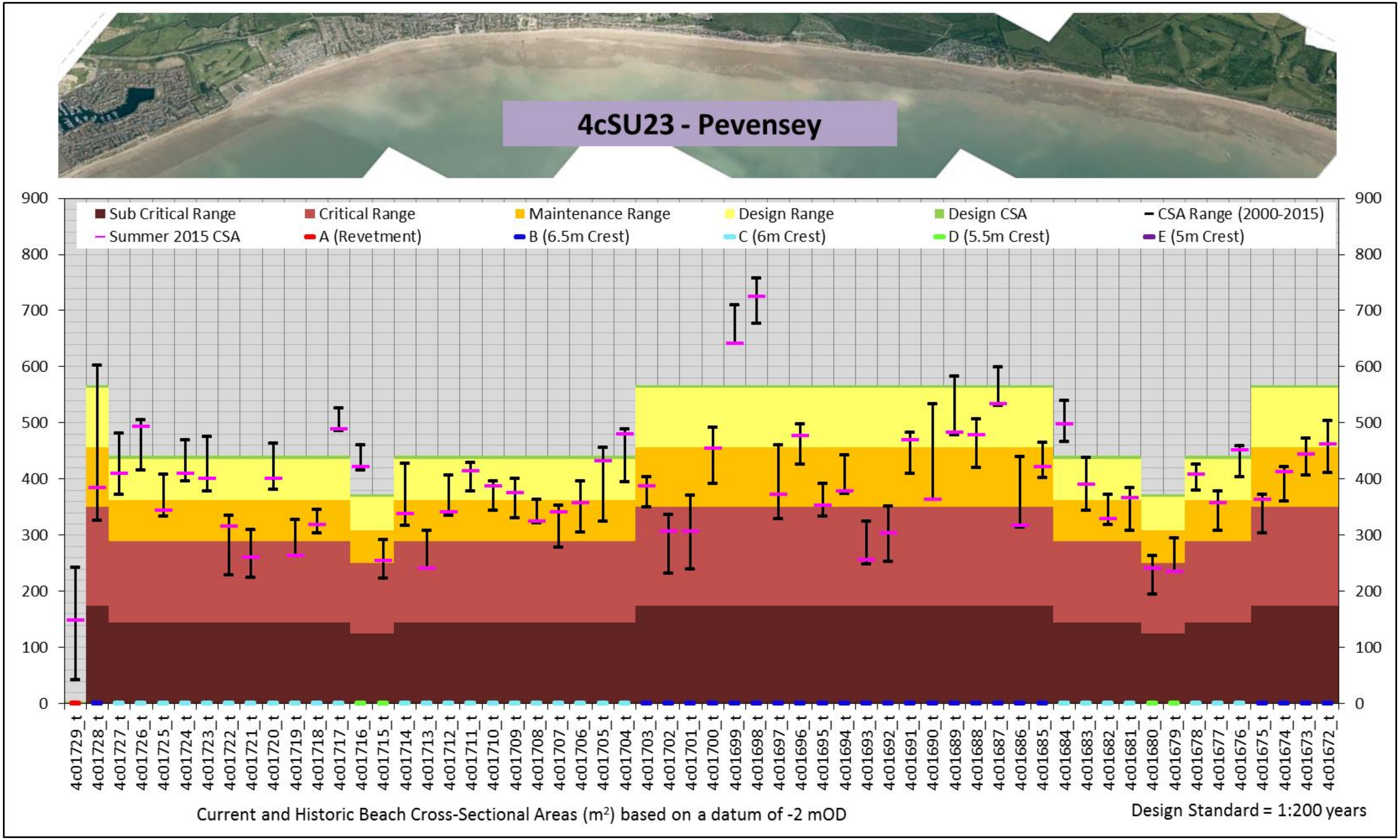

FIGURE 7-5 OBSERVED CSA CHANGES IN PEVENSEY BAY (4CSU23) WITHIN THE CONTEXT OF BEACH TRIGGER LEVELS

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7-3-3 BEXHILL

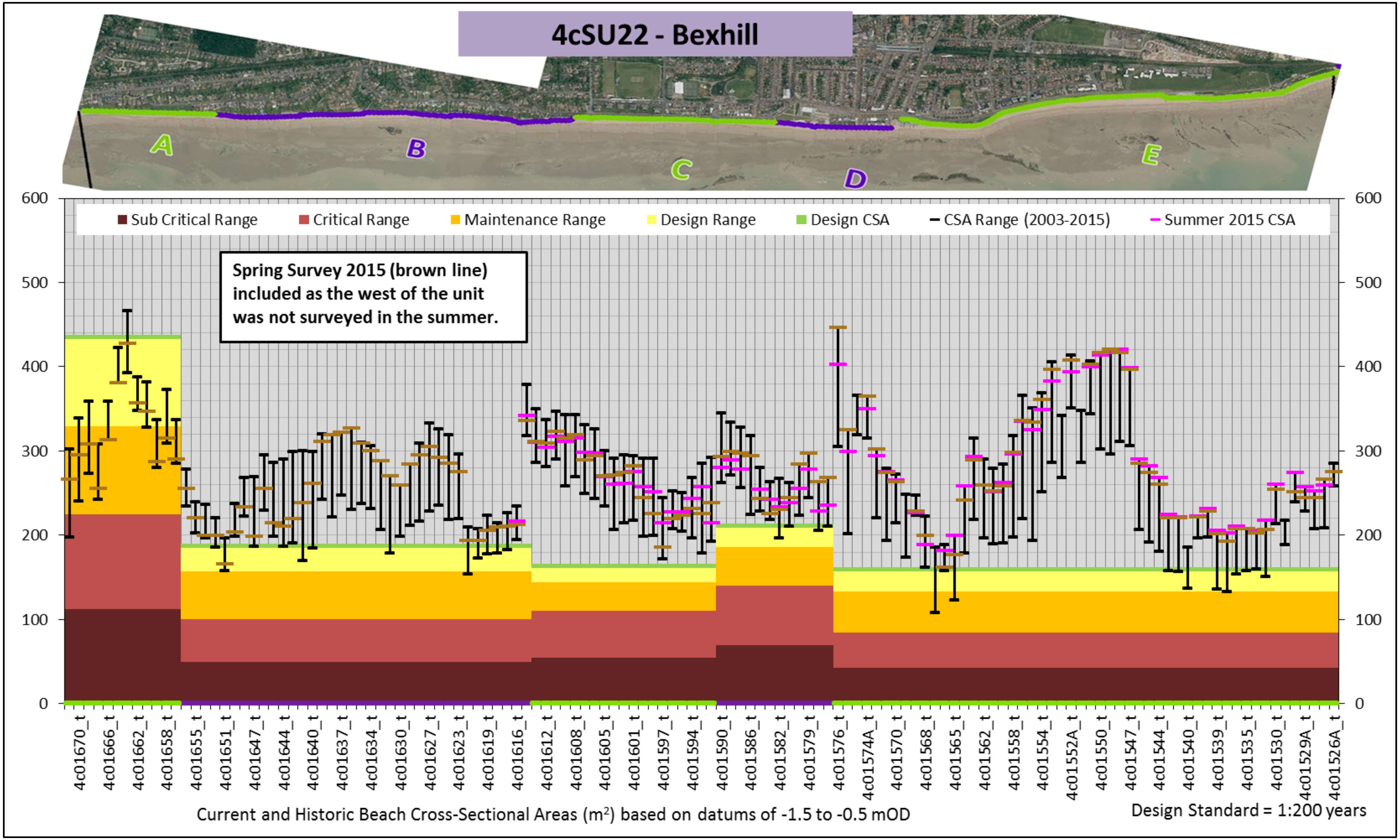
Bexhill is an accretive unit and a direct beneficiary of sediment from Pevensey. The each CSA ranges between 200 and 400 m^2 with the lowest CSA at pinch-points in Sections A and D. Section A is indicating an area of beach with the profile on the design/maintenance threshold. Please refer to the sediment budget for Bexhill for more information.

The majority of the CSAs of the profiles are at the upper limit of their historical ranges throughout the defence sections in Bexhill. This is due to the constant supply of sediment in from the adjacent Pevensey unit. Based on the current beach's condition, the entire unit is above design level. The potential impact throughout this unit is considered low due to the current beach levels exceeding design level requirements.

The individual overtopping charts for each defence section are provided in Appendix G.

TABLE 7-3 BEXHILL 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) L $M^{-1}S^{-1}$	NO. OF PROPERTIES IN FLOOD PLAIN	HINTERLAND	NOTES
A	ROTHER DC	BIG BEACH		OVERTOPPING	225	10	0	RESIDENTIAL	-
B		SEA WALL	WAVE RETURN WALL	OVERTOPPING	100	10			
C		SEA WALL	-	OVERTOPPING	110	10			-
D		SEA WALL	-	OVERTOPPING	140	10			-
E		SEA WALL	-	OVERTOPPING	85	10			-



4cSU22 - Bexhill
A
B
C
D
E
Sub Critical Range
Critical Range
Maintenance Range
Design Range
Design CSA
CSA Range (2003-2015)
Summer 2015 CSA
Spring Survey 2015 (brown line) included as the west of the unit was not surveyed in the summer.
600
500
400
300
200
100
0
4c01670_t
4c01666_t
4c01662_t
4c01658_t
4c01655_t
4c01651_t
4c01647_t
4c01644_t
4c01640_t
4c01637_t
4c01634_t
4c01630_t
4c01627_t
4c01623_t
4c01619_t
4c01616_t
4c01612_t
4c01608_t
4c01605_t
4c01601_t
4c01597_t
4c01594_t
4c01590_t
4c01586_t
4c01582_t
4c01579_t
4c01576_t
4c01574A_t
4c01570_t
4c01568_t
4c01565_t
4c01562_t
4c01558_t
4c01554_t
4c01552A_t
4c01550_t
4c01547_t
4c01544_t
4c01540_t
4c01539_t
4c01535_t
4c01530_t
4c01529A_t
4c01526A_t
Current and Historic Beach Cross-Sectional Areas (m²) based on datums of -1.5 to -0.5 mOD
Design Standard = 1:200 years

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7-3-4 BULVERHYTHE

Bulverhythe is largely accretive due to the influx of sediment from Pevensey and Bexhill. There are soft cliffs to the west and a flood plain in the central region. The whole frontage is backed by a main railway line which runs the south coast of Sussex. Since the construction of the rock revetment the CSA of the beach has been reduced to around 50m^2 as the beach material has been replaced with larger rocks with the purpose of dissipating wave energy. Please refer to the sediment budget for Bulverhythe for more information.

Section A is backed by cliffs, extending approximately half of the 2.5km unit. These beach levels fluctuate across all three design conditions; design, maintenance and critical. Section B, the rock revetment, in the centre of the unit protects railway from erosion and flooding. As the revetment is sufficient to prevent flooding and overtopping, the beach is required to prevent the revetment from undermining. Section C is primarily stable but there are a few areas where the beach levels are currently below critical. The individual overtopping charts for each defence section are provided in Appendix G.

