

HOLBECK – SCALBY MILLS COASTAL DEFENCE STRATEGY

CONTENTS

	Page No.
Project Background	2
Project Methodology	3
The Management Strategy - Fundamental Principles	5
• Seawalls and Breakwaters	
• Land Stability	
Seawall Strategy	6
Wave Overtopping Strategy	7
Cliff Strategy	8
Recommended Further Studies	9
Implementation of the Management Strategy	10
Instrumentation	12

TABLES

1. Summary Table of the Problems Encountered within the Different Coastal Sections
2. Urgent Capital Schemes and Possible Future Improvements
3. Estimated Costs of Implementing the Management Strategy (Year 1-5)
4. Preliminary Scheme Prioritisation and Programme Table (Year 1-60)
5. Summary of the Economics of the Proposed Urgent Capital Schemes

FIGURES

1. A Plan Showing Management Strategy Study Areas and Borehole Inclinator Locations
2. A Summary of the Strategy options
3. A Summary of the Management Strategies for Each Coastal Section

Project Background

The coastal defences of the Scarborough urban area in general terms consist of a series of seawalls and breakwaters which protect the significant assets within the coastal margin of the town from the daily demand of the impact of the North Sea.

Most of the defences along this frontage are old and are either reaching the end of their design life or are in need of regular and costly maintenance.

Inherently the coast at Scarborough is throughout most of its length formed by high cliffs which still retain the legacy of instability initiated by coastal erosion prior to the construction of the coastal defences during the last century or early 20th century.

Thus the town infrastructure is currently threatened by an ageing coastal defence system backed by cliff slopes which have the potential to be unstable to varying degrees.

The Huntcliffe (Saltburn) to Flamborough Head Shoreline Management Plan (SMP) provides the basis for sustainable coastal defence policies along the North Yorkshire coastline.

Further development of these policies specifically for the Scarborough urban coastline involves the production of a Coastal Defence Strategy Plan.

The principal objectives of the Holbeck to Scalby Mills Coastal Defence Strategy Study has been to:

- review all aspects of the coastal defences;
- identify relative priorities and approaches to remedial action;
- form the guideline for the management of the coastal defences within Coastal Process Units 20, 21 and 22 for the next 60 years. These Units have been identified by the Shoreline Management Plan and can be most simply described as being North Bay, Castle Headland, and South Bay; and,
- identify scheme options, priorities, estimates of capital spend and programmes for action including maintenance regimes and monitoring.

Project Methodology

The complete urban area of Scarborough has been divided into 15 sections or Coastal Strategy Study Sections. These are further subdivisions of the SMP subsections and are based on coastal defence units and cliff conditions.

Work included:

- Assessment of nature and conditions of seawalls and breakwaters;
- Assessment of the extent of flooding, coast erosion and cliff instability problems;
- Review history of damages from flooding and instability by means of newspaper reports, maps, charts etc.;
- Review of coastal defence repair costs (historic);
- Identification of environmental issues for each management unit and environmental/ planning issues for potential schemes;
- Setting of specific coastal defence and related environmental objectives for each management unit;
- Review and analyse historic, current and future coastal and beach processes; assess their significance on scheme options;
- Accurate measurements of contemporary ground movement;
- Define risk to existing defences;
- Develop cliff behaviour models. Prepare recession scenarios;
- Identification of coastal defence strategies and a range of scheme options for each management unit;
- Identification, quantification and value of costs, benefits and uncertainties for the preferred option for each management unit;
- Prioritisation of the necessary works;
- Develop a programme of works for the maintenance/ improvements of the coastal defence; and,
- Recommendations of timescale for investment.

In order to achieve these aims a series of investigations and studies were carried out. These included:

- Site investigations of the key areas included sinking 27 boreholes through glacial till and bedrock, which were instrumented with:

14 inclinometers
38 piezometers

- Structural survey of all seawalls and breakwaters; and,
- Analysis and computer modelling of the overtopping performance of the existing seawalls and breakwaters (HR Wallingford).

Analysis and interpretation:

- Consequences and seawall failure;
 - Assess wave overtopping;
 - Risk assessment to the threat to seawalls from landslides;
 - Ranking of the coastal defence options;
 - Preliminary environmental assessment of options;
 - Costings of the preferred strategies;
 - Cost benefits of the preferred options; and,
 - MAFF scoring systems.
- The costing profile for the coastal defence strategy has been prepared.
 - If the strategy is adopted by the Council this will be integrated with the Council's existing capital expenditure programme.

