

GIS-based assessment of coastal flood and erosion risk in England

Method statement

A report prepared for the Committee on Climate Change, UK



SAYERS
AND PARTNERS

REPORT INFORMATION

Report Title: GIS-based assessment of coastal flood and erosion risk in England.
Project Number: P1127
Date started: October 2018
Contractor: Sayers and Partners LLP
Address: 24a High Street, Watlington, OX49 5PY UK,
Contact: Phone: +44 1865 600039
Website: www.sayersandpartners.co.uk
Lead Author: Paul Sayers
Phone(s): +44 1865 600039, +44 7711 798786
E-mail(s): paul.sayers@sayersandpartners.co.uk

Citation suggestion:

Sayers PB (2018) GIS-based assessment of coastal flood and erosion risk in England. Research undertaken by Sayers and Partners on behalf of the Committee on Climate Change. Published by Committee on Climate Change, London.

Approval for release to client:

Name	Position	Project Role	
Paul Sayers	Partner	Lead	

Distribution:

Name	Organisation and contact
Andrew Russell	Committee on Climate Change
Kathryn Brown	Committee on Climate Change

Document revision history:

Version	Date	Author(s)	Description
0.0	18 October 2018	Paul Sayers	Spreadsheet data and method for review
1.0	12 November 2018	Paul Sayers	Summary report
2.0	16 November 2018	Paul Sayers	Updated in response to comments
2.1	22 November 2018	Paul Sayers	Updated in response to comments

Acknowledgments:

The contributions of Andrew Russell (Project Manager), Kathryn Brown and Prof. Jim Hall (Adaptation Sub-Committee member and Director of the Environmental Change Institute, University of Oxford) are gratefully acknowledged together with the research team at Sayers and Partners LLP.

SUMMARY

This report summaries the approach to the analysis of future erosion and flood risks based on published Shoreline Management Plan policies (and associated Policy Management Units and the assessment of costs and benefits developed by Jacobs) together with National Coastal Erosion Risk Management (NCERM, England), Flood Zone and National Receptor Datasets.

The analysis was undertaken during September and October 2018.

Keywords: flood, erosion, coastal risk, climate change, risk assessment, adaptation

NOTICE

This report was prepared under an Agreement made on the 19 October 2018 between the Committee on Climate Change (CCC) of 7 Holbein Palace London and Sayers and Partners LLP.

Sayers and Partners, nor any other person acting on their behalf (a) makes any warranty, express or implied, or assumes any legal responsibility for the accuracy of any information contained in this report or for the completeness or usefulness of any apparatus, product or process disclosed in the report, (b) accepts any liability for the use of, or damages resulting from the use of this report or any apparatus, product or process disclosed in this report or (c) represents that the use of such apparatus, product or process would not infringe upon the rights of third parties.

Any reference in this report to any specific commercial product, process or service by tradename, trademark, manufacturer or otherwise does not necessarily constitute or imply its endorsement or recommendation.

Copyright © 2018 Sayers and Partners LLP. All rights reserved.

Table of contents

1.0	INTRODUCTION	4
1.1	Aims and objectives.....	4
1.2	Target audience.....	4
1.3	Report structure	4
2.0	ASSESSING EXPOSURE TO COASTAL FLOODING IN ENGLAND	5
2.1	Spatial coverage	5
2.2	Temporal coverage	5
2.3	Data used	5
2.4	Analysis approach.....	5
3.0	ASSESSING EXPOSURE TO COASTAL EROSION IN ENGLAND	8
3.1	Spatial coverage	8
3.2	Temporal coverage	8
3.3	Data used	8
3.4	Analysis approach.....	8
4.0	ASSESSING THE BENEFITS AND COSTS OF COASTAL MANAGEMENT IN ENGLAND	11
4.1	Spatial coverage	11
4.2	Temporal coverage	11
4.3	Data used	11
4.4	Analysis approach.....	11

Figures

<i>Figure 2-1 Coastal flooding: An illustration of the analysis steps</i>	<i>6</i>
<i>Figure 2-2 Coastal flood exposure (Present day and in the absence of defences) - Summary results residential and non-residential properties.</i>	<i>7</i>
<i>Figure 3-1 Coastal erosion: An illustration of the analysis steps</i>	<i>9</i>
<i>Figure 3-2 Coastal erosion - Summary results: Expected erosion losses by a given epoch: Residential properties.</i>	<i>10</i>

Tables

<i>Table 1 Summary of SMP policies, costs and benefits</i>	<i>13</i>
--	-----------

1.0 INTRODUCTION

The Adaptation Sub-Committee (ASC) of the Committee on Climate Change commissioned Sayers and Partners to undertake additional GIS-based analysis in support of their assessment of future coastal risks in England and the benefits and costs of the stated Shoreline Management Plan policies. This report provides an overview of the method for this supporting analysis.