Table 7-4 Bulverhythe 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) l $m^{-1}s^{-1}$	No. of properties in flood plain	Hinterland	Notes
A		Big beach	-	Overtopping	275	50		Cliffs/railway line	-
B	Environment Agency	Rock revetment	-	Undermining	-	50	722	Railway line	-
C		Big beach	-	Overtopping	235	50		Cliffs/railway line	-

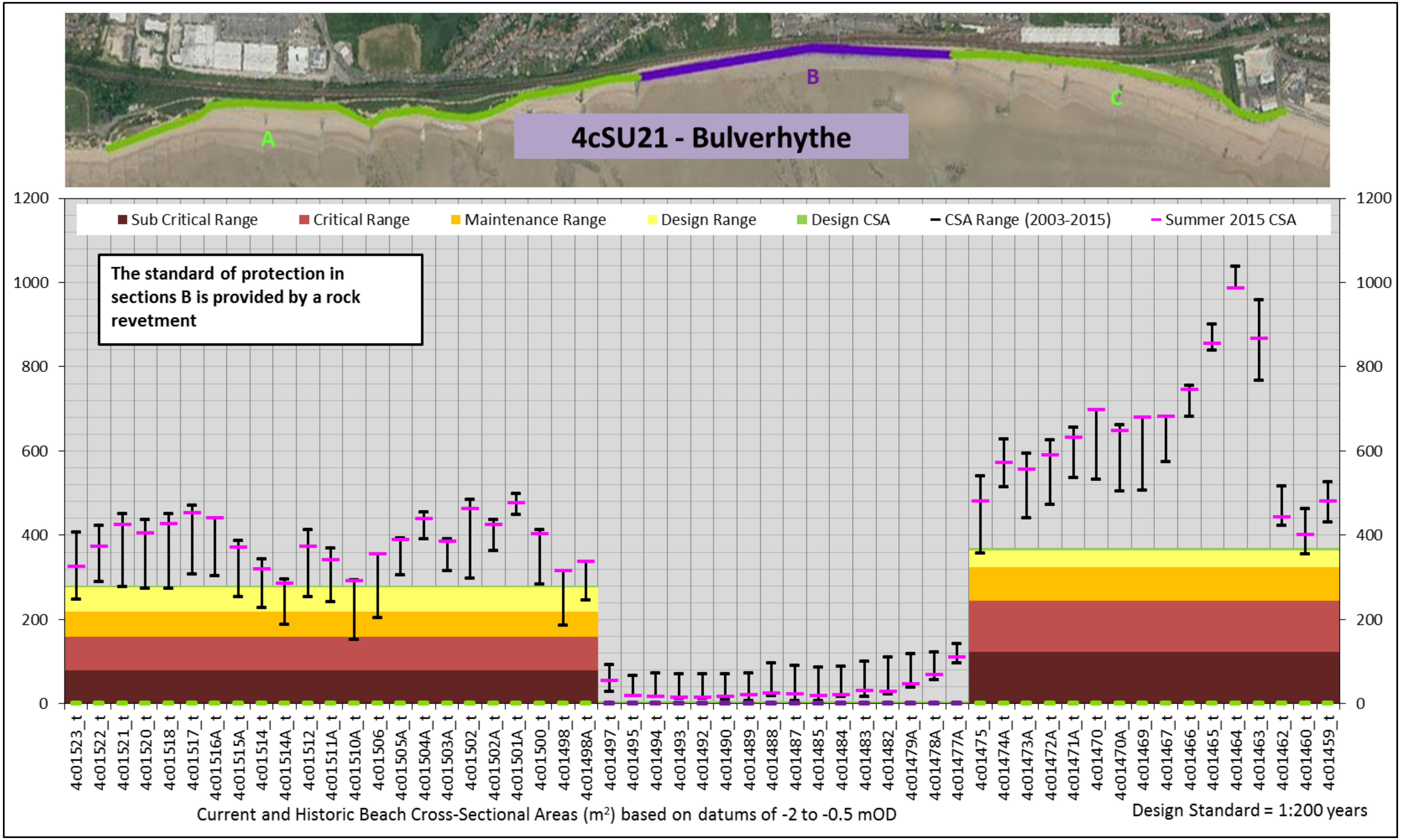

FIGURE 7-7 OBSERVED CSA CHANGES IN BULVERHYTHE (4CSU21) WITHIN THE CONTEXT OF BEACH TRIGGER LEVELS

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7-3-5 HASTINGS

Hastings is a largely stable unit, with a typical historic CSA range of 100m^2. The majority of the beaches have CSA of around 400m^2 however larger beaches ranging up to 1000m^3 are present in the east. Please refer to the sediment budget for Hastings for more information.

The beaches at Hastings are heavily controlled with long timber groynes in the west and central sections and wider spaced rock groynes and terminal structures to the east; hence the CSA chart shows little change over the years. The beaches are above the design condition for units A –E. CSAs of Section F and the start of Section G are below design condition due to low beach levels and risk of overtopping. . The change in orientation of the beach at this point causes a pinch-point where sediment cannot be stored and exposes this section of the sea wall to more energetic and damaging waves. This section is at high risk of failure. Sections H to J exceed the design requirements.

The CSA of the beaches greatly increases to the east. This is due to the two terminal structures – the Hasting's Harbour Arm and the terminal concrete groyne, either side of Fisherman's beach, which encourage the deposition of material which would otherwise be transported towards Fairlight. The individual overtopping charts for each defence section are provided in Appendix G.

TABLE 7-5 HASTINGS 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) $L\ M^{-1}S^{-1}$	NO. OF PROPERTIES IN FLOOD PLAIN	HINTERLAND	NOTES
A	HASTINGS BC	SEA WALL WITH RECURVE	-	UNDERMINING	75	25	0	RESIDENTIAL	-
B		SEA WALL WITH RECURVE	-	OVERTOPPING	70	25		RESIDENTIAL	-
C		SEA WALL WITH RECURVE	-	UNDERMINING	75	10		RESIDENTIAL	-
D (UNDER-GROUND CAR PARK)		SEA WALL WITH RECURVE	SEA WALL	OVERTOPPING	110	10		RESIDENTIAL	-
E (PIER)		SEA WALL WITH RECURVE	-	UNDERMINING	75	10		RESIDENTIAL	-
F		SEA WALL	-	OVERTOPPING	85	10		RESIDENTIAL	-
G		SEA WALL WITH RECURVE	-	OVERTOPPING	135	10		RESIDENTIAL	-
H		BIG BEACH	-	OVERTOPPING	230	10		COMMERCIAL	-
I (FISHERMAN'S BEACH)		BIG BEACH	-	OVERTOPPING	225	25		INDUSTRIAL	-
J		SEA WALL	-	OVERTOPPING	135	25		CLIFF	-

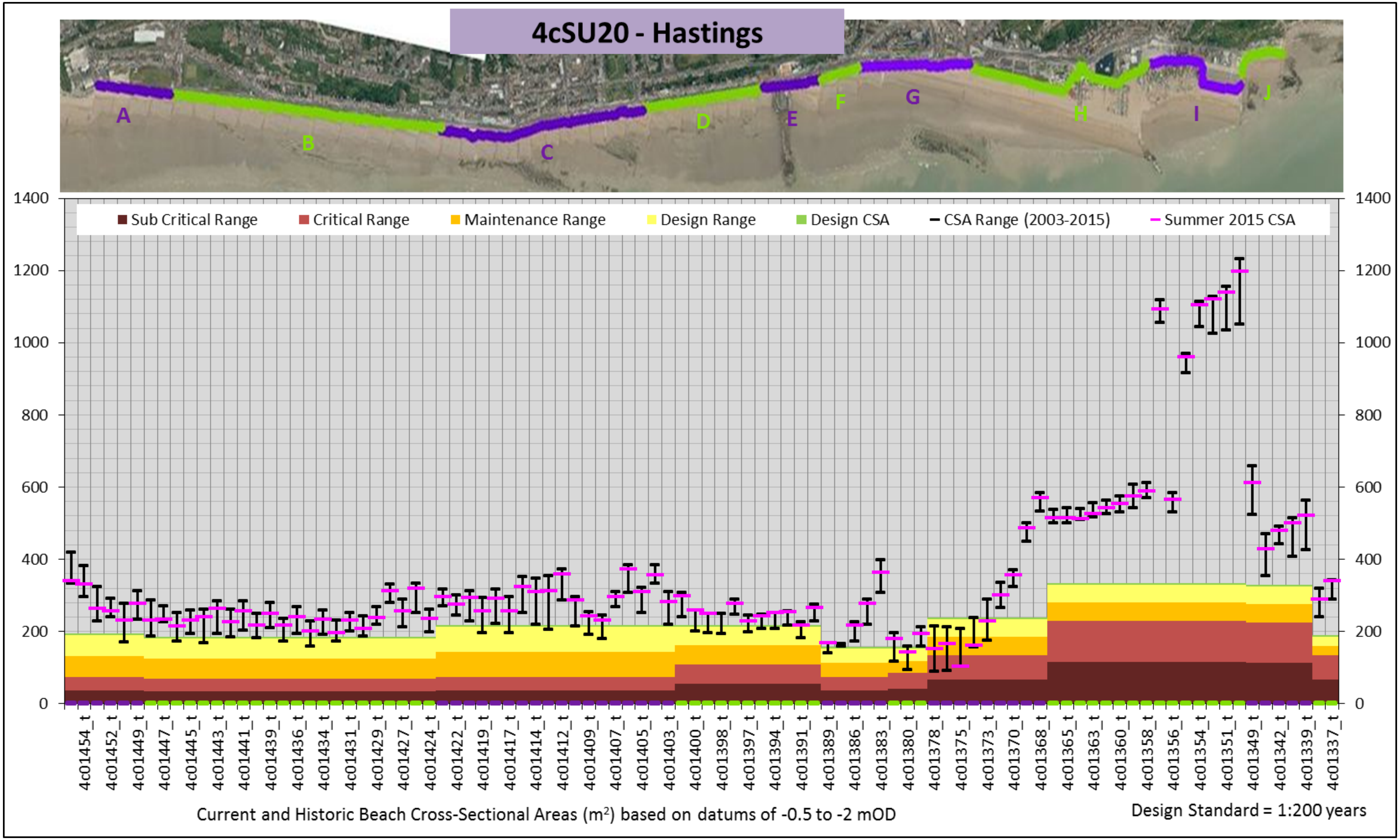

FIGURE 7-8 OBSERVED CSA CHANGES IN HASTINGS (4CSU20) WITHIN THE CONTEXT OF BEACH TRIGGER LEVELS

7-3-6 FAIRLIGHT

Fairlight is a largely undefended unit backed by cliffs which range from 50 -130m in height. Two rock bunds cover a length of 280m combined with an unprotected section in the middle. (At the time of writing this report, a third revetment is at the design stages to fill this gap). The soft sandstone and clay cliffs are eroding, providing a feed of fine sediment into the coastal cell.

The beaches below the cliffs are very small and do not provide protection to the hinterland so it was not possible to apply the same methodology to this unit. The key concern for Fairlight is the erosion of cliffs on which the village of Fairlight is located.

7-3-7 WINCHELSEA

Winchelsea is a highly dynamic unit, with high levels of sediment transport through the unit, gaining approximately 16,000m^3 of material per year. The littoral drift direction is west to east and the western end of Winchelsea loses sediment. Please refer to the sediment budget for Winchelsea for more information.

Regular beach recycling to Section A compensates for the material lost via longshore drift to Sections further east. Pett Levels, lies behind Section A which includes less than 100 properties. Further east of this section the beaches increase in volume and are above the design levels and backed by agricultural and therefore the risk of failure is low but the potential impact of flooding is high. The individual overtopping charts for each defence section are provided in Appendix G.