The Management Strategy

Fundamental Principles

Seawalls, Breakwaters and Foreshore

- promote and undertake urgent improvements to seawalls and breakwaters at high risk (allowing for the effects of sea-level rise);
- design and implement regular programme of seawall and breakwater inspection and maintenance;
- carry out monitoring and management of foreshore and beach levels; and,
- develop contingency plans for the emergency response to serious problems e.g. seawall breaches.

Land Stability

- design and undertake regular monitoring, slope inspections and maintenance of the slopes;
- develop contingency plans for emergency stabilisation measures to a major landslide (and eventual seawall breaches); and,
- continuous consideration of the coastal environment and coastal management objectives.

The Seawall Strategy

Seawall Strategy, S1:

- promote and undertake urgent capital schemes involving the provision of improved coast protection structures where:

there is a high probability of breaching with considerable potential asset losses.

Seawall Strategy, S2:

- design and undertake systematic monitoring and visual inspection of the seawalls to ensure that problems are identified early;
- undertake modest repairs to the seawalls and breakwaters when required, as Emergency Works where:

there is a relatively high probability of breaching, but where breaches could be accessed and could be repaired with minimal short-term threat to adjacent assets.

Wave Overtopping Strategy

Wave Overtopping Strategy, W1:

- improve wave overtopping performance as and when urgent capital schemes (Strategy S1) or emergency seawall repairs (Strategy S2) are implemented.

Wave Overtopping Strategy, W2:

- to undertake foreshore management practices to minimise the flooding problems, notably through ensuring that roads are kept open (except during flood events).

The strategy could involve:

- beach monitoring and management;
- consideration of the potential for a raised foreshore;
- Environment Agency operated flood warnings;
- the use of sand bags etc. by the local businesses and residents to minimise flood damage to the seafront properties;
- the closure of roads by the Police in conjunction with the local authority and Coastguard during high flood risk;
- emergency response by the Environment Agency, local authority, police, fire service, etc. during major flood events;
- clean-up of sand and debris after a flood event by the local authority and local businesses and residents; and,
- to review the effectiveness of the strategy on an annual basis and undertake flood defence improvements when the frequency and scale of losses becomes unacceptable.

Wave Overtopping Strategy, W3:

- to monitor the wave overtopping problems and record the level of damage or losses.

The Cliff Strategy

Cliff Strategy, C1:

- to consider and undertake capital schemes involving slope stabilisation on sections as and when urgent capital schemes (Strategy S1) or emergency seawall repairs (Strategy S2) are implemented

Cliff Strategy, C2:

- to design and undertake a regime of cliff management;
- investigate and treat small-scale landslips as and when they occur to ensure that they do not expand and initiate a major failure;
- implement a combination of automatic and manual monitoring, together with visual inspection and recording to detect early signs of landsliding; and,
- undertaking emergency preventative measures as and when required.

Cliff Strategy, C3:

- to monitor cliff recession on the unprotected coast and the frequency of rock fall activity, with coast protection or cliff treatment works undertaken as and when necessary.

The specific strategies discussed will be complemented by:

- **Maintenance** to ensure that structures and slopes are not allowed to deteriorate to a condition where serious problems become likely;
- **Further studies** to assist the development of sustainable seawall and breakwater improvements i.e. sediment transport studies, physical model studies, additional monitoring sites and automatic monitoring etc.

Recommended Further Studies

A number of additional studies form part of the management strategy, to assist the development of sustainable seawall and breakwater improvements. These include:

1. a **sediment budget study**; which addresses the need to identify and quantify the contemporary sources of beach building material along the North Yorkshire coast, and the sediment transport pathways to North and South Bay.
2. **physical model studies** of North Bay and South Bay, to test the hydrodynamic impacts of the proposed scheme improvements, including beach control measures, rock revetments etc.
3. **hydrographic survey studies** to provide data for the above studies.

Implementation of the Management Strategy

Table 1 summarises the problems encountered within the different coastal sections along the Scarborough coastline.

