STUDLAND MIDDLE BEACH
COASTAL PROCESS AND CONTAMINATION ASSESSMENT
National Trust

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INTRODUCTION

The National Trust has commissioned WSP | Parsons Brinckerhoff to undertake an assessment of coastal processes and potential contamination at Middle Beach, in the Dorset village of Studland. The study responds to issues of degradation of existing coastal structures and explores potential approaches to managing the arising risks.

This site is subject to coastal erosion and is vulnerable to landsliding. These hazards have been managed in recent decades, primarily through the installation of gabion walls and slope stabilisation works. Those defences are ageing and deteriorating; they are also being outflanked by shoreline recession and so the National Trust’s built assets and the land around them are increasingly at risk. There are reasons to be concerned that buried contaminants may be present at the site. Coastal erosion therefore also increases the potential for the release of contaminated sediments and for water pollution.

This study describes the current state of Middle Beach, and the coastal processes acting upon it. The site is described in Section 2 in terms of its geology, topography, coastal processes and the defences and assets within it. Section 3 then describes the outcome of a desk-based contamination assessment (which is provided in full as Appendix A). Information on historic coastal change is often useful in determining how a site might change in the future and so Section 4 describes various records of historic and recent recession at Middle Beach. Section 5 then considers potential options for managing this frontage. Some of these options include allowing natural processes to resume at Middle Beach, and so Section 6 considers the rates of recession that might result, and where assets might be repositioned. Finally, the report’s conclusions and recommendations are presented in Section 7.
SITE DESCRIPTION

Middle Beach is a very popular beach at Studland, in Dorset. It is situated immediately to the north of Redend Point and faces east, across Poole Bay towards the Isle of Wight. It is largely protected from southerly and southwesterly storms by Handfast Point, and also benefits from the more local promontory of Redend Point.

Coastal management policies are developed nationally through Shoreline Management Plans (SMP). The current SMP (Bournemouth Borough Council 2011) specifies the following policies for Middle Beach (Policy Development Zone 4, STU2, Studland Village):

- Managed Realignment to 2025; followed by
- No Active Intervention to 2105.

Managed Realignment represents the intention of allowing retreat, in a controlled manner. No Active Intervention implies the resumption of natural processes.
2.1 ASSETS

Middle Beach has valuable assets, which are critical to the character of the site. These are illustrated in Figure 3 and include a café, business unit and public toilet building, with its associated sewerage system. These particular assets are located in the undercliff area, i.e. the narrow margin of land below a (currently dormant) seacliff.

Figure 3. Middle Beach assets
Access to the site is gained by a road that descends (and cuts through) the cliff on the southern side of the café, and also via steps that descend from the car park. The road terminates at a concrete slipway.

Fronting the café is an outdoor seating area (Figure 4), whilst on the southern side of the road is a public barbeque and picnic area; this extends to the cliffs of Redend Point.

![Figure 4 Café and outdoor seating area](image)

![Figure 5 Picnic and barbeque area, with Redend Point in the background](image)

### 2.2 GEOMORPHOLOGICAL CLASSIFICATION

It appears that the Middle Beach buildings are situated on a dormant ‘undercliff’ area; and it is assumed in this study, in the absence of intrusive geotechnical observations that this is the case. An undercliff is a terrace or lower cliff formed by a cliff failure. The Middle Beach site shows signs of once being an actively eroding cliff, with a steep upper face, and lower levels formed by fallen/slipped material. Wave action would have worked on the fallen material, continuing to destabilise the cliff and cause ongoing erosion. At some stage in the past, the retreat of this cliff stopped when (for external reasons) dunes formed and extended seaward to (at least) the proximity of the...
Redend Point headland. It is likely that some cliff failures occurred after the dunes began to form. However, each cliff failure would have tended to reduce the average slope across the undercliff, increasing its overall stability. Eventually the slope became more stable, cliff failures stopped and vegetation formed.

This interpretation suggests that the current form of the undercliff will be similar to a characteristic post-failure slope. However, it should also be recognised that the topography of the Middle Beach undercliff area has been affected by dune growth. The slope fronting the business unit is apparently composed of dune material and photographic evidence appears to show sand below ground level south of the slipway (see Figure 6).

![Figure 6. Engineering works in sand, apparently south of the slipway](image)

It also seems probable that the historic construction of the road to the slipway involved some cutting of the cliff, and the material this released may have been distributed across the undercliff, raising its level. Other historic activities are likely to have altered the topography of the undercliff and the content of the ground; further discussion of this is presented in Appendix A.

### 2.3 GEOLOGY

The superficial and bedrock geology in the area around Studland is shown in Figure 7.
It can be seen that the bedrock at the site is composed of the Broadstone clay member, and that the same material forms a section of the cliffs south of Redend point. The superficial geology in the area is defined simply as ‘clay, silt, sand and gravel’. This is not shown as being present at the site itself, but instead rests in the valley immediately north of the car park, and other areas further north behind/below the Studland dunes.

The similarity of the geology south of Redend Point to that at Middle Beach is useful, because it offers insight into the retreat rate of an unprotected cliff formed in this material. This is returned to below, in Sections 4 and 6.

### 2.4 SEDIMENT TRANSPORT

Information on the direction and magnitude of transport of littoral sediments is relevant to studies of this type because they influence whether a beach is likely to be stable in the future, or to accrete/recede. This information is also useful when determining whether potential coastal interventions (such as the installation of a groyne field) are likely to be successful.

The local Shoreline Management Plan (Bournemouth Borough Council 2011) summarises the pattern of sediment transport in this area as follows:

- **It is believed that the majority of sand inputs to the Studland system can be attributed to onshore transport from the bed of Studland Bay (SCOPAC 2004). Net accretion appears to have continued to occur until the late 1990s.**

- **A south-east directed tidal sediment transport pathway operates due to the tidal ebb dominance of Poole Harbour entrance. This is likely to have been primarily responsible for the delivery of sediment to the Studland frontage.**

- **Redistributions of material occur at the shoreline and episodes of erosion have been observed in southern parts of Studland Bay and in Shell Bay. As sediment appears to be transported northward by the net littoral drift within the bay, this explains why the southern parts have tended to erode and also supports the assumption of Studland Bay as a sub-cell within the wider log spiral form of Poole Bay.**
This description is supported by a visual representation that is reproduced here as Figure 8. A key point of relevance to this study is that the Middle Beach benefits from little supply of beach sediments from the offshore. The material that does come ashore tends to arrive further north, along the south Haven Peninsula.

Furthermore the direction of alongshore transport is towards the north, and The Foreland acts as a littoral drift boundary. This means that the sediments that pass across the Middle beach shore are limited to the beach grade material released by cliff erosion between Middle Beach and the Foreland. It may also be noted that the recessed nature of Middle Beach (which is effectively in the lee of Redend Point) means that some of the material arriving from the south will bypass Middle Beach, travelling instead through the nearshore zone to reach the beaches further to the north.