TABLE 7-6 WINCHELSEA INTERPRETATION TABLE: RISK MECHANISM AND CONSEQUENCES

<table>
<tr><th>DEFENCE SECTION</th><th>OPERATOR</th><th>PRIMARY DEFENCE</th><th>SECONDARY DEFENCE</th><th>KEY RISK MITIGATED BY BEACH</th><th>CRITICAL CROSS SECTIONAL AREA (M^2)</th><th>ALLOWABLE OT RATE (IF APPLICABLE) $L\ M^{-1}S^{-1}$</th><th>NO. OF PROPERTIES IN FLOOD PLAIN</th><th>HINTERLAND</th><th>NOTES</th></tr>
<tr><td>A</td><td rowspan="6">ENVIRONMENT AGENCY</td><td>SEAWALL</td><td>SEAWALL WITH RECURVE</td><td rowspan="6">OVERTOPPING</td><td>120</td><td>1</td><td rowspan="6">4,790</td><td>RESIDENTIAL</td><td>REGULARLY RECYCLED TO RETAIN BEACH LEVELS</td></tr>
<tr><td>B</td><td>SEAWALL</td><td>-</td><td>115</td><td>1</td><td>LOW LYING ARABLE LAND</td><td>-</td></tr>
<tr><td>C</td><td>EARTH EMBANKMENT</td><td>-</td><td>85</td><td>10</td><td>LOW LYING ARABLE LAND</td><td>-</td></tr>
<tr><td>D</td><td>EARTH EMBANKMENT</td><td>-</td><td>155</td><td>10</td><td>RESIDENTIAL & LOW LYING ARABLE LAND</td><td>-</td></tr>
<tr><td>E</td><td>EARTH EMBANKMENT</td><td>-</td><td>175</td><td>10</td><td>LOW LYING ARABLE LAND</td><td>-</td></tr>
<tr><td>F</td><td>BIG BEACH</td><td></td><td>150</td><td>10</td><td>LOW LYING ARABLE LAND</td><td></td></tr>
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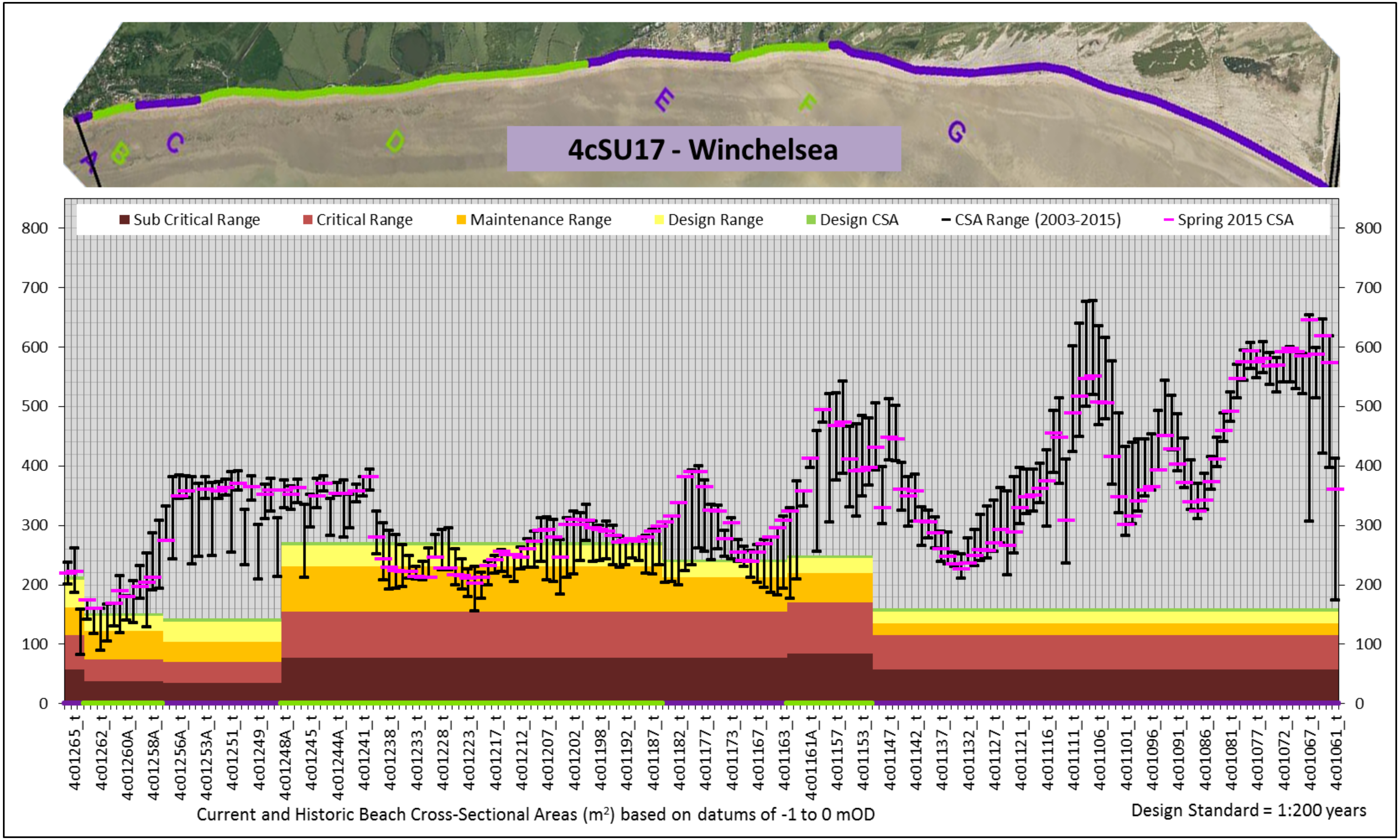

FIGURE 7-9 OBSERVED CSA CHANGES IN WINCHELSEA (4CSU17) WITHIN THE CONTEXT OF BEACH TRIGGER LEVELS

8 BEACH MANAGEMENT PLAN

8-1 4cSU24 – EASTBOURNE

8-1-1 MANAGEMENT SUMMARY

Table 8-1 A summary of defences, standard of protection, longshore drift and recommended management along the Eastbourne frontage (survey unit 4cSU24)

Defence Section	Operator	SMP Policy (short term)	Current SoP (allowable OT*) or (undermining threshold**) and defence type	Sediment budget annual change in m^3)+	Recommended Management	Plant access and environmental restrictions
A **Holywell to the Western Lawns**	Eastbourne Borough Council	Hold the Line	>1:200 (180) Sea wall	-3,943 (-14,323 to 679)	Monitor beach CSA and cliffs	SSSI, rMCZ, BOA, LGS designations. Gated vehicle access.
B **The Western Lawns to the Wish Tower Slopes**		Hold the Line	>1: 200 (180) Sea wall and rear wall	-2,384 (-10,552 to 3,062)	Monitor beach CSA	SSSI, rMCZ, BOA, LGS designations. Gated vehicle access.
C **Wish Tower Slopes to the Pier**		Hold the Line	>1: 200 (1) Sea wall and rear wall	-4,443 (-19,114 to 7,983)	Annual recharge based on monitoring data	rMCZ designation. Gated vehicle & plant access.
D **Pier to the Redoubt**		Hold the Line	>1: 200 (1) Sea wall and rear wall	-3,493 (-16,555 to 13,308)	Monitor beach CSA	rMCZ designation. Ungated vehicle & plant access.
E **Redoubt to tennis courts**		Hold the Line	>1: 200 (1) Promenade	-1,805 (-10,929 to 8,414)	Monitor beach CSA	rMCZ designation. Gated vehicle & plant access.
F **Tennis courts to amusements**		Hold the Line	1: 50 (1) Promenade	-1,948 (-9,373 to 2,715)	Monitor beach CSA	rMCZ designation. Gated vehicle & plant access.
G **Beach fronting Sovereign Centre**		Hold the Line	1: 200 (1) Promenade	-1,274 (-16,886 to 16,136)	Monitor beach CSA	rMCZ, BOA designations. Gated vehicle access.
H **Beach fronting waterworks**		Hold the Line	1: 20 (1) Promenade	2,161 (-5,646 to 12,102)	Monitor beach CSA	rMCZ, BOA designations. Gated vehicle & plant access.
I **Langney point**		Hold the Line	1: 20 (10) Rock revetment	-	Material cleared annually	rMCZ designation. No access.

* Allowable overtopping is measured in l/m/s and determines the SoP
** The minimum CSA (m2) before undermining occurs (bold)
+Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

8-1-2 MANAGEMENT HOTSPOTS

HOLYWELL

With virtually no input of sediment from Beachy Head and very little lost past Sovereign Harbour, Eastbourne is essentially a self-contained unit. There is a known scour problem at the sea wall in defence sections A and B. Due to SSSI restrictions, material cannot be directly replenished to this point. Material can however be replenished to the Wish Tower and allowed to wash through during a few tidal cycles before being recycled by truck into sections A and B.

PIER

Sections C and D at the centre of Eastbourne are backed by a densely populated flood basin. Beach levels are within the maintenance and design range. Material is currently recycled or recharged here on an annual basis in order to provide protection against overtopping and flooding.

FIGURE 8-1 RECYCLING WORKS AT EASTBOURNE PIER, 2012

LANGNEY POINT

A large volume of material accumulates here each year. To prevent shingle blocking the entrance to Sovereign Harbour, it is extracted on an ad hoc basis and bypassed to a stock pile at Pevensey Bay.

8-1-3 RECOMMENDED FUTURE WORKS

Future works at Eastbourne should include variations of the current combination of recycling and/or recharge activities. The benefit and frequency of recycling over recharge or recharge over recycling needs to be assessed in conjunction with works by PCDL and the wider BMP frontage, especially considering how beach material accumulation from towards the downdrift end can be recovered. Beach levels in Sections C and D need to be maintained, with periodic (2-3 yearly) recycling back to Sections A and B (these sections are within a SSSI and so cannot be directly recharged, see Appendix B). The beach levels in Section G should be closely monitored to ensure the Wastewater Treatment Works have an adequate standard if protection, however this area is unlikely to require regular beach management works due to the accretive nature of the frontage here. Another option that should be considered is to use the extracted material from Langney Point to recycle along the Eastbourne frontage, rather than bypassing around to Pevensey. Please refer to the Eastbourne Beach Management Works 2015-2021 business case for more detailed information on current and future management at Eastbourne (Eastbourne Borough Council, 2015).

8-1-4 EMERGENCY WORKS

The beach fronting the Redoubt to the tennis courts (Section E) is accretive and provides a source of shingle for any emergency recycling works required following a storm. The weak areas include the beach from Holywell to the Wish Tower (Sections A and B) are either side of the pier (Sections C and D).

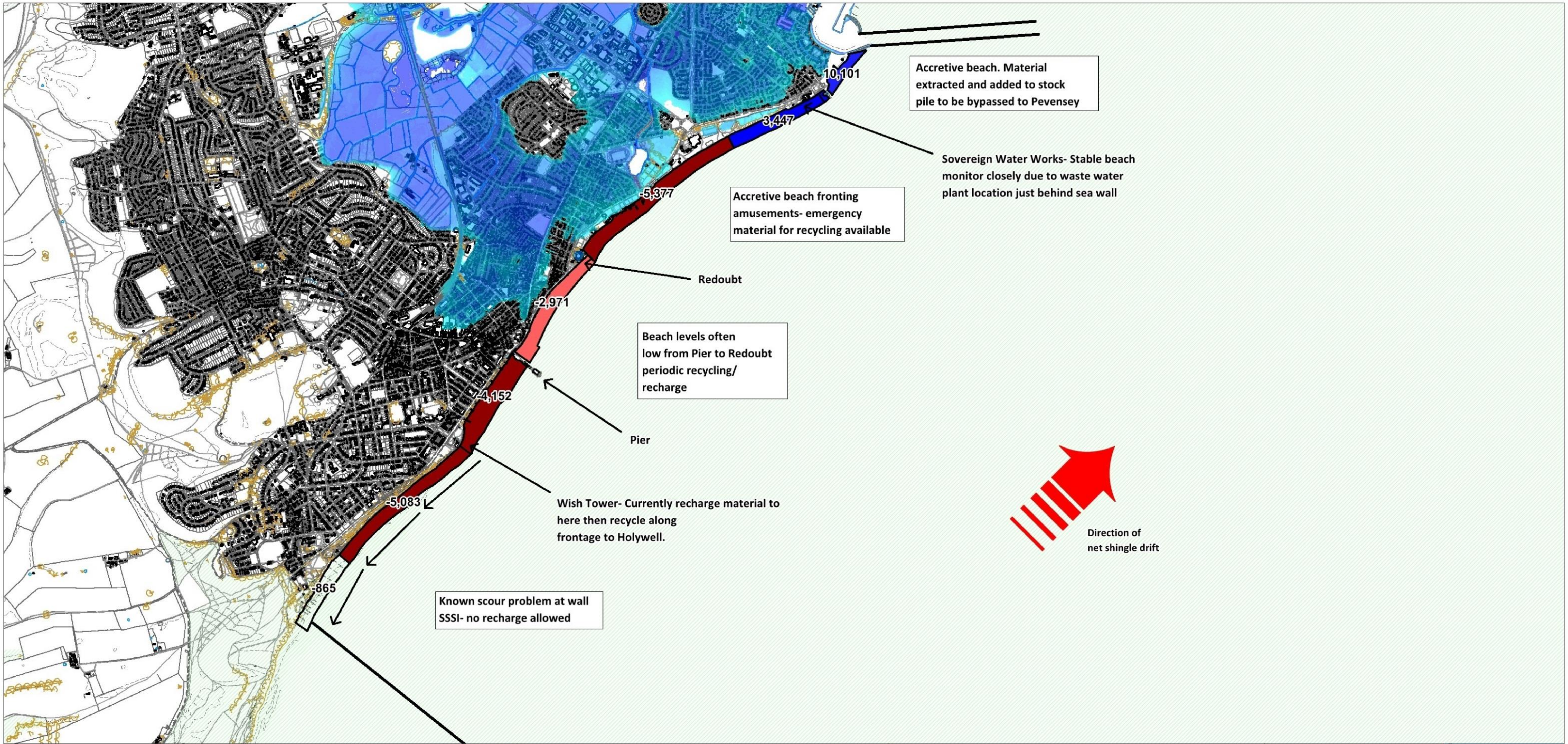

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FIGURE 8-2 SUMMARY OF SEDIMENT TRANSPORT RATES, ENVIRONMENTAL RESTRICTIONS, AREAS OF CONCERN AND RECOMMENDED MANAGEMENT ALONG THE EASTBOURNE FRONTAGE