The proposed schemes subdivided into **urgent capital schemes** and possible future improvements on the basis of priority are summarised in Table 2. The urgent capital schemes comprise:

- i. East Pier;
 - ii. Marine Drive (including The Holms);
 - iii. The Spa complex, including the Spa Chalet cliff.
-
- Design of the urgent capital schemes at East Pier to Marine Drive would run in parallel with a programme of sediment transport studies and physical model studies, which would be supplemented by hydrographic survey studies.
 - If the East Pier and Marine Drive schemes were to be combined, then there could be significant cost and time savings compared with separate contracts.
 - By treating these high risk sections as early as possible, the possibility of breaching and subsequent emergency works will be considerably reduced.
 - The programme strategy is a “living document” and needs to be subject to periodic review on a 5 yearly cycle, as priorities may change.
 - The estimated costs of implementing the strategy over the next 5 years are listed in Table 3, which includes the estimated costs of the proposed urgent capital works (£27m) along with costs for monitoring, maintenance and management, and a contingency for emergency repairs. Table 4 summarises the programme of works and includes the anticipated annual level of expenditure required to implement the strategy over a 60 year period.

- The total costs identified need to be examined further to clarify the breakdown of costs between Scarborough Borough Council, MAFF and other possible sources of funding.
- Each proposed scheme has a Benefit: Cost ratio in excess of 2.5 and MAFF priority scores of 22-26. The estimated costs and benefits of implementing the proposed strategy over the next 60 years are listed in Table 5. However, these costs will need to be reviewed and adjusted if the priorities for capital schemes are changed in subsequent revisions to the management strategy.

The next steps to implement the management strategy should involve the development of:

1. detailed engineering solutions for each of the high priority proposed capital schemes, including environmental assessment and economic evaluation;
2. procedure and implementation of ongoing programme of monitoring, inspection and recording for the slopes, seawalls and foreshore;
3. maintenance programmes for critical sections;
4. contingency plans for emergency slope, seawall works and foreshore;
5. commissioning further detailed studies to assist the development of sustainable engineering solutions; and,
6. a 5-yearly review of the management strategy, taking into account changing priorities and improved understanding of the coastal and slope processes.

HOLBECK SCALBY MILLS COASTAL DEFENCE STRATEGY

COASTAL SLOPE MONITORING - INSTRUMENTATION

- The coastal slopes can be expected to behave differently because of the sensitivity to the effects of destabilising factors (such as rainfall, geology and human activity) will vary from one cliff unit to another.
- Monitoring is critical. Signs of pre-failure movement, identified from regular inclinometer readings and site inspections, will reveal evidence of deterioration in stability that could lead to landsliding and consequential seawall breaches.
- Extensive borehole instrumentation has been installed to monitor groundwater levels and ground displacements undertaken during the site investigation.
- The total number of piezometers installed was 38 between Clarence Gardens (MU 20B/1) and Holbeck Gardens (MU 22B/6).
- The total number of inclinometers installed was 14 between Clarence Gardens (MU 20B/1) and Holbeck Gardens (MU 22B/6).
- Inclinometer monitoring was originally carried out during the maintenance period of the site investigation by Norwest Holst (the Contractor for the SI).
- On completion of the maintenance period the inclinometer monitoring was awarded to Soil Mechanics for 12 months commencing November 1998. The frequency of reading is presently once every 2 months with an option to take additional readings should analyses of the data warrant further investigation.

TABLE 1 A SUMMARY OF THE PROBLEMS ENCOUNTERED WITHIN THE DIFFERENT COASTAL SECTIONS

	Wave Overtopping	Seawall Structural Failure	Landsliding: Major First-time Failure	Landsliding: Reactivation of Major Pre-existing Slides
Sea Life Centre	⊕	●	★	★
North Cliff	⊕	●	★	★
Clarence Gardens	⊕	●	○	○
The Holms	⊕	●	★	○
Marine Drive	⊕	●	★	★
The Harbour	⊕	●	★	★
Foreshore Road	⊕	○	★	○
Spa Chalet	⊕	○	○	★
Spa Cliff	⊕	●	○	○
South Cliff Gardens	⊕	●	★	○
Rose Gardens	⊕	●	○	★
South Bay Pool	⊕	●	★	○
Holbeck Gardens	⊕	●	○	★
Holbeck Cliff	⊕	○	★	○
Wheatcroft Cliff	★	★	○	○

Expected Frequency

- ⊕ Very High Problem expected 1 in 1 years
- High Problem expected 1 in 1 year - 1 in 25 years
- ⊙ Moderate Problem expected 1 in 25 years to 1 in 50 years
- Low Problem expected > 1 in 50 years
- ★ Not applicable to section

Notes:

1. Overtopping: overtopping discharge of 1 l/s/m within 10m of the seawall (maximum tolerable discharge for pedestrians and vehicles)
2. The consequences of these problems vary between sections
3. Reference to landsliding excludes minor landslides which if left untreated could initiate major failure.