The supply of sand to Middle Beach should therefore be expected to be very limited, and this view is consistent with the observed tendency for erosion in this area (see Section 4).

2.5 COAST PROTECTION

The coast protection structures at Middle Beach comprise of two lengths of gabion wall, which extend north and south from the slipway (see Figure 9). Some protection is also afforded to the site by units of rock/ concrete distributed along the front of the southern gabions, but these are informal and of limited value and so are not discussed further.
Historic maps show that construction of the slipway occurred between 1963 and 1985, whilst National Trust records suggest that the gabions were installed in the early to mid 1990s. Design information for the slipway, gabions and the slope behind were not available to this study.

**NORTHERN GABION WALL**

The gabions extending north from the slipway are shown in Figure 10. These range between two and three courses high, and extend over around 40 metres. For most of their length they are backed by a timber retaining wall.
This gabion wall is in a very poor state of repair. At its northern extent the structure has collapsed, and it has tilted forward along much of its central section. As a consequence sand has been placed along the face and crest of the structure, apparently to promote stability (see Figure 10).

The slope immediately to the north of this line of defence (in front of the business unit) underwent significant retreat over the 2014/15 winter season (chiefly in February 2014) leading to the loss of access steps. The shoreline here retreated behind the gabion wall, a situation termed ‘outflanking’. This has resulted from a long term erosional trend along this beach that extends beyond Knoll Beach (see Figure 21 for example). Outflanking is damaging to coastal structures as it allows wave activity to pass behind them, removing slope material and reducing stability. In this instance sand has been placed in front of the business unit slope to temporarily realign the toe in a seaward direction, this can be seen in Figure 11.

![Figure 11. View north from at the northern limit of the gabions showing sand placed on the slope fronting the business unit](image)

The gabions in the central section of the wall have tilted forward (see Figure 10). This type of destabilisation is consistent with beach retreat and lowering.

The timber retaining wall that is present behind the gabions is generally in a very poor state of repair; the material is weathered and in places the structure has been broken. This is a particular concern close to the entrances of the toilet building (Figure 12) as this is the location of the sewer system; ground instability here raises the risk of sewerage contamination.
Figure 12. The northern part of the gabion wall, showing the degraded state of the timber retaining wall and unprotected slope adjacent to the toilet building

At its southern limit, the timber retaining wall is essentially intact; it appears to be protected by the slipway. It is, nevertheless, showing signs of degradation. In Figure 13 it can be seen that a pile appears to have become displaced, and that some of the planking that it supports has moved. No evidence was observed of a geotextile filter behind this structure, and so washout of material may also be occurring.

Figure 13. Detail of the southern limit of the timber retaining wall

SOUTHERN GABIONS

The gabion wall on the southern side of the slipway is around 90 metres in length, and extends from the slipway to the resistant rock of Redend Point (see Figure 14).
Figure 14. The southern gabion wall

This structure is showing signs of degradation (and localised repair) including tearing of the basket fabric, spilling of rock, and undermining (see Figure 15 for example). Basket refilling appears to have been necessary in some locations.

Figure 15. Example of localised damage to the southern gabion wall

CONSEQUENCES OF COAST PROTECTION

Clearly these coast protection structures have protected land and important assets behind them. However, they have also had some negative consequences for the coastal features of the site. It is clear from aerial photography that the shoreline at Middle Beach does not follow the natural alignment of this coast, as illustrated in Figure 16.
Figure 16. Misalignment between the Middle Beach shore (shown in magenta) and the natural shoreline angle (red)

It can be seen that the coast protection structures have allowed the Middle Beach shoreline (shown in magenta) to develop an angle (of about 25 degrees) from the general alignment of the natural coast. The coast now projects further across and down the beach profile than would naturally be the case.

To the north of the structures the beach is wider and the profile is fairly constant from place to place; the water line is a similar distance from the back of the beach. However, where the structures are present the back of the beach is held further forward, so that the beach level at the structures falls, and the beach surface is ultimately submerged (in Figure 16) south of the slipway.

Because the structures are in deeper water they are exposed to greater wave activity, and because gabions reflect more energy than a natural sand beach, they tend to increase wave activity in the nearshore zone. This can be expected to result in increased losses of beach sediment, promoting the local erosive trend.

For these reasons, although these structures have historically protected the land of Middle Beach, they also narrow the width of the beach available to visitors, and may have accelerated beach lowering.
3

CONTAMINATION ASSESSMENT

A (Phase 1) Land Contamination Assessment has been undertaken within this study, and is presented in full as Appendix A. That assessment was informed by a site visit (undertaken on June 21st, 2016) and a desk-based study.

A number of potential sources of land contamination were identified, chiefly associated with the undercliff area (i.e. seaward of the car park). These potential sources included:

- Made ground;
- The sewerage system;
- Historic demolition;
- Unexploded ordnance; and
- The historic use of Fougasse weaponry.

In the context of the site setting, ongoing coastal recession processes and the potential for redevelopment, it is considered that there is a Moderate risk to human health and controlled waters at the site from environmental risks/ constraints. The potential implications are such that a focused ground investigation is recommended to assess potential contamination linkages. Confirmatory soil sampling should be undertaken to assess the identified potential contamination risks.

The contamination risks are considered lower in the area of the car park area than they are in the undercliff. Consequently the need for intrusive surveys/ sampling is reduced in this area. Nevertheless, it is recommended that the sampling extend to the car park; the information revealed may prove valuable in the process of gaining planning permission for future development. The National Trust may also wish to combine this work with geotechnical sampling to inform future foundation design in this area.
4 HISTORIC CHANGE

Past change at the coast is often useful in interpreting how an area might develop in the future. For this reason information on historic recession and historic shoreline position have been assimilated in this section.

4.1 SMP MAPPING

The Shoreline Management Plan (Bournemouth Borough Council, 2011) provides a map of the consequences of a No Active Intervention management policy, and this is reproduced in Figure 17.

Figure 17. SMP erosion mapping of the area around Middle Beach
It can be seen that, due to the uncertain nature of such change, recession is shown as broad ‘indicative erosion zones’ rather than specific lines. This mapping is of limited use to this study because of its ‘broad brush’ nature; it does not show the consequence of coastal erosion on the cliff top, or recession resulting from the early Managed Realignment policy (which, as noted above, is proscribed for this location).

The coastal recession rates on which this map was based are provided in Annex 1 of the SMP, which is titled Residual Life of Defences and Erosion rates Used for Mapping. Table 4-1 below records the recession rates given for the Middle Beach area.