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

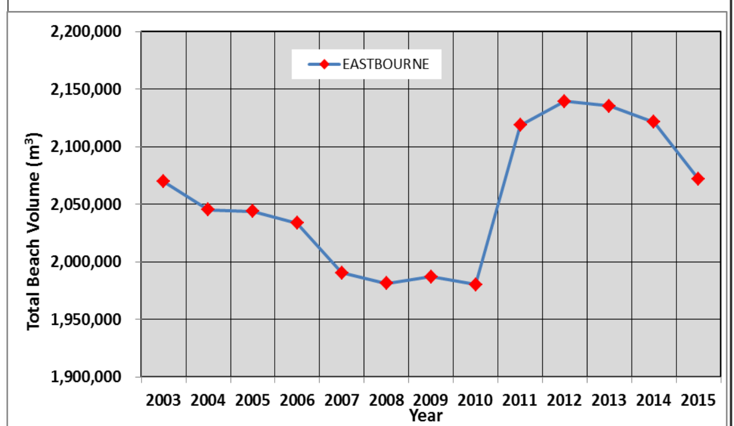
- National or International Designation
- Vegetated Shingle - Restrictions on use of Plant

Floodplain Map

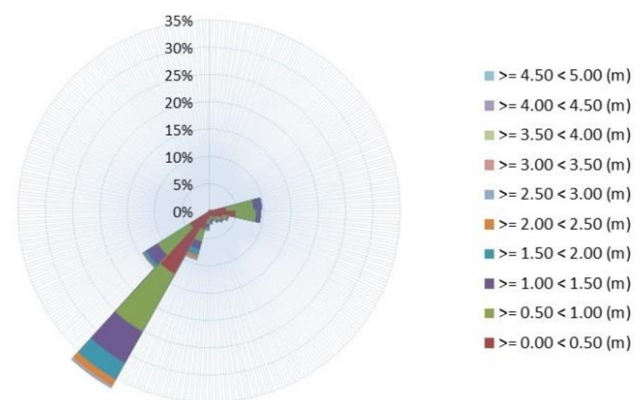
- 1:200 year extreme still water level planar flood map

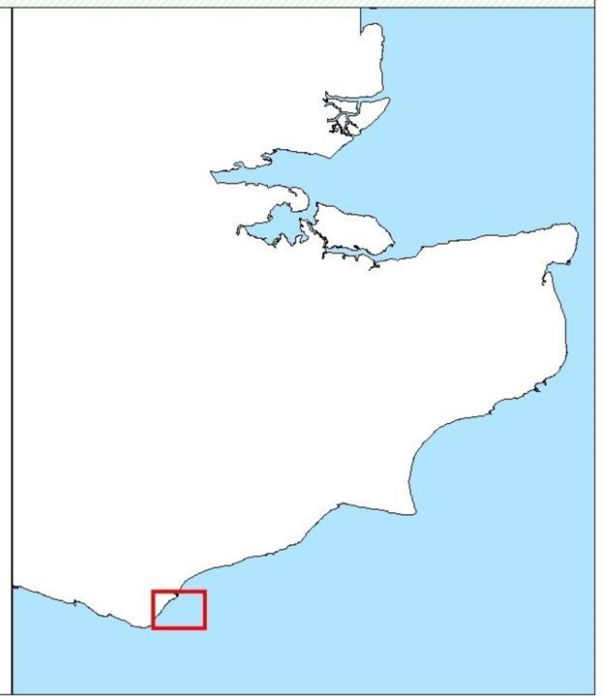
Map Scale 1: 30,000

Total Volume of Beach Material in Eastbourne (2003-2015)



Wave Rose for Pevensey Bay indicative of direction, frequency & magnitude of waves, April 2014 - April 2015





8-2 4cSU23 – PEVENSEY

8-2-1 MANAGEMENT SUMMARY

TABLE 8-2 A SUMMARY OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE PEVENSEY FRONTAGE (SURVEY UNIT 4CSU23)

Defence section	Operator	SMP (Short-Term) Policy	Current SoP (allowable OT*) or (undermining threshold**) and defence type	Sediment budget annual change in m^3)+	Recommended management	Plant access and environmental restrictions
A Pevensey bay	Environment agency	Hold the line	Refer to PDCL (10) Big Beach	-41,456 (-95,180 to -11,562)	As advised by PDCL	RAMSAR, SSSI, RMCZ, BOA, ESS designations. Various gated/ ungated access points

* Allowable overtopping is measured in l/m/s and determines the SoP
** The minimum CSA (m2) before undermining occurs (bold)
+Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

8-2-2 MANAGEMENT HOTSPOTS

Pevensey Coastal Defence Limited (PCDL) continually maintains the beach levels along the frontage between Sovereign Harbour and Norman's Bay. Approximately 28,000m^3 of shingle is imported onto this beach every year (including 8,000m^3 which is bypassed around Sovereign Harbour from Eastbourne), although these volumes may vary depending on the severity of any storm damage. Management hotspots are identified through the PCDL topographic surveys and remedial works are carried out on an ad-hoc basis as required. .

8-2-3 RECOMMENDED FUTURE WORKS

The contract for PCDL is set to continue until 2025.

8-2-4 EMERGENCY WORKS

Please refer to PCDL for details of emergency works.

8-3 4cSU22 – BEXHILL

8-3-1 MANAGEMENT SUMMARY

TABLE 8-3 A SUMMARY OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE BEXHILL FRONTAGE (SURVEY UNIT 4CSU22)

Defence section	Operator	SMP (Short-Term) Policy	Current SoP (allowable OT*) or (undermining threshold**) and defence type	Sediment budget annual change in m³)+	Recommended management	Plant access and environmental restrictions
A Cooden Beach	Rother District Council	Hold the Line	>1:200 (10) Big Beach	382 (-12,237 to 10,578)	Monitor beach CSA	rMCZ, BOA designations. Ungated vehicle & plant access.
B Cooden Beach	Rother District Council	Hold the Line	>1:200 (10) Sea wall and wave return wall	3,570 (-7,628 to 29,448)	Monitor beach CSA	rMCZ, BOA designations. Ungated vehicle & plant access.
C Beach fronting West Parade	Rother District Council	Hold the Line	>1:200 (10) Sea wall	2,141 (-18,268 to 24,604)	Monitor beach CSA	rMCZ designation. Ungated vehicle access.
D Beach fronting Amusements	Rother District Council	Hold the Line	>1:200 (10) Sea wall	347 (-9,317 to 8,421)	Monitor beach CSA	rMCZ designation. Ungated vehicle access.
E Beach fronting De La Warr Parade	Rother District Council	Hold the Line	>1:200 (10) Sea wall	7,424 (-14,828 to 32,790)	Monitor beach CSA	rMCZ, LGS designations. Ungated vehicle & plant access.

* The minimum CSA (m^2) before undermining occurs (bold)
** 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.

8-3-2 MANAGEMENT HOTSPOTS

Section A has no hard defence and beach CSAs currently sit within the maintenance range. Sections B to E are all above design; all sections have demonstrated similar trends since 2003 and are considered stable.

8-3-3 RECOMMENDED FUTURE WORKS

Consideration could be given to removing some of the top planks of the groynes to increase the sediment transport along the frontage into Bulverhythe.

8-3-4 EMERGENCY WORKS

The frontage at Bexhill is well protected and is unlikely to require any emergency recycling works. Material could be made available in defence Section D for emergency recycling either to the eastern end of this frontage. Alternatively, in an emergency material could be forward cycled into Bulverhythe.

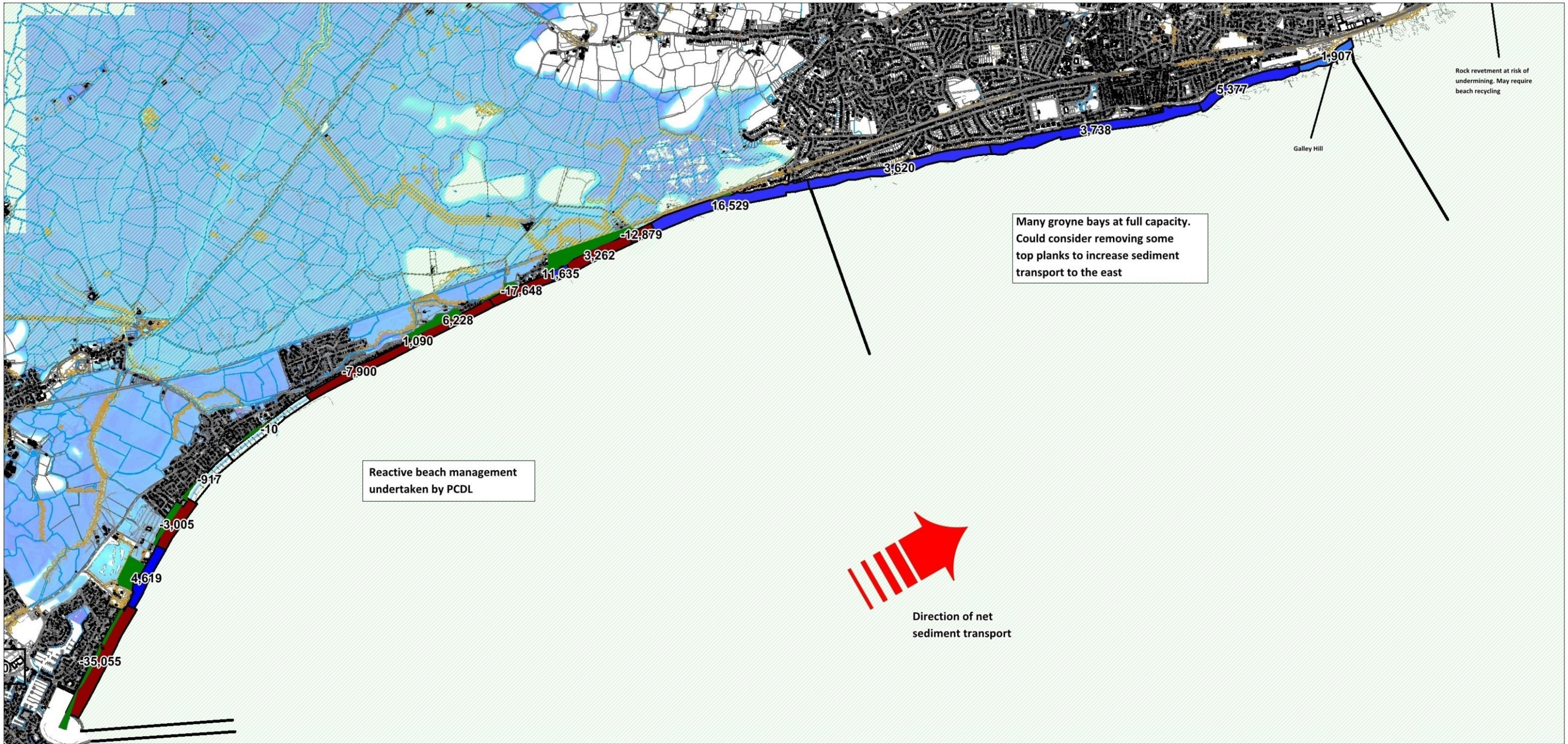


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Figure 8-3 Summary of sediment transport rates, environmental restrictions, areas of concern and recommended management along the Pevensey and Bexhill frontage