TABLE 2 THE URGENT CAPITAL SCHEMES AND POSSIBLE FUTURE IMPROVEMENTS

Coastal Section	Urgent Capital Schemes
Harbour (East Pier)	1:2 rock armour revetment (crest elevation 6.5mOD) along seaward side of breakwater, with recurved wave return wall at crest.
Castlehead Marine Drive (S)	1:2 rock armour revetment (crest elevation 7.5mOD) along seaward side of sea wall, with recurved wave return wall at crest.
The Holms	1:2 rock armour revetment (crest elevation 7.5mOD) along seaward side of sea wall, with recurved wave return wall at crest.
Spa Complex (including Spa Chate/ Spa Access Road)	≈30m reclamation to provide toe restraint to landslide, non reflective, wave screen wall seaward of reclamation (crest elevation 7.0mOD) with recurved wave return wall
Possible Future Improvements	
Holbeck Gardens	Abandon lower promenade, 1:2 rock armour revetment with recurved wave return wall adjacent upper promenade level (crest elevation 6.0mOD)
South Bay Pool	1:2 Rock armour revetment adjacent to existing promenade (crest elevation 3.5mOD), infill bathing pool. 1:2 sloping concrete block seawall rising from crest of rock armour wall, with recurved wave return wall at 6.5mOD, level area for redevelopment at 7.0mOD
Rose Gardens	Demolish lower promenade, 1:2 rock armour revetment (crest elevation 6.5mOD), recurved wave return wall adjacent to upper promenade
South Cliff Gardens	Raise lower promenade level to 6.5mOD with recurved wave return wall along outer edge, 1:2 rock wall adjacent to upper promenade
Foreshore Road	Construct flood protection barriers
Foreshore Road (St Nicholas Cliff)	≈30m reclamation to provide toe restraint to landslide, non reflective, wave screen wall seaward of reclamation (crest elevation 7.0mOD) with recurved wave return wall. Transition zone into adjacent Spa area
Clarence Gardens	Sand recharge (crest elevation 3.0mOD), recurved wave return wall along existing sea wall.
North Cliff	Sand recharge (crest elevation 3.0mOD), recurved wave return wall along existing sea wall.
Sea Life Centre	A 50m wide rock armour apron.

NOTES

1. All Cliff Sections: Monitoring of existing instrumentation, and routine inspection required to assess onset of instability
2. All scheme options subject to confirmation based on further studies, modelling and detailed design

TABLE 3 ESTIMATED COSTS OF IMPLEMENTING THE MANAGEMENT STRATEGY (YEAR 1-5)

	Urgent Capital Schemes	Studies	Emergency Repairs	Monitoring	Foreshore management	Cliff management	Maintenance	Strategy Consultant Fees
Sea Life Centre		12	37.5	1	1		10	1
North Cliff		12	20.2	1	1	8.75	10	1
Clarence Gardens		12	31.2	1	1	12	10	1
The Holms	4500	12	9.4	1	1	10	10	1
Marine Drive	8500	12	34.5	1	1		10	1
The Harbour	4500	12	45	1	1		10	1
Foreshore Road		12	3.3	1	10	4.5	10	1
Spa Chalet Cliff	3500	12	3.5	1	1	4.5	10	1
Spa Cliff	6000	12	6.5	1	1	7.5	10	1
South Cliff Gardens		12	18.5	1	1	3.5	10	1
Rose Gardens		12	18.3	1	1	4.5	10	1
South Bay Pool		12	20	1	1	3.5	10	1
Holbeck Gardens		12	20	1	1	4.5	10	1
Holbeck Cliff		12	5.5	1	1	3	10	1
Wheatcroft Cliff		12	-	1	1	0.5	10	1
Annual Total	27000	180	273.4	15	23	66.75	140	15
Total PV (Year 1-5)	27000	180	1211.162	66.45	101.89	295.70	620.2	90*
Overall Total (PV Year 1-5)	29475.40							