Table 4-1 Historic and future coastal recession rates provided by the local Shoreline Management Plan (Bournemouth Borough Council 2011); rates relating to Middle Beach are highlighted in red

<table>
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<th>MANAGEMENT UNIT</th>
<th>DEFENCE RESIDUAL LIFE</th>
<th>AVERAGE RATE OF EROSION (m/y)</th>
<th>EXTRAPOLATE FOR YEARS (m/y)</th>
<th>SOURCE</th>
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<tr>
<td>STUD Knoll Beach carpark to Redend Point</td>
<td>NA</td>
<td>-0.64</td>
<td>-12.8</td>
<td>-32.0</td>
</tr>
<tr>
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<td>-0.64</td>
<td>-12.3</td>
<td>-32.2</td>
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<td>-0.64</td>
<td>-12.3</td>
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</tr>
<tr>
<td>STUD Knoll Beach carpark to Redend Point</td>
<td>NA</td>
<td>-0.64</td>
<td>-12.3</td>
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<tr>
<td>STUD Knoll Beach carpark to Redend Point</td>
<td>NA</td>
<td>-0.64</td>
<td>-12.3</td>
<td>-32.3</td>
</tr>
<tr>
<td>STUD Knoll Beach carpark to Redend Point</td>
<td>NA</td>
<td>-0.64</td>
<td>-12.3</td>
<td>-32.3</td>
</tr>
<tr>
<td>STUD Knoll Beach carpark to Redend Point</td>
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<td>-12.3</td>
<td>-32.3</td>
</tr>
<tr>
<td>STUD Knoll Beach carpark to Redend Point</td>
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<tr>
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<tr>
<td>STUD Knoll Beach carpark to Redend Point</td>
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<td>-9.6</td>
<td>-26.8</td>
</tr>
<tr>
<td>STUD Knoll Beach carpark to Redend Point</td>
<td>S</td>
<td>-0.64</td>
<td>0.0</td>
<td>11.2</td>
</tr>
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It is possible to identify the rows that refer to Middle Beach (shown here within a red square) by their proximity to Redend Point, and by the presence of structures (indicated by the numeric values in column 2). It should be stressed that these values are approximations, despite the precision with which they are quoted. The historic rate of 0.64 m/y does not, for example, distinguish between the cliffs of Middle Beach and the dunes further north. In addition it can be seen that no coastal ‘catch-up’ has been accounted for (a tendency for a period of high erosion following the loss of structures) and that the recession rates are not assumed to increase in future years (despite accelerating sea level rise).

4.2 HISTORIC MAP ANALYSIS

Figure 18 represents shoreline change as revealed by a sequence of historic maps, and a recent aerial photograph.
Figure 18. Historic and recent shoreline positions at Middle Beach

The lines in this figure represent the locations shown for ‘mean high water’ in historic Ordnance Survey maps. The data seems to show no movement in the shoreline (other than change that can reasonably be attributed to mapping error) between 1938 and 1963, but this is implausible. The most likely explanation is that this feature was not resurveyed in 1963, and the earlier line was reused.

Photographic evidence also shows that, historically, the coast was much further seaward of its current location (see Figure 19).
Figure 19. Historic photographs confirming the earlier more seaward position of the shoreline at Studland, close to the end of Redend Point

Although shoreline mapping is subject to inherent uncertainty, it is nevertheless clear that the coast here has undergone substantial recession since the late 19th century, and through the 20th century; apparently until the construction of coast protection. The distance between the current coast protection and the 1888 line ranges between around 80 and 90 metres. Given the evidence that the structures were installed around 100 years after the earliest map, this suggests that the long term recession rates at Middle Beach have approached one metre per year.

RECESSION SOUTH OF REDEND POINT

Cliff recession rates on the southern side of Redend Point are useful because geological mapping shows the cliffs in this areas composed of the same geological type (Broadstone Clay Member) to those at Middle Beach. They therefore offer insight into how quickly undefended cliffs of this type may retreat.

Figure 20 shows a comparison between the cliff toe position recorded in the 1888 and 1987 Ordnance Survey maps south of Redend Point; later maps have been rejected because they show zero recession (which is implausible).
Figure 20. Change in cliff toe position south of Redend Point (1888–1987); gridlines are spaced 200m apart

It can be seen that the recession rates increase slightly with distance from Redend Point; this may be due to protection afforded by more resistant sandstone at this headland. The recession along the southern half of the area marked with magenta (which is less likely to be directly influenced by Redend Point) has been quantified as between 17 and 20 metres. This provides a range of long-term recession rates in this area of between 0.17 and 0.20 metres per year.

4.3 TOPOGRAPHIC CHANGE

The Environment Agency provide topographic survey data derived using the Light Detection And Ranging (LiDAR) technique, and this may be used to understand how the coast changes shape. Figure 21 shows the difference in ground elevations between two such surveys, which were recorded in 2007 and 2013.
Figure 21. Ground surface level change between 2007 and 2013, note that the colour scale was set to only show lowering between the range of 0 and 1 metre.

This image reveals a strong recent erosive trend between Middle Beach and Knoll Beach. Of particular interest are the changes shown in darkest red, indicating lowering of around a metre, or more. These values arise because of the loss of vegetated dune edge. Close inspection of this figure reveals recession rates of around one metre per year, on average, between Middle Beach and Knoll Beach.

During a site inspection on the 21st June, 2016, much visual evidence was found that these high recession rates continue. Figure 22 shows a selection of photographs demonstrating several characteristics of erosion, including exposed sand ‘cliffing’, overhanging dune turf, and the remains of a tree resting substantially seaward of the dune edge.
Figure 22. Evidence of ongoing erosion north of Middle Beach
5 FUTURE MANAGEMENT

5.1 INTRODUCTION

This section considers the implications of alternative coastal management policies at Middle Beach. Five have been considered, from the construction of new coast protection through to the restoration of natural conditions, and these are termed: No Active Intervention, Do Minimum, Hold the Line, Advance The Line and Restoration of Natural Conditions. A range of possible approaches might be taken to adopt a Hold The Line policy, and several are presented here.

5.2 NO ACTIVE INTERVENTION

A No Active Intervention (NAI) approach to coastal management essentially involves allowing the effects of natural processes to occur without further human intervention. In practice this would not be permitted at Middle Beach because of the associated hazards to people and the environment. Nevertheless projecting the short-term and long-term consequences of this approach provides a useful ‘baseline’ condition against which other options may be judged.

Under a NAI approach, negative consequences are certain, and the timing of their occurrence can be estimated. Geomorphic processes would continue, including a tendency for shoreline retreat and for outflanking of the northern end of the gabions. The existing potential for landsliding/land creep in front of the café, business unit and toilet building would grow. Beach lowering in front of the gabion structures and slipway is likely; deterioration of the gabion units is certain, leading to rupture of their wire baskets and spilling of the contents.