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

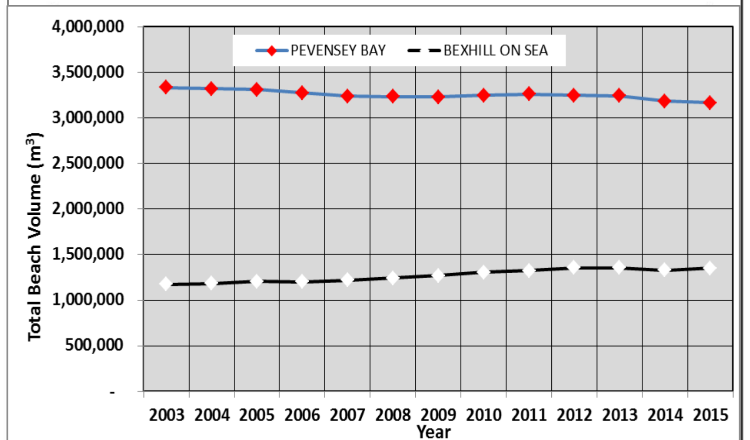
- National or International Designation
- Vegetated Shingle - Restrictions on use of Plant

Floodplain Map

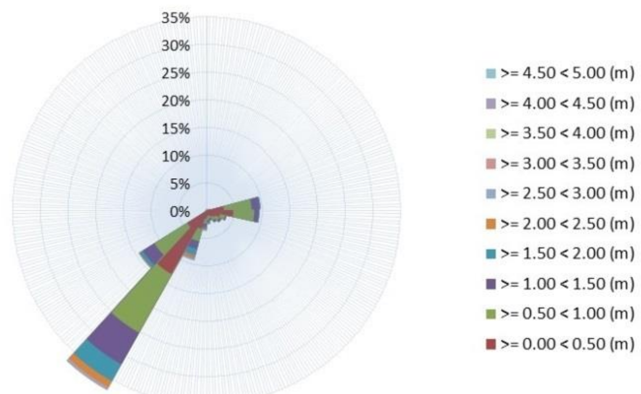
- 1:200 year extreme still water level planar flood map

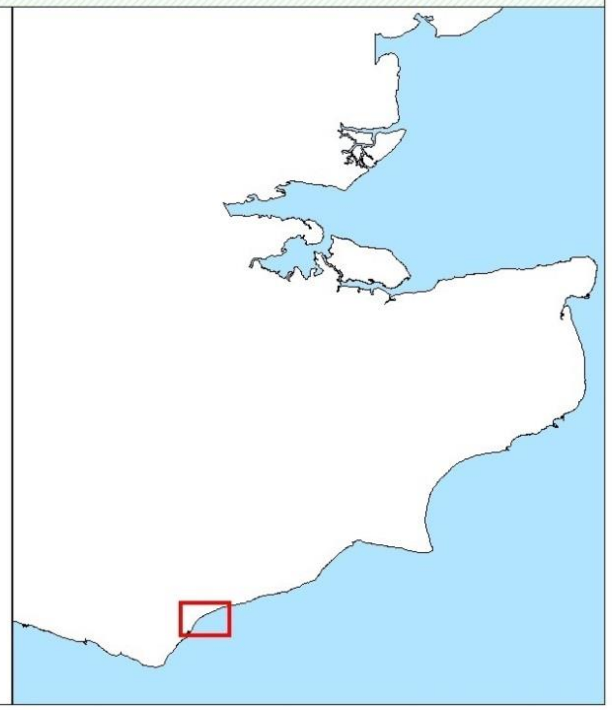
Map Scale 1: 35,000

Total Volume of Beach Material in Pevensey and Bexhill (2003-2015)



Wave Rose for Pevensey Bay indicative of direction, frequency & magnitude of waves, April 2014 - April 2015





8-4 4cSU21 – BULVERHYTHE

8-4-1 MANAGEMENT SUMMARY

TABLE 8-4 A SUMMARY OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE BULVERHYTHE FRONTAGE (SURVEY UNIT 4CSU21)

Defence section	Operator	SMP (Short-term) Policy	Current SoP (allowable OT*) or (undermining threshold**) and defence type	Sediment budget annual change in m^3)+	Recommended management	Plant access and environmental restrictions
A Glyne Gap beach	Environment Agency	Hold the line	>1:200 (50) Big beach	6,960 (-12,172 to 38,104)	Monitor beach CSA	rMCZ, LGS designations. No access.
B Rock revetment beach		Hold the line	>1:200 (50) Rock revetment	-3,816 (-24,512 to 9,027)	Monitor beach CSA and rock revetment	rMCZ designation. No access.
C East of revetment beach		Hold the line	>1:200 (50) Big beach	5,662 (-21,882 to 17,275)	Monitor beach CSA	rMCZ designation. Gated plant access.

* Allowable overtopping is measured in l/m/s and determines the SoP
** The minimum CSA (m^2) before undermining occurs (bold)
+Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

8-4-2 MANAGEMENT HOTSPOTS

GLYNE GAP BEACH

Beach levels along Glyne Gap have, at one time or another, sat in the critical, maintenance and design bands. The current beach levels fall within or above the design level band. The beach backs straight onto soft cliff where there is potential for erosion if the beach levels were to reduce into the critical bands.

ROCK REVETMENT BEACH

The rock revetment is a crucial defence along this stretch of coastline as the railway line is in close proximity to the beach and requires protection. The revetment may be at risk of undermining if the beach levels drop too low; hence forward recycling of material has been carried out in the past. However if there is too much material in front of the revetment it can be pushed up the beach face and into the voids between the rock, causing the revetment to act as a ramp for the water instead of dissipating the energy.

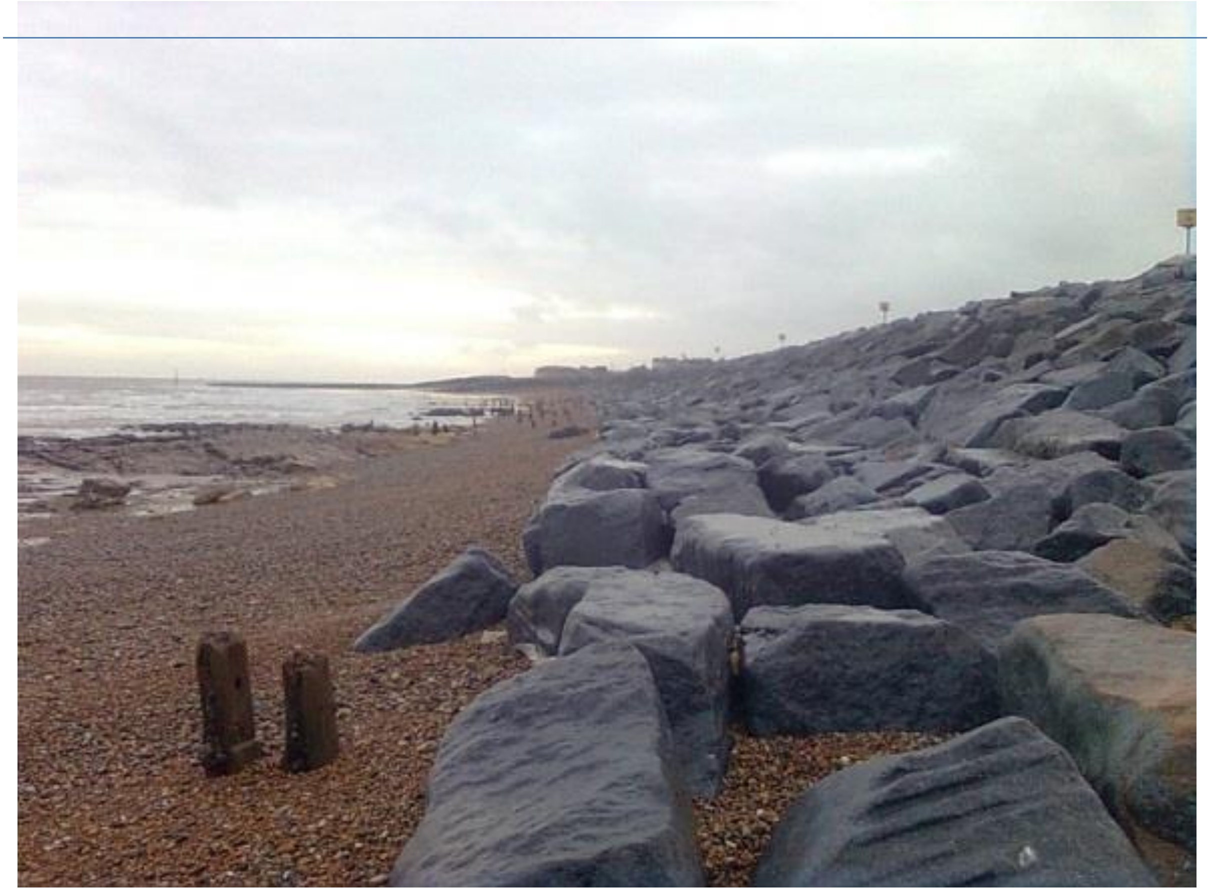


FIGURE 8-4 BEACH LEVELS IN FRONT OF THE ROCK REVETMENT AT BULVERHYTHE, 2012

8-4-3 RECOMMENDED MANAGEMENT

ROCK REVETMENT BEACH

Beach levels need to be closely monitored in front of the rock revetment. Shortening of groynes at the western end of the revetment could increase the amount of shingle naturally feeding the rock revetment beach and reduce the undermining risk, and potentially reduce or eliminate the need for recycling works.

8-4-4 EMERGENCY WORKS

Following a storm event material is available for forward recycling from the Glyne Gap or standard recycling from the Hastings end of the unit, in the east, as both of these sections are above design levels.

8-5 4cSU20 – HASTINGS

8-5-1 MANAGEMENT SUMMARY

TABLE 8-5 A SUMMARY OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE HASTINGS FRONTAGE (SURVEY UNIT 4CSU20)

Defence section	Operator	SMP (Short-Term) Policy	Current SoP (allowable OT*) or (undermining threshold**) and defence type	Sediment budget annual change in m^3)+	Recommended management	Plant access and environmental restrictions
A Beach fronting Seaside Road	Hastings Borough Council	Hold the Line	>1:200 (75) Sea wall with recurve	91 (-9,330 to 21,921)	Monitor beach CSA	rMCZ designation. Gated vehicle access.
B Beach fronting Sea Road		Hold the Line	>1:200 (25) Sea wall with recurve	154 (-21,964 to 34,494)	Monitor beach CSA	rMCZ designation. Designation Gated vehicle access.
C Marina Road		Hold the Line	>1:200 (75) Sea wall with recurve	748 (-16,430 to 27,696)	Monitor beach CSA	rMCZ designation. Designation Gated vehicle access.
D Warrior Square to the Pier		Hold the Line	>1:200 (10) Sea wall with recurve	135 (-10,943 to 11,629)	Monitor beach CSA	rMCZ designation. Gated vehicle access.
E The Pier		Hold the Line	>1:200 (75) Sea wall with recurve	-179 (-3,152 to 2,508)	Monitor beach CSA	Gated vehicle access.
F White Rock		Hold the Line	>1:200 (10) Sea wall	-324 (-3,152 to 2,508)	Monitor beach CSA	Gated vehicle access.
G Carlisle Parade		Hold the Line	>1:2 <1:5 (10) Sea wall with recurve	-649 (-14,278 to 8,175)	Monitor beach CSA	Gated vehicle access.
H Beach fronting Amusements		Hold the Line	>1:200 (10) Big beach	2,813 (-19,654 to 9,845)	Monitor beach CSA	Ungated vehicle & plant access.
I Rock-a-Nore Road		Hold the Line	>1:200 (25) Big beach	165 (-6,969 to 11,454)	Monitor beach CSA	Gated vehicle & plant access.
J Fishermans beach		Hold the Line	>1:200 (25) Sea wall	472 (-6,485 to 4,669)	Monitor beach CSA	BOA designation. Ungated vehicle access.