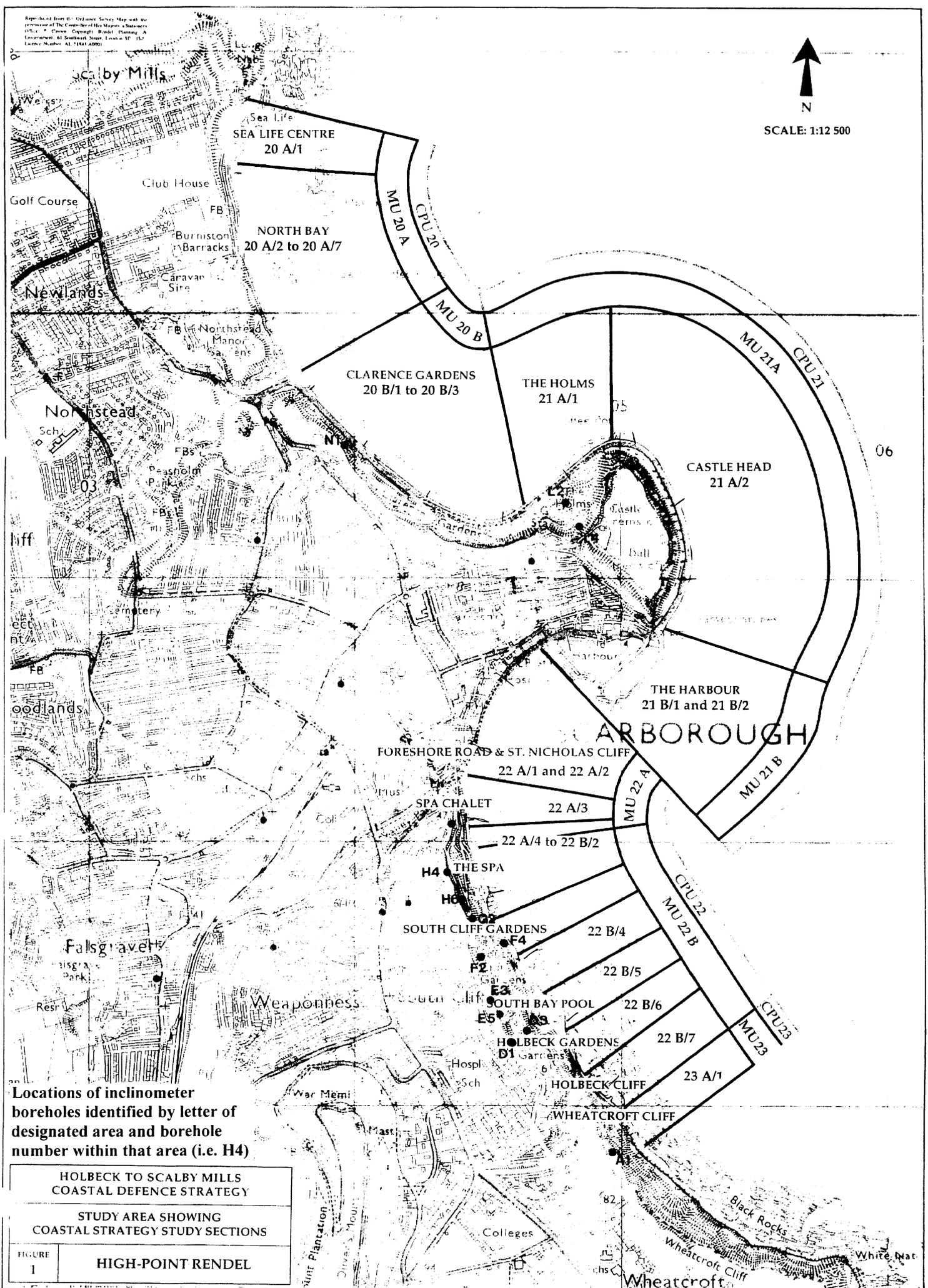
Notes:

1. the estimated costs for emergency works are calculated as follows: Annual Probability of Breach x Estimated Cost of Repairs (£250K)
2. the estimated costs for cliff treatment works are calculated as follows: Annual Probability of Landslide x Estimated Cost of Repairs
3. all costs £ x 1000

* Includes £15,000 initial set up fee



SCALE: 1:12 500



Locations of inclinometer boreholes identified by letter of designated area and borehole number within that area (i.e. H4)

HOLBECK TO SCALBY MILLS COASTAL DEFENCE STRATEGY	
STUDY AREA SHOWING COASTAL STRATEGY STUDY SECTIONS	
FIGURE 1	HIGH-POINT RENDEL