The slope behind the northern gabions should be expected to continue to degrade, particularly in the northern areas, close to the toilet building and business unit. Rupture of the sewerage system would be expected, leading to a contamination event. The mode of failure of this slope would influence the contamination risk. If this failure occurred through a large and obvious event, which led to the immediate decommissioning of the sewerage system and closure of the toilets, then the scale of the contamination could be minimised. However, a greater pollution risk would be associated with a slower failure, involving the gradual movement of the slope and rupture of the sewerage system without obvious indications at the ground surface. This could lead to the occurrence of more severe contamination over an extended period.

Instability issues are also present close to the café seating area, and these would worsen. Over time, the entire coastal slope behind the northern gabion wall would become active and retreat. The business unit and toilet would probably be lost first because of the more deteriorated state of the defences in this area, and greater exposure of the coastal slope.

Degradation of the gabions south of the slipway would lead to landsliding and the progressive loss of the grassy ground around the barbeque area. The slipway would be undermined, cracked and broken, becoming unusable.

A period of accelerated erosion should be expected following structure loss, as the shore moves towards a more natural configuration (i.e. towards the solid red line in Figure 16). Ultimately the cliff face (behind the structures) would be destabilised, activated and begin to retreat. It is reasonable to expect the timeframes of asset loss shown in Table 5-1.

<table>
<thead>
<tr>
<th>Asset</th>
<th>No Active Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 5.3 DO MINIMUM

A ‘Do Minimum’ approach generally seeks to retain existing defences at minimum cost. At Middle Beach this would amount to repair and maintenance of the existing gabion defences. This approach could be undertaken to the south of the slipway, and along the southern section of the northern gabions. However, it would be unsuitable for the defences fronting the toilet building. The high coastal recession rates north of these defences mean that reinstated gabions would be rapidly outflanked, exposing the coastal slope behind. Ongoing works would be necessary to extend the defence in line with this retreat. Given the coupled problem of beach lowering, gabions could not be expected to remain stable for a useful period.

In general terms the required works would be significant, but the benefit would persist for a short period. It is therefore considered that the Do Minimum approach is not viable at Middle Beach.

### 5.4 HOLD THE LINE

A Hold The Line (HTL) approach would seek to maintain the current line of defence to protect assets. However, it does not necessarily mean that the shore would remain in its current state, since natural processes would continue to drive change. The coast would remain in an engineered state, with the associated benefits (protection of assets, lessened probability of landsliding) and drawbacks (the site continuing to emerge from the adjacent shoreline as an artificial headland, little release of sediments to feed the beach, and amplified lowering of the foreshore). A Hold The Line approach could be realised in a number of different ways, including the following:

<table>
<thead>
<tr>
<th>ASSET</th>
<th>NO ACTIVE INTERVENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Café outdoor seating area</td>
<td>0 to 5</td>
</tr>
<tr>
<td>Business unit</td>
<td>0 to 3</td>
</tr>
<tr>
<td>Toilet building</td>
<td>0 to 3</td>
</tr>
<tr>
<td>Sewerage system</td>
<td>0 to 3</td>
</tr>
<tr>
<td>Cafe</td>
<td>0 to 5</td>
</tr>
<tr>
<td>Slipway</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Barbeque area and surrounding grass</td>
<td>5 to 10</td>
</tr>
<tr>
<td>Shed</td>
<td>5 to 10</td>
</tr>
<tr>
<td>Beach road</td>
<td>Progressive loss</td>
</tr>
</tbody>
</table>

The timeframes of loss shown in Table 5-1 are relatively short; most include a lower bound of zero. This may appear to be at odds with the fact that many of the gabions are relatively intact. The zero values recognise that: (1) slope stabilisation structures behind the gabions have, in places, deteriorated strongly, (2) some indications of movement have been observed in front of the café seating area and (3) recent recession of the coastal slope fronting the business unit has been very rapid.
OPTION 1: CONSTRUCTION OF A LINEAR DEFENCE

The shoreline could be held through substantial capital investment in the construction of a linear defence. This could be augmented with works to stabilise the cliff slope, and in this way maintain the existing assets. In this setting a rock armour revetment would be more appropriate than a sloping or vertical seawall as it would cause less beach scour.

A scheme such as this is typically designed for the long term (e.g. 100 years). Over that period the coast to the north would continue retreating, tending to outflank the structure and necessitating ongoing periodic extension of the defence. The foreshore should be expected to continue to lower and this, coupled with sea level rise, would ultimately result in the loss of the intertidal zone. Under this condition the low tide line would be at the structure face; no beach would be seen.

The cost for a rock armour revetment has been calculated by assuming design parameters typical for this setting, and utilising the Environment Agency’s Long Term Costing Tool. It has been assumed that there would be a requirement for approximately 2500 m³ of rock, with a structure length of 110 m, a height of around 3 m (some of which will be buried) and a seaward slope of 1 in 2. The design allows for beach draw down of up to 1.5 m. The derived cost for this approach is given below, in Section 5.7.

OPTION 2: GROYNE INSTALLATION

Coastal protection is achieved in many places through the construction of an array (or ‘field’) of groynes. These reduce the capacity of waves to move beach sediment along the shore. Consequently, given an influx of wave-driven material along a beach, groynes can help to increase beach width.

The installation of a groyne field (without beach nourishment) is not expected to be an effective solution at Middle Beach for several reasons. Key amongst these is the fact that alongshore sediment transport in this location is from the south (see Figure 8), i.e. from the opposite side of Redend point. Much of the beach material transported around Redend Point is likely to bypass groynes at the southern end of Middle Beach, and so beach growth rates should be expected to be very low.

The costs associated with the installation of groynes were calculated using the Environment Agency’s Long Term Costing Tool. The assumed configuration of the groynes was based on knowledge of the local coastal processes and consideration of groyne fields in similar nearby settings. The key design assumptions that influence costs are the height and length of each groyne, and these were assumed to be 3 m and 50 m respectively. It was also assumed that 10 structures will be installed at 75 m intervals for an extent of approximately 750 m north of Redend Point. The estimated cost of this approach is given below, in Section 5.7.

5.5 ADVANCE THE LINE

A policy of advancing the line seeks to move the shoreline in a seaward direction. This is typically achieved through beach nourishment (artificially importing beach material) coupled with groyne construction.

This approach would likely be the most effective means of promoting increased beach width at Middle Beach. Ideally such nourishment would return the shoreline to that seen in the late 19th Century, where dunes extended seaward of the position of the current defences to Redend Point. This would encourage more connectivity between the beach and dunes and sediment transport from the south around Redend Point. The groynes would necessarily be long (around 50 metres), and would have to be implemented along an extended length of coast, of the order of 750 m or more.
The design assumptions associated with the groyne element of this option are set out in the description of Option 2. Costs for the beach recharge were based on assumptions that 12,000 m$^3$ of material would be required. No assumptions were made with regards to the source of the material or the viability of transporting it to Middle Beach. Once deposited on the beach, it is anticipated that a significant proportion of the placed beach material would be transported northwards, and therefore operation and maintenance costs account for a large proportion of the total cost of this option.