* Allowable overtopping is measured in l/m/s and determines the SoP
** The minimum CSA (m2) before undermining occurs (bold)
+Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

8-5-2 MANAGEMENT HOTSPOTS

CARLISLE PARADE

Where the coastline changes in orientation at Carlisle Parade, beach levels are low, increasing the risk of overtopping and sea wall failure. The shingle beach crest is often very narrow and the CSA of Profile 4c01375 is in the critical range. Continued erosion would expose the sea wall to wave impact damage.

FIGURE 8-5 LOW BEACH LEVELS AT CARLISLE PARADE, HASTINGS, 2012

FISHERMANS BEACH

A large volumne of material accumulates here annually due to the Harbour Arm, which acts as a terminal groyne. The CSA vastly exceeds the 1 in 200 year design standard. However, there are restrictions against using this material for recycling due to the working nature of the beach. Accumulation at the western side of the harbour arm has caused beach steepening.

8-5-3 RECOMMENDED MANAGEMENT

CARLISLE PARADE

There have been several recycling schemes at Carlisle Parade; however material has continued to erode from this section. Consideration should be given to the construction of a second controlling structure, such as a rock groyne, in order to retain the material in front of Carlisle Parade. A scheme to build another rock groyne is going ahead in 2017.

8-5-4 EMERGENCY WORKS

In the event of an emergency, it is recommended that material is extracted from the beach fronting the amusements as this acts as a sediment store and beach levels are well above design levels. Material should be placed along weaker sections of the frontage, in particular at Carlisle Parade.

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FIGURE 8-6 SUMMARY OF SEDIMENT TRANSPORT RATES, ENVIRONMENTAL RESTRICTIONS, AREAS OF CONCERN AND RECOMMENDED MANAGEMENT ALONG THE BULVERHYTHE TO HASTINGS FRONTAGE

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

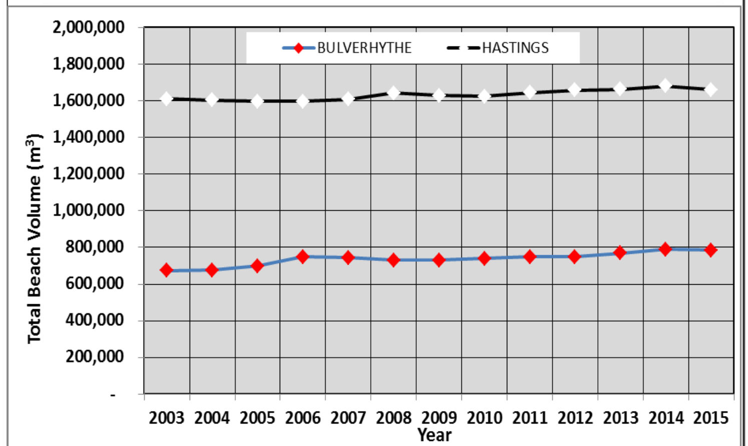
- National or International Designation
- Vegetated Shingle - Restrictions on use of Plant

Floodplain Map

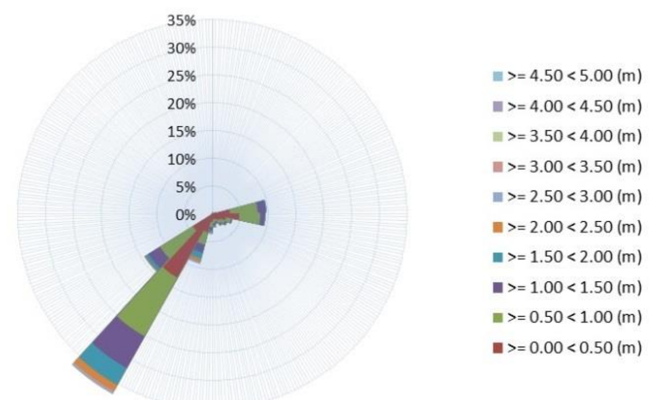
- 1:200 year extreme still water level planar flood map

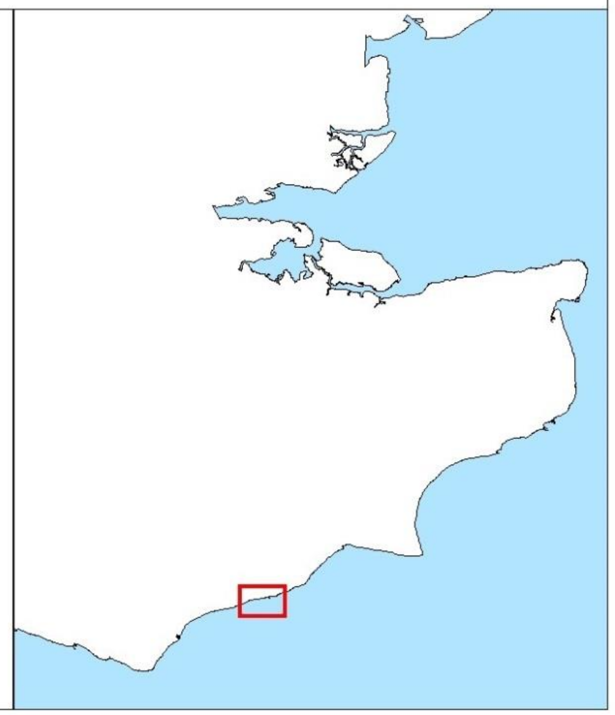
Map Scale 1: 20,000

Total Volume of Beach Material in Bulverhythe and Hastings Units (2003-2015)



Wave Rose for Pevensey Bay indicative of direction, frequency & magnitude of waves, April 2014 - April 2015





8-6 4cSU18 – FAIRLIGHT COVE

8-6-1 MANAGEMENT SUMMARY

TABLE 8-5 A SUMMARY OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE FAIRLIGHT COVE FRONTAGE (SURVEY UNIT 4CSU19)

Defence section	Operator	SMP (Short-Term) Policy	Current SoP (allowable OT*) or (undermining threshold**) And defence type	Sediment budget annual change in m³)+	Recommended management	Plant access and environmental restrictions
A Fairlight cove	Rother District Council	No Active Intervention/Hold the line	N/A Rock revetment	-2,051 (-39,355 to 47,832)	Monitor beach CSA	AONB, SSSI, BOA, ESS, LGS designations.

* Allowable overtopping is measured in l/m/s and determines the SoP
** The minimum CSA (m2) before undermining occurs (bold)
+Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

The majority of the frontage at Fairlight is designated No Active Intervention. SMP Policy Unit 4c21 is Hold The Line and 4c20 is Managed Realignment. Two unconnected rock bunds extend approximately 750m in total, with a 260m gap in between. The design life of these rock bunds, is until 2040 for the Sea Road bund, and 2057 for the Rockmead Road bund. A central rock bund is currently under construction, which will connect the existing defences.

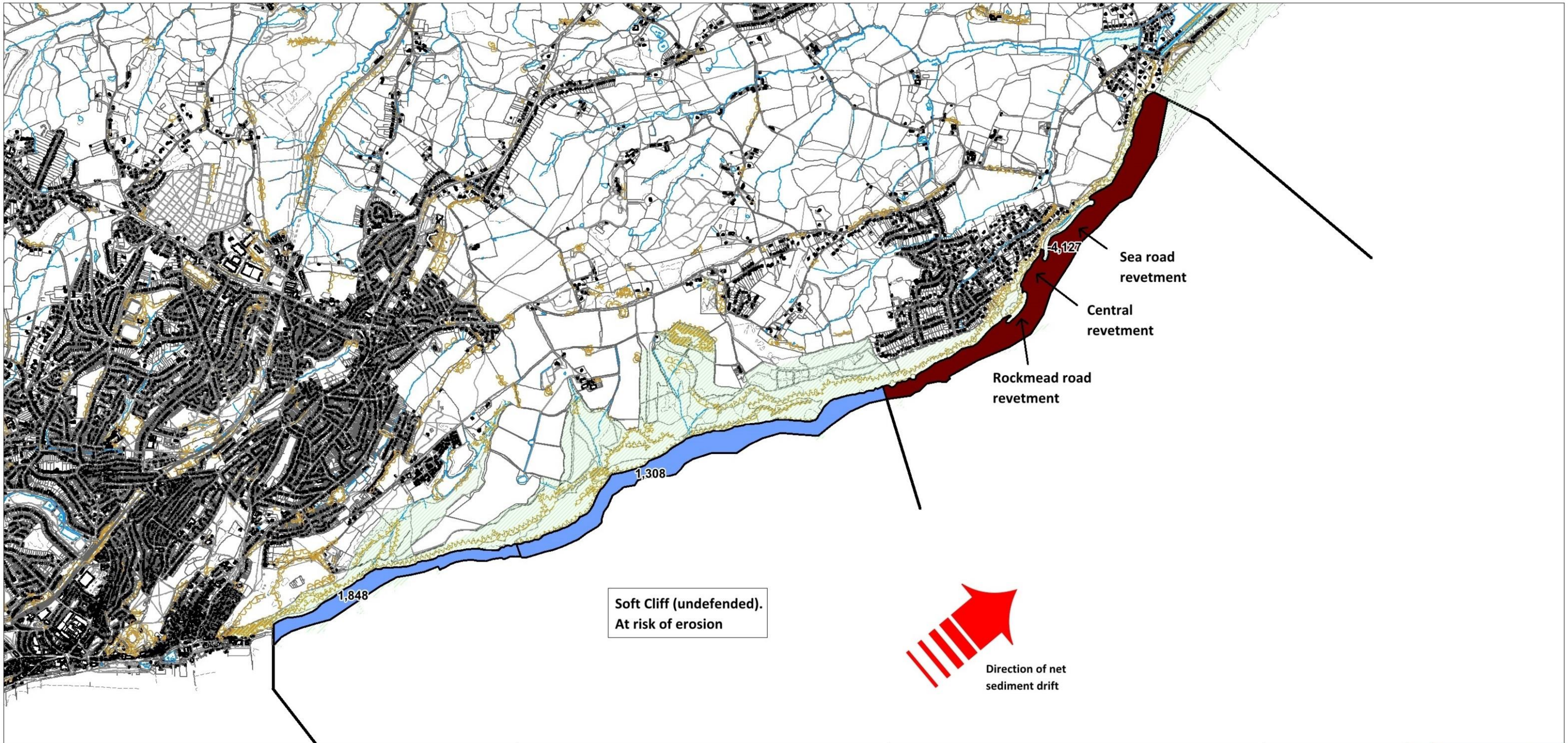


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FIGURE 8-7 SUMMARY OF SEDIMENT TRANSPORT RATES, ENVIRONMENTAL RESTRICTIONS, AREAS OF CONCERN AND RECOMMENDED MANAGEMENT ALONG THE FAIRLIGHT FRONTAGE

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

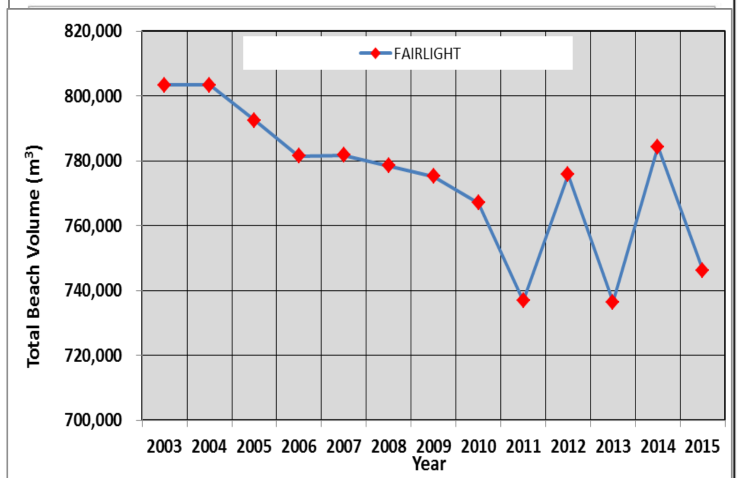
- National or International Designation
- Vegetated Shingle - Restrictions on use of Plant