1.1 Aims and objectives

The project objectives set out by the ASC (Brown to Sayers 3 August 2018):

- *Analysis requirement (flooding)*: Count the number of properties in the floodplain for each Policy Management Unit (PMU) (properties located in flood zone 2 and flood zone 3) – using the EA Flood Map polygons for coastal flooding and the GIS property location dataset. Divide the floodplain between PMUs using a normal to the coastline (or similar method).
- *Analysis requirement (erosion)*: Using a GIS property location dataset and a GIS layer of erosion contour vectors, count the numbers of properties in each SMP for each erosion contour. To disaggregate this to policy unit level, cut up the strip of properties associated with each erosion contour into sub-strips for each PMU. To do this, project a normal to the coastline at the end of each PU, using a shoreline vector sub-divided into Policy Units.

A subsequent request was made (Russell to Sayers 25 September 2018) to provide a high level, rapid assessment of the benefits and costs of SMP policy choices, based on the new GIS data above. To do this, results of the above assessments were considered alongside the analysis into costs and benefits completed by Jacobs (2018).

1.2 Target audience

The primary audience for this report is the ASC (as represented by Andrew Russell).

1.3 Report structure

The method statement is divided into two primary chapters:

- **Chapter 2:** Assessing exposure to coastal flooding in England
- **Chapter 3:** Assessing exposure to coastal erosion in England
- **Chapter 4:** Assessing the benefits and costs of coastal management in England

2.0 ASSESSING EXPOSURE TO COASTAL FLOODING IN ENGLAND

2.1 Spatial coverage

The analysis covers England only.

2.2 Temporal coverage

The analysis reflects exposure to coastal flooding in 2018.

Note: The assessment does not consider the potential expansion of the coastal floodplain due to sea level rise in the future.

2.3 Data used

- National Receptor Datasets provided by the ASC under licence (including WAAD Reportable field as used by State of the Nation, 2018)
- Environment Agency Flood Zones: v201802 (Feb 2018)
- Policy Management Units (PMU) from ShorelineManagementPlan2.shp Open Data downloaded from data.gov.uk on 10/08/18

2.4 Analysis approach

Select the Flood Zone 2 polygons where type is 'tidal' or 'coastal'

- Identify the start and end nodes of each PMU
- Project a shore normal from each node to the Flood Zone 2 boundary (inland from the coast)
- Manually review to ensure that the sub-division of the Flood Zone is sensible in complex settings such as estuaries and coastal inlets (particular in areas where the PMU differs on either side of the estuary or inlet)
- Limit the inland floodplain extent in major estuaries (such as the Humber and the Thames) to avoid counting properties that are located inland from end of the SMP / policy unit.
- Find the nearest PMU to each Flood Zone 'portion'.
- Select all property points that fall within the Flood Zone 2 and assign appropriately to a PMU
- Select all property points that fall within the Flood Zone 3 and assign appropriately to a PMU
- Package the data into a spreadsheet to record the number of floodplain properties associated with each PMU (for present day only).

The analysis approach is illustrated in Figure 2-1 with summary results (by SMP) provided in Figure 2-2.

Full results are available in the spreadsheets that accompany this report: Full results are available in the file "Flooding - By PU - All properties v4_1.xlsx"