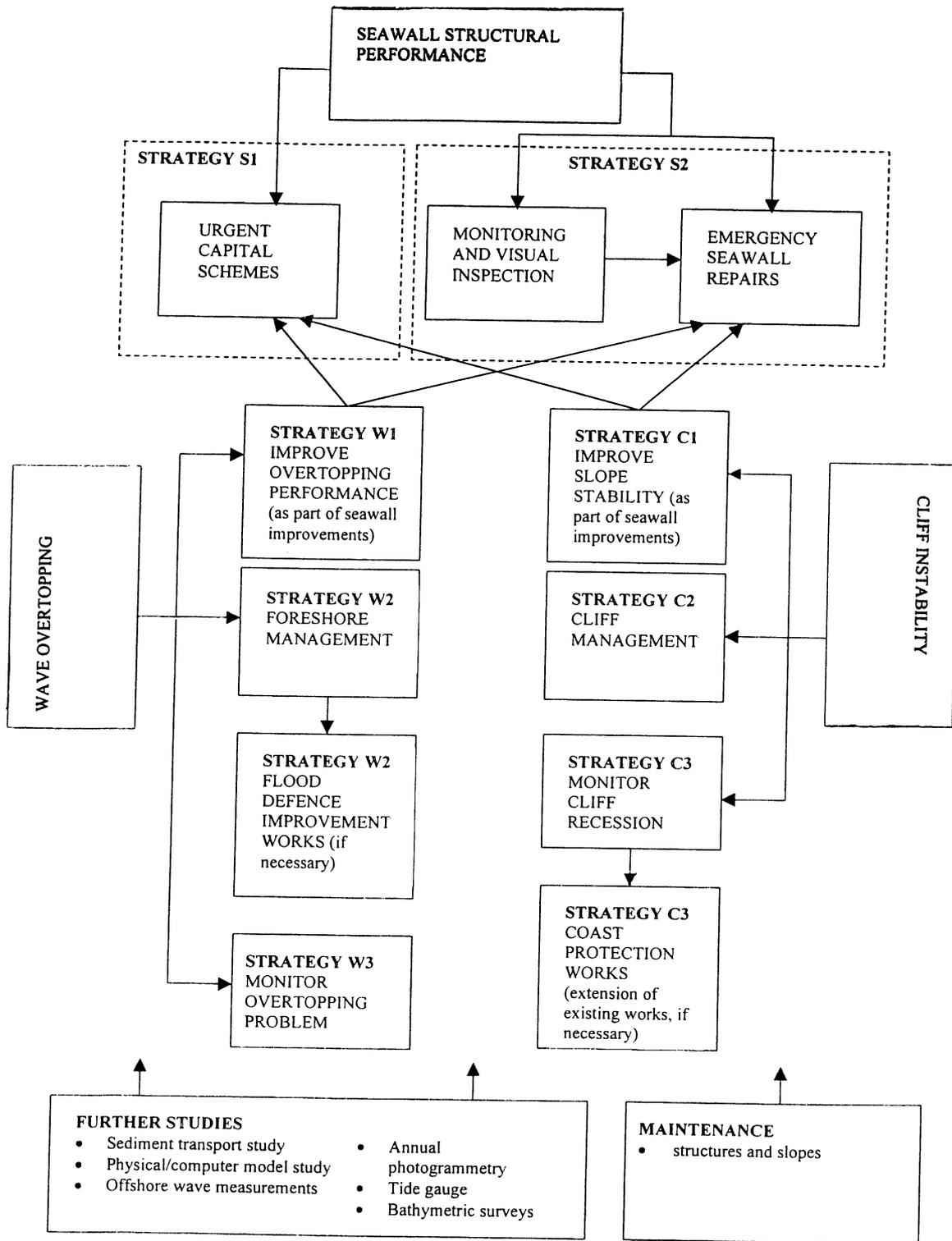
TABLE 5 SUMMARY OF THE ECONOMICS OF THE PROPOSED URGENT CAPITAL SCHEMES

	PV Damages		Seawall Strategy	Estimated Benefit		MAFF Prioritisation Score			Total
	(£K)	Ranking		Cost (K)	Cost ratio	Priority	Urgency	Economics	
Sea Life Centre	21860	4	Monitoring/emergency repairs	807	27.1	8	8	10	26
North Cliff	6629	9	Monitoring/emergency repairs	542	12.2	8	8	10	26
Clarence Gardens	15001	8	Monitoring/emergency repairs	721	20.8	8	8	10	26
The Holms	16406	7	Urgent capital scheme	4728	3.5	8	8	8	24
Marine Drive	17982	5	Urgent capital scheme	8679	2.1	8	8	6	22
The Harbour	46159	1	Urgent capital scheme	4745	9.7	8	8	10	26
Foreshore Road	16479	6	Monitoring/emergency repairs	469	35.1	8	8	10	26
Spa Chalet	36510	3	Urgent capital scheme	3753	9.7	8	8	10	26
Spa Cliff	40514	2	Urgent capital scheme	6301	6.4	8	8	10	26
South Cliff Gardens	3535	11	Monitoring/emergency repairs	513	6.9	8	8	10	26
Rose Gardens	3207	12	Monitoring/emergency repairs	509	6.3	8	8	10	26
South Bay Pool	3846	10	Monitoring/emergency repairs	538	7.1	8	8	10	26
Holbeck Gardens	2579	13	Monitoring/emergency repairs	538	4.8	8	8	10	26
Holbeck Cliff	399	14	Monitoring/emergency repairs	301	1.3	8	8	2	18
Wheatcroft Cliff	8	15	Monitoring/emergency repairs	8	1.0	8	8	2	18