Floodplain Map

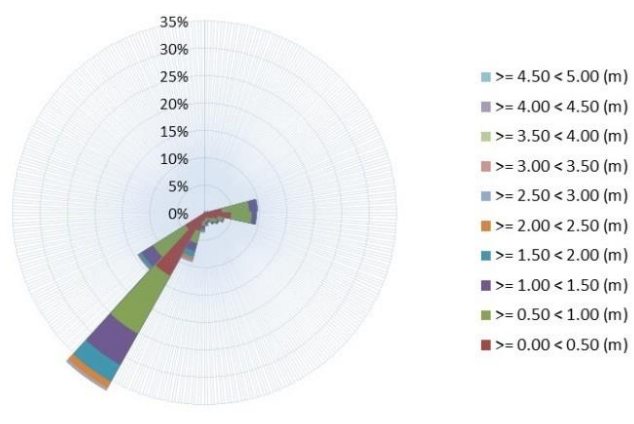
- 1:200 year extreme still water level planar flood map

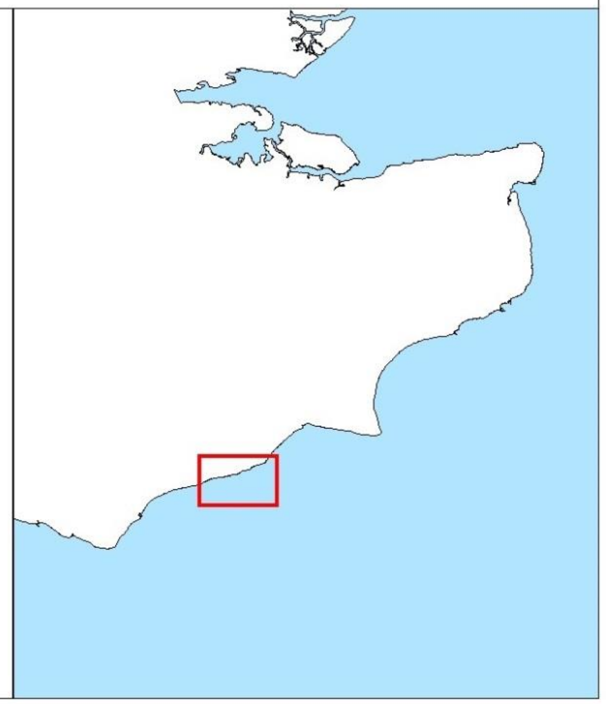
Map Scale 1: 30,000

Total Volume of Beach Material in Fairlight (2003-2015)



Wave Rose for Pevensey Bay indicative of direction, frequency & magnitude of waves, April 2014 - April 2015





8-7 4cSU17 – WINCHELSEA

8-7-1 MANAGEMENT SUMMARY

TABLE 8-6 A SUMMARY OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE WINCHELSEA FRONTAGE (SURVEY UNIT 4CSU17)

Defence section	Operator	SMP (Short-Term) Policy	Current SoP (allowable OT*) or (undermining threshold**) and Defence Type	Sediment budget annual change in m³)+	Recommended management	Plant access and environmental restrictions
A Pett Level Beach	Environment Agency	Hold the Line	>1:200 (10) Beach	-1,297 (-5,765 to 2,181)	Monitor beach CSA	AONB, SSSI, BOA, designations. Gated vehicle access.
B Pett Level Beach	Environment Agency	Hold the Line	>1:200 (10) Sea wall with recurve and rear wall	-1,122 (-7,786 to 7,166)	Monitor beach CSA	AONB, SSSI, BOA, designations. Gated vehicle access.
C Pett Level Road	Environment Agency	Hold the Line	>1:200 (1) Sea wall	-304 (-4,965 to 10,782)	Monitor beach CSA	AONB, SSSI, BOA, designations. Gated vehicle access.
D Pett Level Road to the Winchelsea Beach Café	Environment Agency	Hold the Line	>1:200 (10) Earth embankment	-15,753 (-46,332 to 15,201)	Monitor beach CSA	AONB, SSI, BOA, designations. Gated plant access.
E Winchelsea Beach Café to Dogs Hill Road	Environment Agency	Hold the Line	>1:200 (10) Earth embankment	5,145 (-18,078 to 13,105)	Monitor beach CSA	SSSI, BOA designations. Gated vehicle access.
F Dogs Hill Road to Rye Harbour Nature Reserve	Environment Agency	Hold the Line	>1:200 (10) Earth embankment	1,503 (-13,334 to 17,220)	Montor beach CSA	SPA, SAC, Ramsar, SSSI, BOA designations. Gated vehicle access.
G Rye Harbour Nature Reserve to Rye Harbour	Environment Agency	Hold the Line	>1:200 (50) Big beach	-22,265 (-16,550 to 35,860)	Annual recycling from borrow pit	SPA, SAC, Ramsar, SSSI, BOA designations. Gated vehicle & plant access.

* Allowable overtopping is measured in l/m/s and determines the SoP
** The minimum CSA (m²) before undermining occurs (bold)
+Sediment budget figures show annual average natural change, with the highest positive and negative changes in brackets.

8-7-2 MANAGEMENT HOTSPOTS

PETT LEVEL BEACH

There is a small settlement, Pett Level Village situated behind the sea wall in Defence Section A. This section is erosive and in order to maintain healthy beach levels, annual recycling is undertaken using material taken from Nook Point (Section G).

NOOK POINT

Nook point acts as a sediment sink for the Winchelsea frontage. Material can be taken from a 50m stretch, from the main crest of the beach back to the first line of vegetated material. Any shingle that has established vegetation cannot be used for recycling. Between 15,000-30,000m^3 of material is taken in March annually.

FIGURE 8-8 EXTRACTION OF BEACH MATERIAL AT NOOK POINT, WINCHELSEA, 2012

8-7-3 RECOMMENDED MANAGEMENT

The beach levels should continue to be monitored as part of the RCMP. Extraction of material at Nook Point should continue to replenish the depleted beach at Cliff End (Pett Level Beach) as and when required. Any material not recycled quickly becomes vegetated and is then unavailable for recycling due to environmental restrictions.

8-7-4 EMERGENCY WORKS

The majority of the frontage at Winchelsea has healthy beach levels, above design, with the exception of Cliff End (Pett Level beach). In the event of accelerated erosion at Cliff End, beach recycling programme should be brought forward and material recycled from Nook Point.

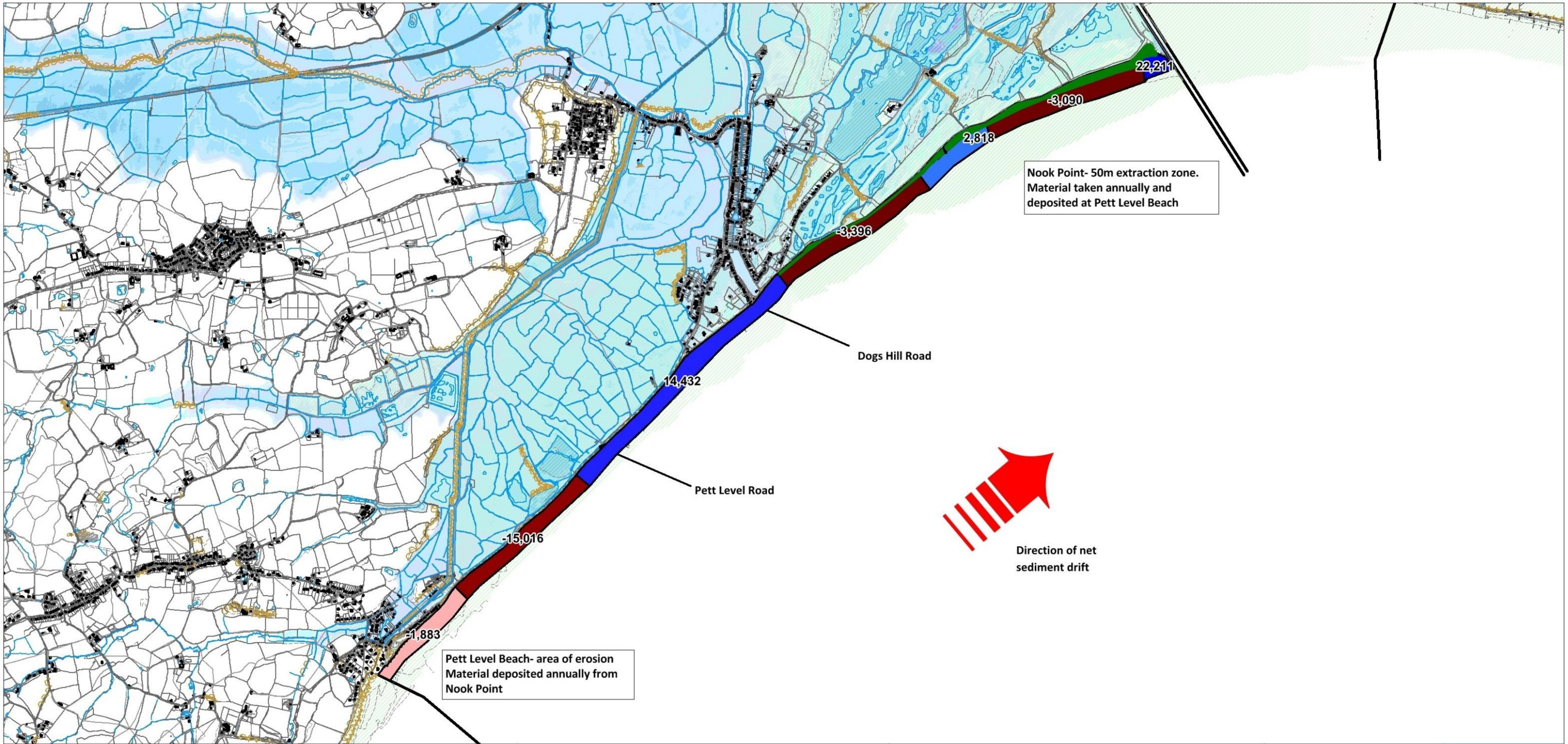


FIGURE 8-9 SUMMARY OF SEDIMENT TRANSPORT RATES, ENVIRONMENTAL RESTRICTIONS, AREAS OF CONCERN AND RECOMMENDED MANAGEMENT ALONG THE WINCHELSEA FRONTAGE

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

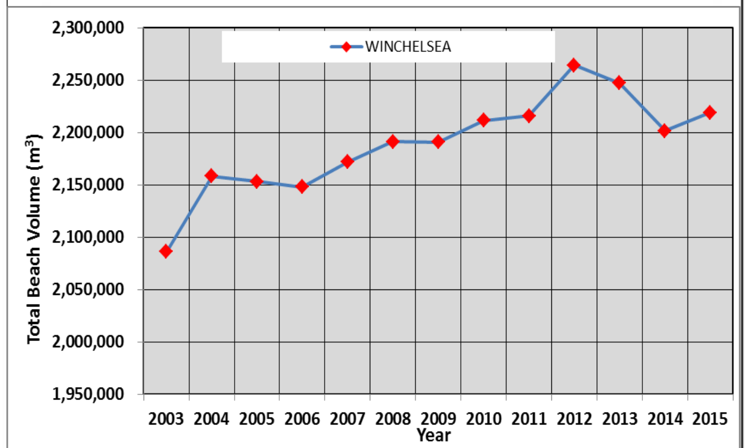
- National or International Designation
- Vegetated Shingle - Restrictions on use of Plant