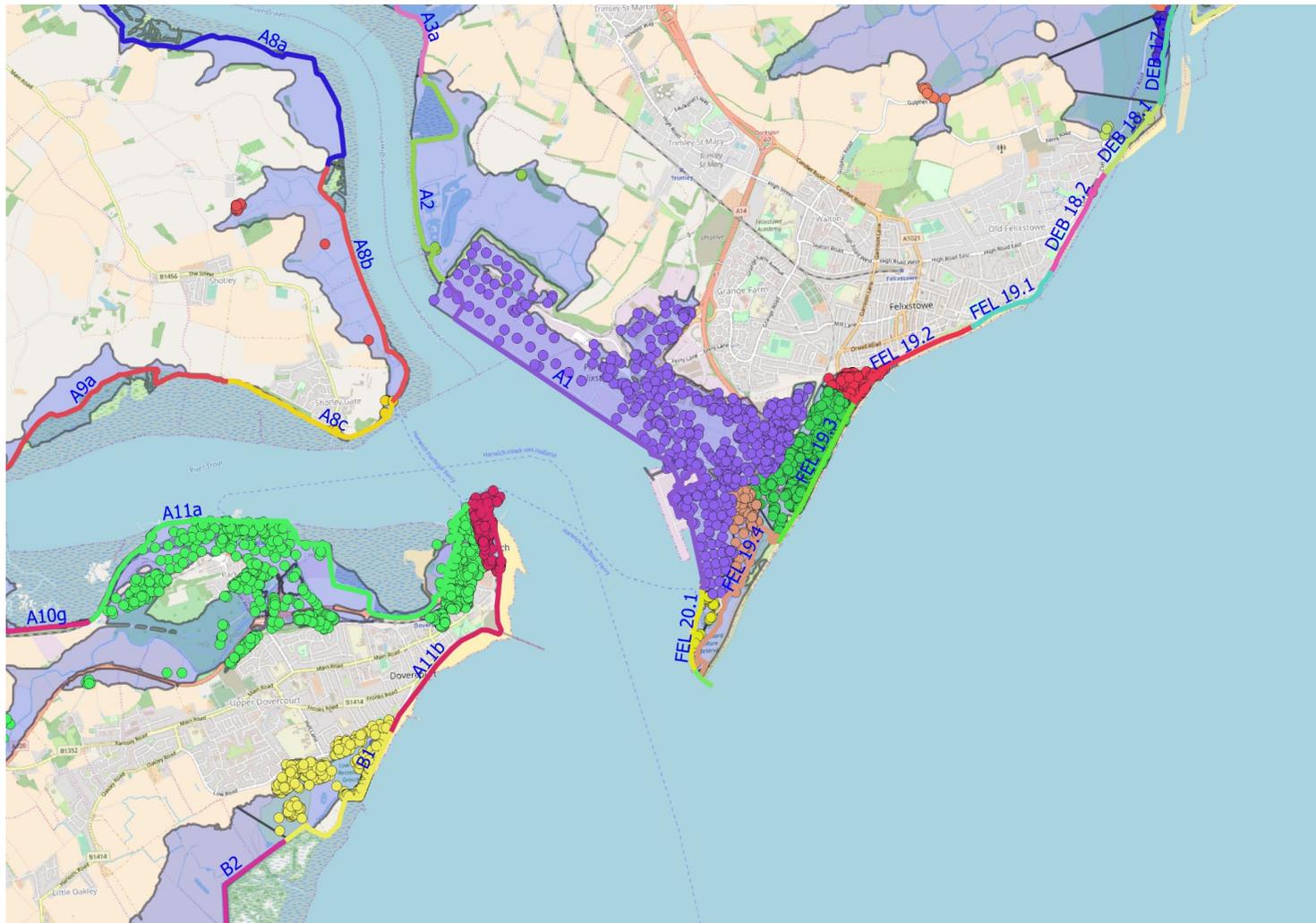