There are a number of important environmental designations at and close to Middle Beach, these include:

- Sites of Special Scientific Interests (designation for the cliffs and for the heathland)
- Special Area of Conservation (SAC) (Dorset Heaths and Studland Dunes)
- Special Protection Area (SPA) (Dorset heathlands, including Studland and Godlingston)
- Area of Outstanding Natural Beauty (encompassing most of Dorset’s coastline)
- Heritage Coast

Within these designations and citations, the near shore habitats and the coastal morphology are noted as important features. This means that any works that could affect habitats or process will be subject to particular scrutiny and testing.

The European designations of SAC and SPA mean that the Habitats Regulation Assessment process will need to followed. This is because an advance the line options is not directly connected with the conservation management of the site’s features. Where Significant Effects on the features cannot be excluded, assessing them in more detail through an Appropriate Assessment (AA) is required to ascertain whether an adverse effect on the integrity of the site can be ruled out.

Where such an adverse effect on the site cannot be ruled out, and no alternative solutions can be identified, then the project can only then proceed if there are Imperative Reasons Of Over-Riding Public Interest and if the necessary compensatory measures can be secured. This process is very time consuming and costly - and in the case of an Advance the Line Option it is questionable that suitable compensatory measures could be secured.

An Advance he Line Option could have significant adverse impacts on the habitats and morphology due to introducing new material to the system that would smother existing habitats and change coastal processes.

5.6 RESTORATION OF NATURAL CONDITIONS

Restoring more natural behaviour to Middle Beach would mean allowing coastal erosion to proceed. The Middle Beach frontage would begin to interact with neighbouring coasts in a more natural way. This would chiefly occur through the release of sediments (that would feed nearby beaches) and by allowing the emergence of a shoreline more in balance with its surroundings.
These changes would mean that the beach level (which is currently depressed) would be expected to rise.

Such an approach would differ from the Do Nothing option in that investment would be made to manage hazards arising to people and the environment. Restoring natural conditions at the site would not prevent the loss of the built assets and would also make the hazard of release of contaminated sediments more pressing. In addition, as the cliff becomes active, hazards associated with falling material and (people) falling from height would increase. Such risks would have to be considered and managed. The stages through which natural conditions could be restored are described in Table 5-2.

**Table 5-2 Restoration of natural conditions – suggested stages of implementation**

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>COMMENTS/ RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decommissioning of sewerage infrastructure</td>
<td>A high priority given the possibility of landslip in this area and the arising contamination hazard</td>
</tr>
<tr>
<td>Land contamination assessment (see Section 3)</td>
<td>This is recommended for Middle Beach regardless of whether defences are maintained or removed.</td>
</tr>
<tr>
<td>Contamination remediation/ removal</td>
<td>Remediation/ removal of contamination if necessary</td>
</tr>
<tr>
<td>Installation of temporary facilities (e.g. mobile toilets)</td>
<td>Positioning to be informed by the contamination assessment. If possible these should be placed in the car park area or (if on the undercliff) on the southern side of the road where erosion/ instability issues are less pressing</td>
</tr>
<tr>
<td>Decommissioning of other buildings and associated infrastructure in the undercliff area</td>
<td>If more permanent facilities are to be developed then these should be located behind the cliff line, and be designed with the expectation that the cliff will retreat. Such structures would, ideally, be moveable, with services (e.g. water supply, power and sewerage) arranged accordingly.</td>
</tr>
<tr>
<td>Decommissioning and removal of gabion defences and slipway</td>
<td>It is recommended that this be sequenced to protect the slipway for as long as possible, for ease of access.</td>
</tr>
</tbody>
</table>

The estimated cost of this approach is shown in Table 5-3.

### 5.7 OPTION COSTS

The estimated costs of the various options are shown in Table 5-3. They have been calculated using both the Environment Agency’s Long Term Costing Tool and SPON’s Civil Engineering and Highway Works Price Book 2014. The total cost allows for the following:

- Construction costs;
- Overheads and other costs including general site prelims, temporary works etc;
- Professional fees/associated costs;
- Maintenance costs; and
- Optimum Bias (assumed to be 60% of the construction cost).
Maintenance costs have been based on a 100 year period, and account for maintenance, replacement and in some cases extension of the options.

Although fairly high, an optimum bias of 60% is considered to be reasonable as the specific requirements of each of the options are still largely unknown e.g. whether site investigation, statutory approval costs, compensation for land purchase costs etc. would be required. These costs are suitable for option ranking, but are not sufficiently detailed for other purposes.

**Table 5-3 Summary of option costs**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>COMMENT</th>
<th>COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Active Intervention</td>
<td>Not allowable due to negative environmental consequences</td>
<td>NA</td>
</tr>
<tr>
<td>Do Minimum</td>
<td>Repair and maintenance of gabions would not be effective</td>
<td>NA</td>
</tr>
<tr>
<td>Hold The Line (Rock Armour Revetment)</td>
<td>Would likely be effective in holding the line, but with sea level rise the beach would be permanently submerged.</td>
<td>£600,000</td>
</tr>
<tr>
<td>Hold The Line (Groynes)</td>
<td>Unlikely to be effective, due to the small influx of beach material</td>
<td>£1,750,000</td>
</tr>
<tr>
<td>Advance The Line (Groynes with beach nourishment)</td>
<td>Most likely to protect Middle Beach and prevent future submergence of the beach. Would require regular costly maintenance</td>
<td>£2,800,000</td>
</tr>
<tr>
<td>Restoration of natural conditions</td>
<td>Demolition of the existing coast protection</td>
<td>£105,000 - £135,000*</td>
</tr>
</tbody>
</table>

* Costs only account for the removal of the gabions

**5.8 ENVIRONMENTAL PERMITTING**

The coastal environment is heavily regulated; and a variety of consents and approvals are often required before works can be carried out. This situation reflects the dynamic and sensitive nature of our coastlines and the large number of regulatory control mechanisms in place. The spatial extents of these mechanisms are indicated in Figure 23.
There are a number of bodies (in addition to the National Trust) with professional interest in the coastal elements of Middle Beach, and these include:

- The Environment Agency – Maintains a strategic overview of the coast, in particular they set the direction for how flood and coastal risk is managed (through Shoreline Management Plans), ensure the strategic direction is delivered (through approving investment schemes and allocating grant funding), facilitate joined-up working with all those working on the coast and respond to the needs of communities. They are also the commissioning authority on some coastal schemes;

- Purbeck District Council – Coast Protection Authority under the Coast Protection Act 1949;

- Natural England – The non-departmental public body of the UK Government responsible for ensuring that England’s natural environment, including its land, flora and fauna, freshwater and marine environments, geology and soils, are protected and improved;

- Crown Estate – the Crown owns the foreshore below Mean Low water.