Floodplain Map

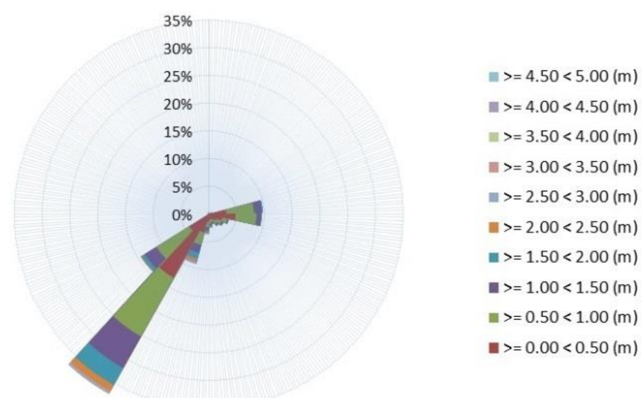
- 1:200 year extreme still water level planar flood map

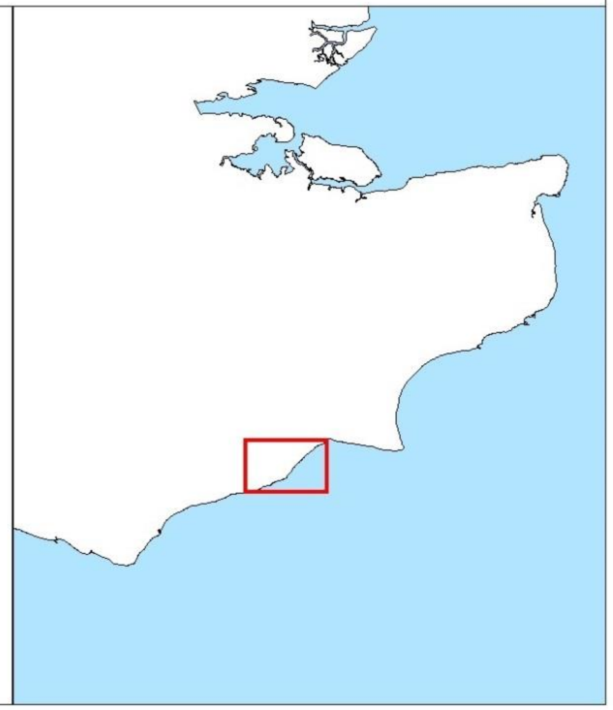
Map Scale 1: 30,000

Total Volume of Beach Material in Winchelsea (2003-2015)



Wave Rose for Pevensey Bay indicative of direction, frequency & magnitude of waves, April 2014 - April 2015





8-8 REGIONAL OVERVIEW

TABLE 8-7 A REGIONAL OVERVIEW OF DEFENCES, STANDARD OF PROTECTION, LONGSHORE DRIFT AND RECOMMENDED MANAGEMENT ALONG THE EASTBOURNE TO RYE FRONTAGE (SURVEY UNITS 4CSU24 – 4CSU17).

UNIT	SMP SHORT TERM POLICY	CURRENT SOP	SEDIMENT BUDGET ANNUAL CHANGE (M^3)*	MANAGEMENT	RESTRICTIONS
EASTBOURNE	HTL	1 IN 20 TO <1 IN 200	-17,127 (-103,378 TO 64,399)	AD HOC RECYCLING FROM WISH TOWER TO HOLYWELL AND PIER	ENVIRONMENTAL DESIGNATIONS
PEVENSEY	HTL	REFER TO PCDL	-41,456 (-95,180 TO -11,562)	REFER TO PCDL	ENVIRONMENTAL DESIGNATIONS
BEXHILL	HTL	<1 IN 200	13,863 (-62,277 TO 105,841)	MONITORING	ENVIRONMENTAL DESIGNATION
BULVERHYTHE	HTL	<1 IN 200	8,806 (-58,566 TO 64,406)	MONITORING	ENVIRONMENTAL DESIGNATION
HASTINGS	HTL	1 IN 200	3,426 (-11,2356 TO 134,898)	MONITORING	ENVIRONMENTAL DESIGNATION
WINCHELSEA	HTL	<1 IN 200	-34,094 (-112,810 TO 101,515)	ANNUAL RECYCLING FROM NOOK POINT TO PETT LEVEL BEACH	ENVIRONMENTAL DESIGNATION

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

The majority of the beaches from Eastbourne to Rye are above design levels. Fishermans beach at Hastings and the Bexhill frontage CSAs exceed the 1 in 200 year design standards. However there are a few management hotspots, including the beach at Carlisle Parade, Hastings and at Bulverhythe.

The key areas which need close monitoring are:

Eastbourne – Low beach levels at Holywell and around pier, recycling undertaken on an ad hoc basis.

Pevensey – Refer to PCDL guidelines

Bulverhythe – Low beach levels in front of revetment

Hastings – Low beach levels at Carlisle Parade

Winchelsea – Recycle from Nook Point on an annual basis

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9 MONITORING

Future monitoring is imperative to ensuring all aspects of the coastline are maintained and recorded using a controlled method which meets the minimum requirements for individual beaches along the Eastbourne to Rye stretch. Due to the similar nature of many of the sites, the required data collection is similar for most of this coastline. Fairlight is the only anomaly as most is undefended and the narrow shingle beach is backed by cliffs. All data required for each site is detailed below with explanations to what is required, when it is required and how to obtain it.

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 Eastbourne to Rye 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.

For the majority of this coastline a mobile laser scanner is mounted onto an ATV and driven along the beach to create a dense 3D point cloud. Beach levels can be extracted from this laser scan along predetermined beach profiles and across the beach face to create a 3D model of the beach. GPS equipment is also mounted on an ATV to code the substrate of the beach (Figure 9-1).

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.

FIGURE 9-1 MOBILE LASER SCAN MOUNTED ON AN ATV – HASTINGS (2012)

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 whole frontage twice per year in Spring and Autumn. The survey requirements of the individual locations are listed in Table 9-1. All beaches are to be laser scanned using a mobile ATV scanner, with the exception of Fairlight which will use a Static Laser Scanner.

TABLE 9-1 FUTURE SURVEY REQUIREMENTS 2017-2021

LOCATION	RISK	SEVERITY	SURVEY REQUIREMENTS
EASTBOURNE	DENSELY POPULATED, LARGE SETTLEMENTS AND FLOOD BASIN	SEVERE DAMAGE TO PROPERTY, SERVICES, HUMAN LIFE AND INFRASTRUCTURE	• MAXIMUM SURVEY ALLOWANCE OF 2 FULL LASER SCANS • PROVISION FOR POST STORMS • LIDAR SURVEY BI-ANNUALLY
PEVENSEY BAY	A BARRIER BEACH PROTECTING PEVENSEY LEVELS	SEVERE DAMAGE TO PROPERTY, SERVICES, HUMAN LIFE AND INFRASTRUCTURE	• MAXIMUM SURVEY ALLOWANCE OF 2 FULL LASER SCANS • PROVISION FOR POST STORMS • LIDAR SURVEY BI-ANNUALLY

BEXHILL	A DENSELY POPULATED LARGE SETTLEMENT	SEVERE DAMAGE TO PROPERTY, SERVICES, HUMAN LIFE AND INFRASTRUCTURE	• MAXIMUM SURVEY ALLOWANCE OF 2 FULL LASER SCANS • PROVISION FOR POST STORMS • LIDAR SURVEY BI-ANNUALLY
BULVERHYTHE	MAIN RAILWAY DIRECTLY BEHIND THE BEACH	SEVERE DAMAGE TO INFRASTRUCTURE	• MAXIMUM SURVEY ALLOWANCE OF 2 FULL LASER SCANS • PROVISION FOR POST STORMS • LIDAR SURVEY BI-ANNUALLY
HASTINGS	A DENSELY POPULATED LARGE SETTLEMENT	SEVERE DAMAGE TO PROPERTY, SERVICES, HUMAN LIFE AND INFRASTRUCTURE	• MAXIMUM SURVEY ALLOWANCE OF 2 FULL LASER SCANS • PROVISION FOR POST STORMS • LIDAR SURVEY BI-ANNUALLY
FAIRLIGHT	SOFT CLIFFS, PARTLY UNPROTECTED	SEVERAL PROPERTIES WOULD BE LOST, NO MAIN SERVICES	• 1 LASER SCAN PER YEAR • LIDAR SURVEY BI-ANNUALLY
WINCHELSEA	A BARRIER BEACH PROTECTING PETT LEVELS	SEVERE DAMAGE TO PROPERTY, SERVICES, HUMAN LIFE AND INFRASTRUCTURE	• MAXIMUM SURVEY ALLOWANCE OF 2 FULL LASER SCANS • 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 the 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 (Section 9-8-7).

9-2 BATHYMETRIC SURVEYS

The seabed requires surveying as the cross shore exchange between subtidal and intertidal sediment is not 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 Eastbourne to Rye Training Wall 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.

Further bathymetric surveys would be of benefit to Sovereign Harbour, Pevensey Bay and Pett Levels to Rye Harbour due to the high volume of fines on the foreshore which continually interact with the intertidal flats and are not covered by the laser scan.

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 five years as a minimum.

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 re-bar.

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.

Vulnerable areas include the seawall in the centre of Eastbourne, between the Redoubt and Wishing Tower, Hastings seawall just east of the Pier, the harbour arm at Hastings. The timber groynes at Cliffe End and Hastings require monitoring as well as the rock revetments at Sovereign Harbour, Bulverhythe and Holywell.

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.

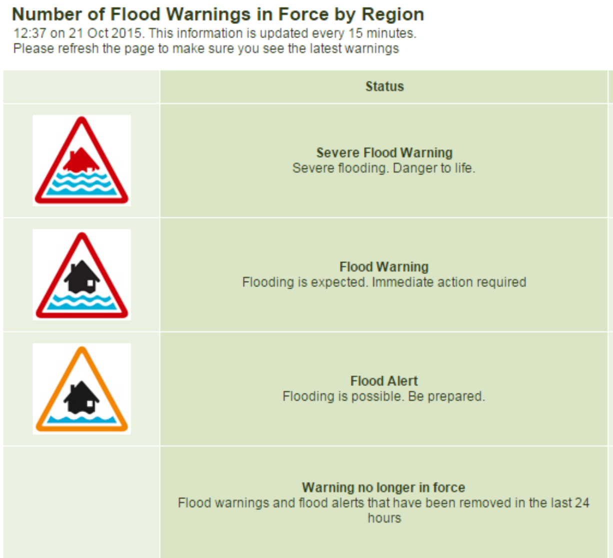
9-6 HYDROLOGICAL MONITORING

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. A new tide gauge will be installed on Hastings Pier over the 2016/17 winter. 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 9-2). 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 9-2 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 buoy currently in action is Pevensey.

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 lie within the following SANDS databases.

TABLE 9-2 SANDS DATABASES

LOCATION	RCMP UNIT	SANDS DATABASE
EASTBOURNE	4cSU24	EASTBOURNE
PEVENSEY BAY	4cSU23	ROTHER
BEXHILL	4cSU22	ROTHER
BULVERYTHE	4cSU21	HASTINGS
HASTINGS	4cSU20	HASTINGS
FAIRLIGHT GLEN	4cSU19	HASTINGS
FAIRLIGHT COVE	4cSU18	ROTHER

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

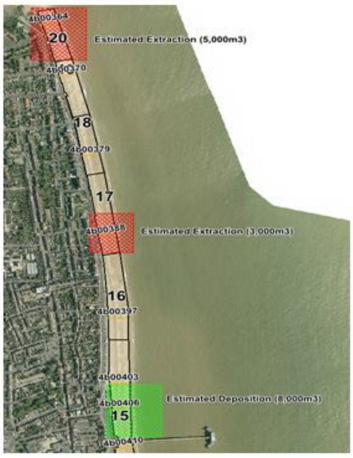
It is important that all beach management works (recycling, beach recharge, reprofiling) should be logged on the appropriate form to indicate the extraction and deposition locations, the quantities moved and the start and end date of the activity (Figure 9-3).

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 send it 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 9-3 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 m³ 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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