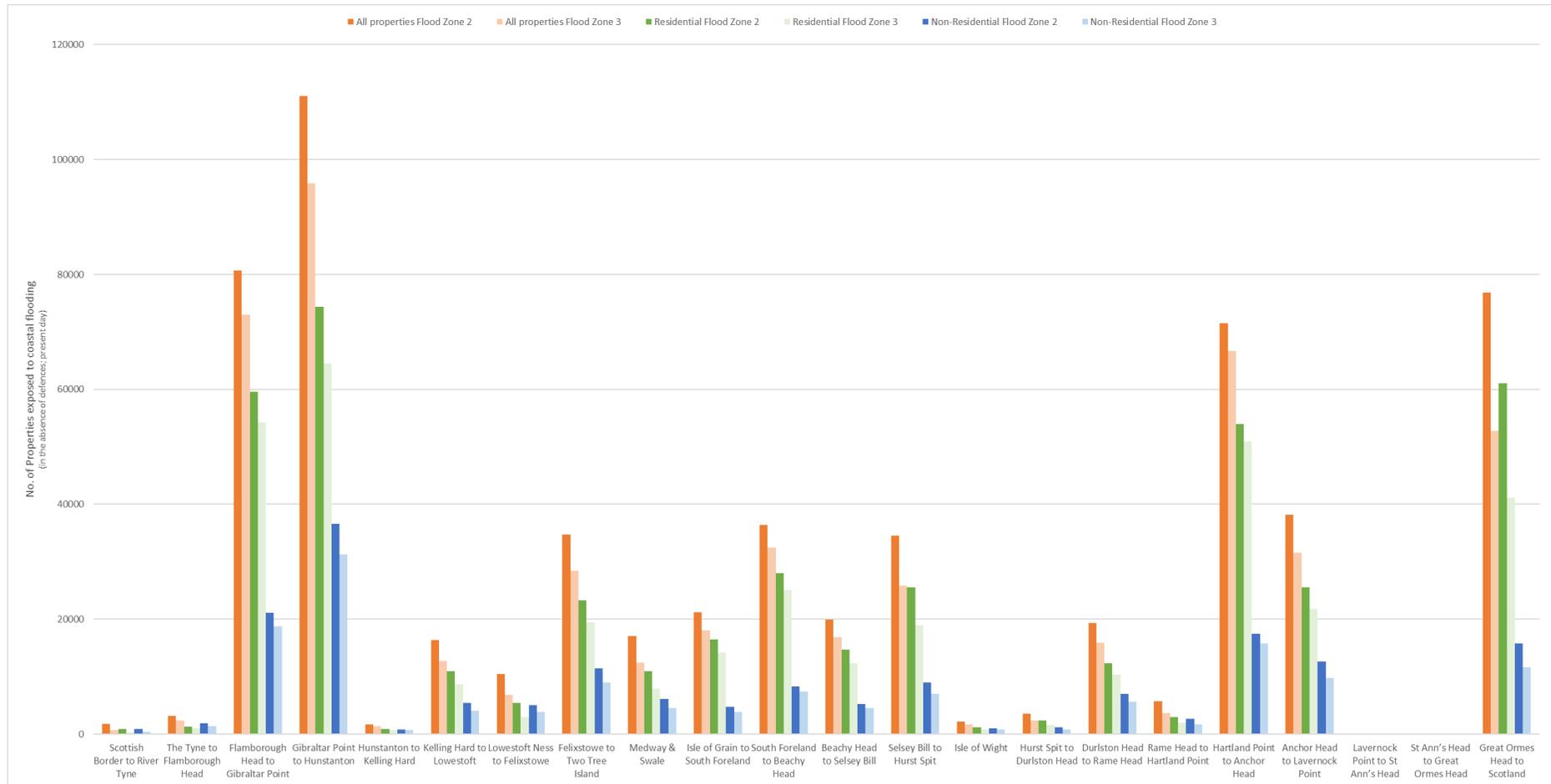