Whichever approach is selected the Environment Agency and Natural England should be informed and consulted. It is also suggested that the National Trust discuss their intentions with Purbeck District Council and Dorset County Council, even if no new coast protection is planned.

**MARINE LICENCE**

A Marine Licence is required before undertaking work below Mean High Water Springs. This Licence falls under the Marine and Coastal Access Act, administered by the Marine Management Organisation (MMO). It is very likely that a licence would be required for the installation of any new coast protection. If a Do Minimum policy was adopted, or restoration of natural conditions, then the need for a Marine Licence is less clear. However work would be required on the existing
gabions, and observations made during the site visit suggest that the base of at least some of these is below Mean High Water Springs. It is recommended therefore that, if one of these policies is adopted, the MMO be contacted to ascertain whether a Marine Licence would be required.

ENVIRONMENTAL IMPACT ASSESSMENT

Given the local environmental designations an Environmental Impact Assessment (EIA) would likely be required to implement any policy under which new defences were to be built. Although the need for an EIA is less clear for the implementation of a Do Minimum policy, or the restoration of natural conditions, it would be prudent to screen for an EIA under both the Town and Country Planning Act (Purbeck District Council) and the Marine and Coastal Access Act (the MMO). It may be noted that, although these are separate processes a Coastal Concordat has been published which recognises that many of the consultees are the same and allowing for one EIA (if needed) to be produced. As noted in Section 5.5 for the need for a Habitats Regulation Assessment will have to be considered for some options.

5.9 SUMMARY OF OPTIONS

The Advance the Line approach would be most effective in preventing shoreline retreat at Middle Beach. As described above, this would involve the construction of a groyne field, coupled with beach nourishment. Other approaches would either be ineffective (Do Minimum) or would allow the beach to become entirely submerged (Hold The Line).

The challenges associated with an Advance The Line approach tend to include:

- Economic – whether the relative scale of the necessary capital investment is proportionate to the value of the protected assets;
- Environmental – whether the impact on the environment (such as loss of the intertidal zone, visual intrusion and necessity for ongoing extension to the north) would be acceptable to the public and regulators; and
- Sustainability – this approach requires a high level of initial capital investment, but also period investment to enable both: (1) defence extension to avoid outflanking or replenishment of the beach and (2) replacement of the overall defence with a larger structure once the structure(s) reaches the end of its lifetime.

As noted above in Table 5-3, the Advance The Line approach is the most expensive option (at £2.8m) and this is disproportionality high when compared to the economic value of the assets such a scheme would protect.

This approach would also be the most problematic in terms of environmental permitting, and so would require considerable commitment to seek implementation. Permission would be made more challenging because this approach would be counter to the coastal policy in this area, (defined in the Shoreline Management Plan), which is to allow natural processes to remerge in a controlled manner. For these reasons the construction of an ‘Advance the line’ policy is not recommended.

In terms of economic cost, environmental impact and sustainability it is instead recommended that Middle Beach be managed to return to a more natural condition.
COASTAL RECESION POTENTIAL

As discussed in the preceding chapter, the café and toilet building at Middle Beach are vulnerable to coastal erosion. If they are lost, and replacements are provided, then these would have to be located further inland, within the current car parking area.

Clearly the car park would, at some stage, also undergo coastal erosion and so the optimum location of such new facilities would provide proximity to the shore (to minimise access distance for beach users and allow a sea view), without being so close that they would be threatened by coastal erosion in the immediate near-term. In discussions with the National Trust, it has been determined that any such new buildings should not be threatened before 2045.

The recession projections provided in the local Shoreline Management Plan (Bournemouth Borough Council, 2011) provides the obvious basis for locating these buildings. However, it was decided to only use the SMP for comparative purposes because they do not account for: (1) the transition from dune erosion to cliff recession at Middle Beach, (2) future erosion acceleration due to sea level rise, (3) coastal ‘catch-up (see below), (4) the three-dimensionality of the coast at this location (partly caused by the close proximity of Redend Point) and (5) the natural tendency for uncertainty in shore position to increase through time. In addition the SMP projections are provided relative to the beach position, rather than the cliff top, and so are not immediately applicable to the required assessment. More site-specific projections of future recession were therefore made.

It has been assumed that future recession will progress through the site in two phases, a first relatively fast phase in which the cliff face will be reactivated, and a second (slower) phase in which the site retreats as a coastal cliff. A further important assumption has been made that the retreat of this coastal cliff will be similar to that observed in the area to the south of Redend Point. Geological mapping shows this area to be composed of similar material, and it is of similar height. The outcomes of this assessment are therefore conditional on the accuracy of the geological maps, and the homogeneity of the geological strata; it is recommended that these be tested through ground investigations if greater certainty is required.

6.1 PHASE 1 – ACTIVATION OF THE CLIFF FACE

The timeframe around the activation of the cliff face has been discussed in the preceding chapter, from the perspective of the losses of the built assets. The total timeframe over which that can reasonably be expected is short and depends on (amongst other things) the undercliff width and slope.

UNDERCLIFF SLOPE

As described above, the undercliff area is (essentially) the margin of land between the cliff edge and the beach. This area is likely to include an element of dune material immediately behind the defences, but the boundary between relic cliff and dune is not known (in the absence of intrusive ground investigations). A series of transects have been examined across the undercliff, at the locations shown in Figure 24.
Figure 24. Locations of transects across the Middle Beach undercliff

The profiles of these transects (as recorded by EA LiDAR data) are shown in Figure 25. It should be noted that these transects are influenced by the presence of vegetation; in some areas the data show the upper surface of trees rather than the ground itself.

Transects A and E were rejected from the initial set of five because these were considered likely to contain a significant volume of dune material. Maximum and minimum slopes and undercliff widths were then estimated for the remaining three transects (shown with the dashed black lines in the lower panel of Figure 25). The resulting estimates of gradient and undercliff width are shown in Table 6-1.
Figure 25. Middle Beach undercliff transects (top panel) and selected transects with estimated maximum and minimum gradients, shown as dashed black lines (bottom panel); the approximate elevation of the upper beach is shown with the horizontal dashed yellow line.

Table 6-1 Estimated slope parameters

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max slope</td>
<td>50 degrees</td>
</tr>
<tr>
<td>Min slope</td>
<td>23 degrees</td>
</tr>
<tr>
<td>Max undercliff width</td>
<td>28 metres</td>
</tr>
<tr>
<td>Minimum undercliff width</td>
<td>12 metres</td>
</tr>
</tbody>
</table>

The undercliff widths in Table 6-1 provide an indication of the forms that the cliff might adopt if it were to retreat. In the absence of intrusive ground investigations it is not possible to establish more precise estimates of these parameters.