Note: Wheatcroft Cliff currently unprotected; monitoring proposed with possible long term requirement for limited transition works.

STRATEGY STUDY AREA NOTATIONS

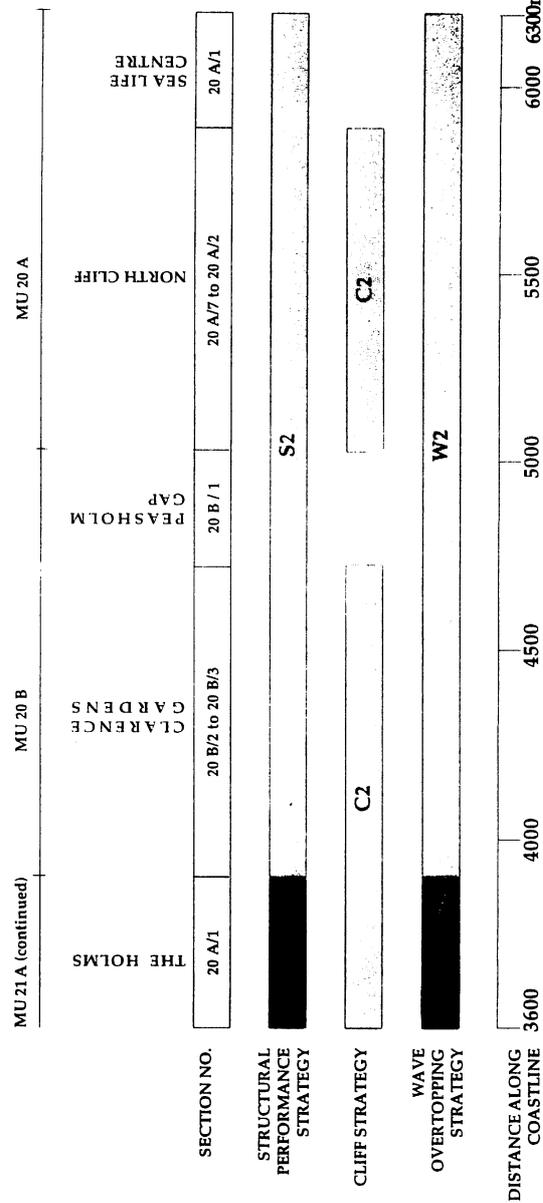
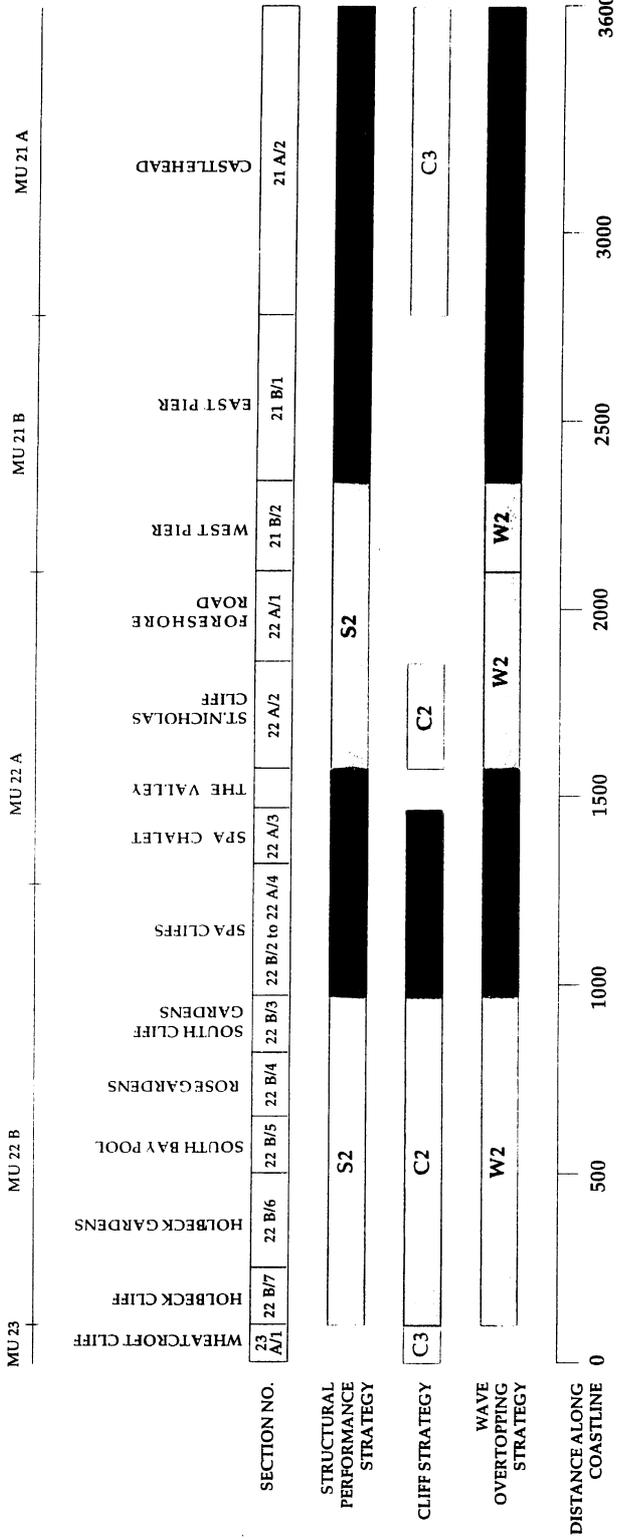
Littoral Sub Cell	Coastal Process Unit	Scarborough Area	SMP Management Unit	Coastal Strategy Study Section	Preliminary Risk Assessment Report	Coastal Strategy Scheme Section	North Co-ordinate of Section	
							Northing	Easting
1d Huntcliff to Flamborough Head	20	North Bay	MU20A	20 A/1 Sea Life Centre		Sea Life Centre	490825.0	503565.45
				20 A/2 North Cliffs		North Cliffs	490569.1	503540.85
				20 A/3 Burniston Cliffs				
				20 A/4 – A/6 Northstead Cliffs				
				20 A/7 Corner Cliff				
			MU20B	20 B/1 Peasholm Cliff	O	Clarence Gardens	489795.92	503759.69
				20 B/2 Clarence Gardens North	N			
				20 B/3 Clarence Gardens South	M			
			21	Scarborough Castle Headland	MU21A	21 A/1 The Holms	L	The Holms
	21 A/2 Castlehead	K				Castlehead	489523.34	504972.98
	MU21B	21 B/1 East Pier				The Harbour	488826.33	505172.43
		21 B/2 West Pier						
	22	South Bay	MU22A	22 A/1 Foreshore Rd		Foreshore Rd	488731.25	504692.65