Figure 2-1 Coastal flooding: An illustration of the analysis steps



Note: SMPs 20 and 21 have been excluded from the analysis as they cover Wales.

Figure 2-2 Coastal flood exposure (Present day and in the absence of defences) - Summary results residential and non-residential properties.

3.0 ASSESSING EXPOSURE TO COASTAL EROSION IN ENGLAND

3.1 Spatial coverage

The analysis covers England only.

3.2 Temporal coverage

The analysis reflects coastal erosion risks through the three standard SMP epochs:

- Epoch 1 (2005-2025)
- Epoch 2 (2025-2055)
- Epoch 3 (2055-2105)

Note: The assessment does not consider the potential expansion of the coastal floodplain due to sea level rise.

3.3 Data used

The datasets used in the support of the analysis are as follows:

- Future erosion data (National Coastal Erosion Risk Management, FCERM, data provided by the ASC August 2018)
- National Receptor Datasets provided by the ASC under licence (including WAAD Reportable field as used by State of the Nation, 2018)
- Environment Agency Flood Zones: v201802 (Feb 2018)
- Policy Management Units (PMU) from ShorelineManagementPlan2.shp Open Data downloaded from data.gov.uk on 10/08/18

3.4 Analysis approach

The analysis has been implemented through the following steps:

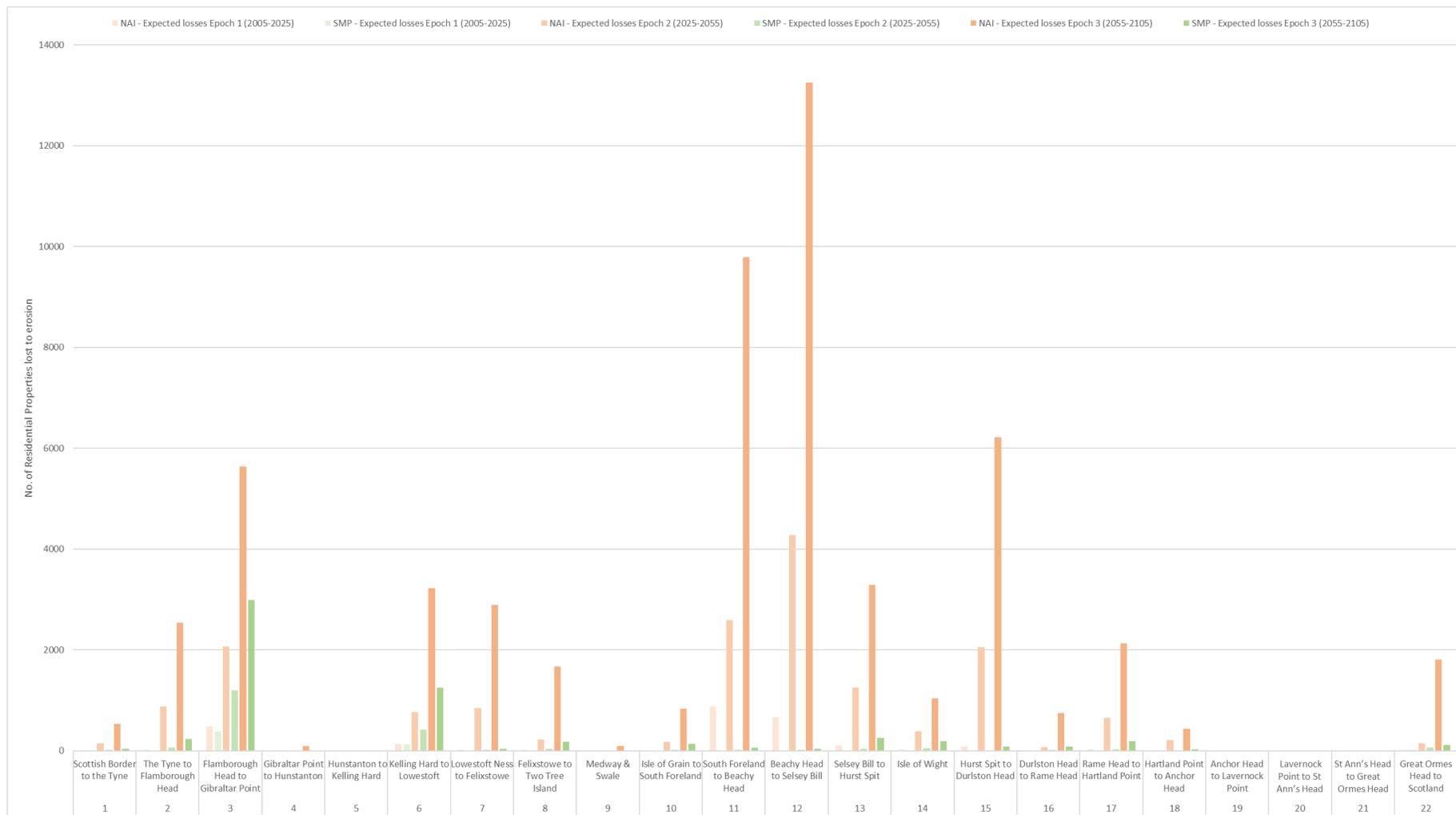
- Identify the erosion zones (5%, 50% and 95% confidence limits) for policies of No Active Intervention (NAI) and SMP preferred policy choices for each epoch.
- Identify the erosion zones that relate to each PMU – A shore normal is a projection to the insertion with the 95 percentile erosion contours.
- Identify the properties (residential and non-residential) potentially 'at risk' from erosion
- Identify properties within the 5, 50 and 95 percentile contours, sum and assign to each PMU
- Calculate the expected number of properties lost to erosion (through a simple probability weighted summation)
- Aggregate PMU based erosion losses by SMP.
- Package the data into a spreadsheet summarizing property losses for each confidence level, epoch, PMU and SMP.