Erosion of the base of the slope would clearly diminish its overall stability. The parameters in Table 6-1 suggest that, when over-steepened by wave action the undercliff width might approach 12 metres; after cliff failure this may be closer to 28 metres. This further suggests that erosion of around 16 metres might occur (in the area of transects B, C, and D) before cliff failure occurred. However, given that cliff failures are highly uncertain in terms of their size, frequency and also their pre-landslide angle, failure could well occur before this condition is reached. It is reasonable therefore to see the difference between the maximum and minimum undercliff widths as a zone of increasing instability; with recession through it increasing the likelihood of a cliff failure event. This raises the question of how rapidly the undercliff would be narrowed, and this instability increased.
RECESSION THROUGH THE UNDERCLIFF

Recession immediately north of the site is progressing at the high rate of around 1 metre per year, and this behaviour might be expected through the undercliff. However, it is clear that the coast here is out of alignment with its natural setting, and this strongly suggests that a process of ‘catch-up’ would be likely.

As was illustrated in Figure 16 the Middle Beach structures have allowed the land to project further across and down the beach profile than would naturally be the case. Once the structures are lost, the ground revealed behind will be steep, soft and immediately exposed to wave action. It is reasonable to expect, therefore, that there will be a period of rapid recession, above the longer term average rates in the area. This recession would continue until a more natural profile had re-emerged (see Walkden et al, 2015, for a fuller description of this mode of response).

PHASE 1 TIMEFRAME

Due to the narrow nature of the zone of increasing instability, the likelihood that catch-up processes will be significant, and the high neighbouring and historic recession rates, it is reasonable to project that the first phase of response to structure removal (i.e. the period over which the cliff face will be reactivated) will be short; it is estimated to be one decade.

6.2 PHASE 2 – RECESSION OF THE CLIFF FACE

Once the undercliff has been cut back and the cliff instability processes have been reactivated, the cliff will retreat through episodic failure events. Material that descends to the lower cliff will provide temporary protection, before it is removed by wave action, allowing further recession and cliff destabilisation. The size and frequency of failure events will vary randomly, but the average recession rate can be expected to be more regular.

The magnitude of this average recession rate is a key uncertainty. Historic and neighbouring recession rates at Middle Beach are unlikely to be a good indicator of the future because they represent retreat through dunes rather than cliff. In addition, there are no direct observations of the Middle Beach cliff geology, and even if there were, the relationship between geology and recession rate can be complex. For these reasons it is necessary to look to neighbouring areas for information. As has been noted above, the cliff immediately to the south of Redend point is shown in geological maps as being composed of the same material, and this is why historic mapping was examined to assess the rates of change in this area (which were between 0.17 and 0.20 metres per year, as described in Section 4.2).

INFLUENCE OF SEA LEVEL RISE

Sea level rise drives cliff retreat. As the rate of sea level rise increases, coastal cliffs are expected to retreat more rapidly. The Environment Agency publishes guidance on the future sea level rise, and this is reproduced in Table 6-2.

<table>
<thead>
<tr>
<th>AREA OF ENGLAND</th>
<th>1990 TO 2025</th>
<th>2026 TO 2055</th>
<th>2056 TO 2085</th>
</tr>
</thead>
<tbody>
<tr>
<td>East, east midlands, London, south east</td>
<td>4 (140 mm)</td>
<td>8.5 (255 mm)</td>
<td>12 (360 mm)</td>
</tr>
<tr>
<td>South West</td>
<td>3.5 (122.5 mm)</td>
<td>8 (240 mm)</td>
<td>11.5 (345 mm)</td>
</tr>
<tr>
<td>North west, north east</td>
<td>2.5 (87.5 mm)</td>
<td>7 (210 mm)</td>
<td>10 (300 mm)</td>
</tr>
</tbody>
</table>
It is not clear whether Studland would be within the south east or south west area, as defined by the Environment Agency, and so the average of the two has been adopted. This is shown in Figure 26.

\[ R_2 = R_1 \left( \frac{s_2}{s_1} \right)^{1/2} \]

Where \( R \) represents equilibrium recession rate and \( S \) the rate of sea level rise. Subscripts 1 and 2 represent past and future conditions respectively. Historic (relative) sea level rise in the area has been established by Haigh et al. (2009) from the Portsmouth tide gauge as between 0.9 and 1.5 mm/y.

If it is assumed that 10 years pass before the cliff recession is fully activated, then the Walkden and Dickson equation provides the recession rates shown in Figure 27. These are made based on the assumption that recession of the cliff face begins in one decade (i.e. in 2026). These rates are presented as upper and lower limits around a central estimate to capture uncertainty in: (1) historic sea level rise and (2) historic recession rates. It may be noted that the Environment Agency express their projection of future sea level rise in a deterministic manner, i.e. without an estimate of its uncertainty.
6.3 MAPPING FUTURE VULNERABILITY

Information provided in the preceding sections has been used to map zones of vulnerability across the Middle Beach car park. These have been mapped for 2045, which is a convenient year for financial planning purposes and also 2075. The later year is intended to provide a visual representation of the rate of growth of recession, and the associated uncertainties.

In order to represent the inherent uncertainties, both a ‘dynamic zone’ and a ‘vulnerable’ zone have been mapped, in red and orange respectively. The dynamic zone is intended to represent areas that it is reasonable to expect to be seaward of the cliff edge. The orange zone is intended to represent areas that may be seaward of the cliff edge, based on the assessment described above.

In each case the boundary between red and orange is defined by the minimum cliff recession distance shown in Figure 27 for the year in question (this is applied to the current cliff edge). The other (landward) boundary of the orange zone is defined by the maximum recession distance shown in Figure 27, plus the (16 metre) band of uncertainty in the undercliff width, defined in Table 6-1.
Figure 28. Projections of vulnerability across the Middle Beach car park in 2045.

Figure 29. Projections of vulnerability across the Middle Beach car park in 2075

The mapped zones have been curtailed across the most southern part of the car park; because uncertainties are particularly high and this is not the intended location of relocated assets.
It may be noted that the vulnerable zones (in orange) represent the areas within which the future cliff edge may migrate (depending chiefly on cliff recession rate and cliff angle). However the boundaries of these zones should not be interpreted as representing the likely future alignment of the cliff. It may be expected that the cliff edge will tend to become aligned with the general angle of the coast (indicated by the magenta lines).

It is reasonable to compare these results with SMP projections of future recession. To allow this, the SMP ‘Indicative erosion zone’ for 2055 (shown above in Figure 17) has been remapped in Figure 30, using the data presented in Table 4-1.