				22 A/2 Blands Cliff	J			
				22 A/3 Spa Chalet	I	Spa Chalet	488300.0	504438.42
				22 A/4 Spa Cliff	H	Spa Cliff	488055.69	504427.83
				22 B/1 Spa Cliff				
				22 B/2 Prince of Wales Cliff	G			
				22 B/3 South Cliff Gardens	F	South Cliff Gardens	487707.06	504508.02
				22 B/4 The Rose Garden	E	The rose Garden	487556.46	504611.13
			MU22B	22 B/5 South Bay Pool	D	South Bay Pool	487428.15	504708.21
				22 B/6 Holbeck Gardens	C	Holbeck Gardens	487300.00	504788.24
				22 B/7 Holbeck Cliff	B	Holbeck Cliff	487130.33	504881.59
23 A/1 Wheatcroft Cliff				A	Wheatcroft Cliff			
23				MU23				



HOLBECK TO SCALBY MILLS COASTAL DEFENCE STRATEGY

A SUMMARY OF THE STRATEGY OPTIONS (KEY FACTORS INFLUENCING COASTAL DEFENCE STRATEGY ARE SHADED)

FIGURE 2 HIGH-POINT RENDEL



**HOLBECK TO SCALBY MILLS
COASTAL DEFENCE STRATEGY**

**A SUMMARY OF THE MANAGEMENT STRATEGIES
FOR EACH COASTAL SECTION**

FIGURE
3

HIGH-POINT RENDEL

NOTE: Individual strategies involve a combination of specific structural (S), wave overtopping (W) and cliff (C) strategies, for descriptions see the Management Strategy section.