The analysis approach is illustrated in Figure 3-1 with summary results (by SMP) provided in Figure 3-2.

Full results are available in the spreadsheets that accompany this report: "Erosion - By PU - Non-Residential v4_1.xlsx" and "Erosion - By PU - Residential v4_1.xlsx".



Figure 3-1 Coastal erosion: An illustration of the analysis steps



Note: SMPs 20 and 21 have been excluded from the analysis as they cover Wales.

Figure 3-2 Coastal erosion - Summary results: Expected erosion losses by a given epoch: Residential properties.

4.0 ASSESSING THE BENEFITS AND COSTS OF COASTAL MANAGEMENT IN ENGLAND

4.1 Spatial coverage

The analysis covers England only (i.e. as for the analysis above, SMPs 20 and 21 are excluded as they cover Wales).

4.2 Temporal coverage

The analysis spans the three standard SMP epochs: Epoch 1 (2005-2025); Epoch 2 (2025-2055); Epoch 3 (2055-2105).

4.3 Data used

- The assessment of coastal erosion for all epochs (from Section 2)
- The assessment of present day coastal flood risk (from Section 3)
- The assessment of the benefits and costs associated with each SMP from Jacobs 2018.

4.4 Analysis approach

The cost-benefit analysis undertaken here looks to assess the costs of implementing the SMP policies as calculated in the SMP documents themselves, against the benefits in terms of the number of properties protected, only (i.e. any wider benefits of implementing the SMPs are not included). This analysis builds on that conducted by Jacobs at the level of the SMP, and breaks down the cost-benefit assessment further to give results at the level of the policy management unit, which is the unit at which different SMP policy options are implemented (hold the line, managed realignment, advance the line, no active intervention).

Given the constraints of time and the significant work already embedded in the Jacobs analysis the results presented here have been developed by adding an additional layer of analysis to summarise the costs and benefits in a way that brings together coastal flood and erosion costs and benefits taking account of their spatial distribution within each SMP. The basic steps in the analysis are:

- **Erosion losses for No-Active Intervention (NAI) and SMP Policy choices**
The benefits of implementing the SMP policies in terms of avoided erosion (in all three epochs) are calculated by assessing the difference between the NAI scenario and the SMP policy scenario, to derive the number of properties protected from erosion by implementing the SMP policy compared to a 'do nothing' scenario. The NAI and the SMP results for the 3 Epochs are derived directly from the erosion loss data presented in earlier sections.
- **Flood losses for the Do nothing counterfactual and SMP Policy choices**
Similarly, the number of properties protected by implementing the SMP policy is calculated by comparing the SMP policy against a 'do nothing' scenario. The future SMP and do nothing results are based on the Jacobs analysis but amended using the present day distribution of the properties by PMU calculated in Sections 2 and 3. Because of the need for this 'correction' the level of confidence in the flood losses is less than that for erosion. It is also assumed that the number of properties in the coastal floodplain (flood zones 2 and 3) does not change
- **Intervention costs for SMP policy choices**
These have been taken directly from the Jacobs (2018) analysis for each epoch and total present value costs.

Summary results by SMP are provided in Table 1. The analysis indicates that approximately 1,400-1,500km of England's coastline designated as Hold-the-Line is unlikely to receive central government funding based on the number of properties being protected alone (assuming a BCR of at least 2 would

be needed). Of those that anticipate major investment in shoreline management (greater than £25m Present Value) between 130-150km may not be cost effective to implement (achieving a BCR less than 1). Where the most significant expenditure is planned (greater than £50m Present Value) between 51-62km of coastline fails to achieve a BCR greater than 1 where the policy is to 'hold-the-line' in all three epochs and between 86-97km where the policy is to 'hold-the-line' in Epoch 1 and 2.

Results are available in the spreadsheets that accompany this report: "Coastal futures - CBA 27112018".

Note: The analysis presented is high level and relies upon existing analysis. The conclusions should be caveated in that context, and further developments could significantly improve some of the assumptions necessarily made. The results at an individual PMU scale should not be relied upon and the results viewed as credible at aggregated scales only.