![Google earth](image)

**Figure 30. Shoreline Management Plan ‘Indicative erosion zone to 2055’**

When comparing this figure with Figure 28 and Figure 29 the following should be noted:

- Figure 30 represents a situation 10 years after that shown in Figure 28;
- Given the ambiguity in the spatial position of the SMP data presented in Table 4-1, Figure 30 shows the maximum distance given for this timeframe (32 metres); and
- No attempt has been made in this mapping to correct for the issues noted above in Section 4.1 (e.g. the SMP projections do not appear to account for coastal catch-up, cliff instability, accelerated sea level rise or the transition from dune to cliff).

The value of comparing the SMP projections with those of this study is therefore limited. Nevertheless it may be useful to note that the ‘dynamic zone’ for 2045 (Figure 29) is further landward than the Shoreline Management Plan ‘Indicative erosion zone’ for 2055 (Figure 30), despite representing an earlier condition.

Decisions on asset position based on Figure 29 would therefore be more conservative (safer) than decisions based on Figure 30.
CONCLUSIONS AND RECOMMENDATIONS

Studland Middle Beach is a small but highly valued recreational coastal site. It has many natural assets, including a sandy beach. However the beach is retreating due to a net loss of sediment from this area. Recession of the shoreline is currently prevented by two lengths of gabion coast protection that are, in some places, backed by slope stabilisation structures. Holding a retreating shoreline with linear hard defences tends to result in wave reflection and beach lowering, and this has happened at Middle Beach. The beach is now lower than it would naturally be, reducing the period of time that it is above the tide, and narrowing the area that can be accessed by visitors. If the structures were to be maintained then this trend would continue, and the situation would worsen. The structures are therefore progressively diminishing the natural value of Middle Beach.

In contrast the valuable built assets of Middle Beach (chiefly the café, business unit and Public Toilets, which are situated in the undercliff area) have benefited from the coast protection. That benefit is now coming to an end as natural shoreline recession and beach lowering undermines and outflanks the gabions and the existing timber slope stabilisation structure is damaged and lost. This process is progressive; it is most advanced in the north and should be expected to move towards the south.

This trend will increase the likelihood of landsliding through the undercliff area. Some signs indicative of slope movement are already present in front of the café outdoor seating area. Also of concern is the progressed state of disrepair of the slope stabilisation structure fronting the toilet building. The lack of an intact slope stabilisation structure here suggests that the sewerage system in this location is vulnerable to ground movement, which raises the hazard of cracking and a consequential contamination incident. It is recommended that ongoing attention be paid to signs of slope instability around this system, as relatively small movement could result in its rupture and consequential sewerage contamination.

In addition to the risks associated with loss of the existing built assets, coastal erosion and landsliding also brings the risk of the release of contaminated ground and pollution of water. There are several potential sources of such contamination that arise from the historic use of Middle Beach, its role during the Second World War and historic demolition of previous structures.

In formal terms it is considered that there is a Moderate risk to human health and controlled waters at the site. The potential implications are such that a focused ground investigation is recommended to assess potential contamination linkages. Confirmatory soil sampling should be undertaken to assess the identified potential contamination risks.

This study has explored alternative approaches to managing this coast in the future. These have ranged from policies that attempt to fix the current shoreline alignment through construction of new defences, through to those that allow coastal retreat (and management of the consequences). A ‘Do Minimum’ approach is unlikely to be effective because of the lowered beach, deteriorated state of the northern gabion wall, and the slope stabilisation structure behind it. It would not be reasonable to expect replacement gabions to remain stable, and so a more developed solution would be necessary; perhaps a rock revetment with a new slope stabilisation structure. For these reasons a ‘Do Minimum’ option would have to be similar to a ‘Hold the Line’.

An ‘Advance The Line’ approach could both prevent shoreline retreat and avoid the beach becoming entirely submerged. This coastline is, however, covered by a number of environmental designations that provide it with strict protection against projects that could result in detrimental impacts. This includes works that could affect the coastal processes or the coastal habitats. An ‘Advance the Line’ option, whilst providing coast protection and recreational benefits would also
be likely to result in detrimental impacts on habitats and morphology. Achieving cost effective mitigation of these impacts, coupled with the high capital and maintenance costs of an ‘Advance the Line’ have resulted in this option being rejected.

A policy of managing the coast to allow it to return to a more natural (eroding) state is therefore recommended. This would be in line with the coastal management policy for the area, as published in the local Shoreline Management Plan and is the most cost-effective solution.

This would involve decommissioning and removal of the existing coast protection and built assets and so would come with significant losses in the short term. Also, as the cliff becomes active, hazards associated with falling material and (people) falling from height would increase. Consequently it is recommended that an appropriate safety assessment be undertaken of associated issues before the cliff becomes active.

Such an approach would also make the hazard of contaminated sediment release more pressing. As noted above, a more focussed study of the contamination hazard is recommended, with intrusive investigation and sampling. The results of that study should be used to plan the appropriate excavation and disposal of any contamination found before decommissioning of coast protection.

If services are to be maintained through the installation of new facilities then it is recommended that these are not located in the undercliff area, unless they are self-contained temporary buildings. Such buildings (if used) should be located on the south side of the road, where the existing coast protection structures appear to be more intact and effective.

More permanent facilities should be located behind the cliff line. These should be designed with the expectation that the cliff will retreat and would (ideally) be moveable, with services (e.g. water supply, power and sewerage) arranged accordingly. This study contains mapping of future cliff positions to aid the appropriate placement of such facilities. Clearly the further landward these structures are positioned then the longer will be the period of time before they would have to be decommissioned/ relocated. However the value of these facilities for visitors diminishes as their distance from the coast increases. It is recommended that the vulnerability maps provided within this report be used to identify an optimum location.

The question of what slope the cliff and undercliff would adopt is an important one, as it relates to both the future position of the cliff, and angles to which these may be cut during the decommissioning of coast protection. The angles derived and used in this report are based on analysis of contemporary LiDAR data, and are presented in Table 6-1. These provide an indication of the forms that the cliff might adopt if it were to retreat. It is not possible to establish more precise estimates of these parameters (using the data available to this study) in the absence of intrusive ground investigations.

Any mapping of future shorelines is subject to uncertainty. In this study uncertainty has been managed through: (1) quantification (of the historic rate of sea level rise, the proxy cliff recession rate and undercliff width), (2) use of standard guidance (e.g. the EA projection of future sea level rise) through the adoption of conservatism (e.g. in the use of the Walkden and Dickson equation) and by employing expert judgement.

The mapping is conditional on the accuracy of the local geological map, the homogeneity of the geological strata and also the characteristics of the pre/ post landslide slope of the cliff, whilst eroding. Further geotechnical investigations would be likely to provide useful informative in this respect. Consequently, if greater confidence in projected recession rates is need then it is recommended that intrusive ground investigations be undertaken. Such investigations should map the underlying geology, assess likely slope characteristics and test the assumption that the material of the cliff is the same as that found on the south of Redend Point. Geotechnical investigations would also allow more informed estimation of the timeframes around losses of the Middle Beach assets.
BIBLIOGRAPHY