Table 1 Summary of SMP policies, costs and benefits

	Length of coastline with a given policy choice (km) (Absolute value - Epoch 1; Change values - epochs 2 and 3)												Cost SMP Policy (PVC) £ 000's	Erosion Avoided erosion losses (PVbe) All properties £ 000's	Coastal flooding Avoided flood losses (PVbf) All Properties £ 000's	Benefits Total (PVb) All Properties £ 000's	Net Present Value All Properties £ 000's
	NAI			MR			HLT			ATL							
	Epoch 1	Change in Epoch 2	Change in Epoch 3	Epoch 1	Change in Epoch 2	Change in Epoch 3	Epoch 1	Change in Epoch 2	Change in Epoch 3	Epoch 1	Change in Epoch 2	Change in Epoch 3					
SMP	1,534	32	54	415	200	21	2,636	-430	-141	11	0	0	7,277,731	3,899,612	9,432,486	13,332,098	6,054,367
01 - Scottish Border to River Tyne	79	-2	-2	37	0	15	64	3	-13	0	0	0	46,713	46,490	20,052	66,542	19,829
02 - The Tyne to Flamborough Head	127	0	4	11	2	0	59	-2	-4	0	0	0	252,935	124,092	145,361	269,453	16,518
03 - Flamborough Head to Gibraltar Point	70	0	0	7	-7	0	125	0	-38	0	0	0	932,408	120,498	687,200	807,698	-124,710
04 - Gibraltar Point to Hunstanton	2	0	-2	0	0	0	103	-101	0	0	0	0	127,033	4,735	1,403,395	1,408,130	1,281,098
05 - Hunstanton to Kelling Hard	10	0	0	16	6	-4	33	-8	-8	0	0	0	81,376	11,268	105,463	116,731	35,355
06 - Kelling Hard to Lowestoft	6	18	1	27	-10	21	47	-11	-19	0	0	0	53,081	106,419	367,564	473,983	420,902
07 - Lowestoft to Felixstowe	45	3	5	22	2	5	52	-5	-10	0	0	0	307,230	387,627	93,380	481,007	173,777
08 - Essex and South Suffolk	18	0	3	38	40	-1	463	-29	-13	11	0	0	609,606	576,890	479,331	1,056,222	446,616
09 - River Medway and Swale Estuary	9	5	0	44	4	0	107	-49	0	0	0	0	434,054	6,083	418,680	424,763	-9,292
10 - Isle of Grain to South Foreland	18	0	0	4	21	2	66	-26	-2	0	0	0	330,061	44,614	872,122	916,737	586,676
11 - South Foreland to Beachy Head	15	0	0	9	0	12	85	0	-15	0	0	0	284,513	664,987	624,534	1,289,521	1,005,009
12 - Beachy Head to Selsey Bill	5	-1	0	4	1	2	35	0	-4	0	0	0	157,326	777,031	261,718	1,038,748	881,423
13 - Selsey Bill to Hurst Spit	63	-2	12	8	-1	-2	267	19	-12	0	0	0	1,382,151	191,780	445,788	637,568	-744,583
14 - Isle of Wight	113	2	1	1	1	3	44	-3	-5	0	0	0	119,681	109,527	222,819	332,346	212,665
15 - Hurst Spit to Durlston Head	53	1	-1	19	2	1	55	-3	-12	0	0	0	198,505	325,274	132,922	458,196	259,691
16 - Durlston Head to Rame Head	276	-1	0	35	7	-6	171	-14	3	0	0	0	498,105	101,948	606,686	708,634	210,529
17 - Rame Head to Hartland Point	279	0	8	22	29	-5	127	-39	-3	0	0	0	221,310	171,732	117,896	289,628	68,318
18 - Hartland Point to Anchor Head	109	6	1	8	21	-7	174	-53	4	0	0	0	291,537	41,267	628,336	669,603	378,066
19 - Anchor Head to Lavernock Point	65	0	0	37	1	4	167	-1	-4	0	0	0	72,669	139	1,040,867	1,041,006	968,337
22 - Great Ormes Head to Scotland	171	4	21	68	82	-20	393	-110	14	0	0	0	877,438	87,211	758,370	845,581	-31,857