

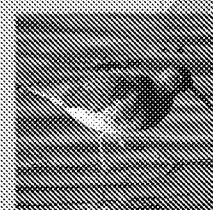
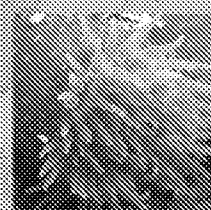
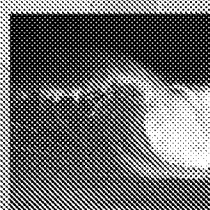
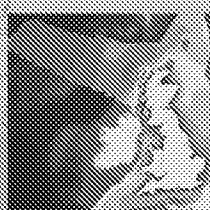
Pagham Parish Council

Managed Breach of Shingle Spit at Pagham: Flood Risk Assessment

Report R.2520

October 2015

Creating sustainable solutions for the marine environment



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Pagham Parish Council

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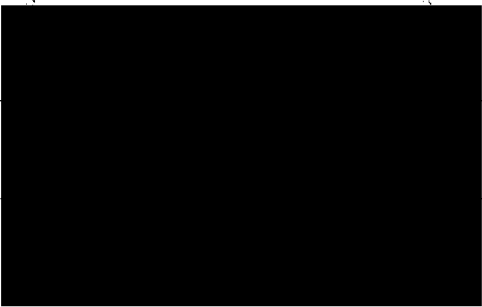
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Managed Breach of Shingle Spit at Pagham: Flood Risk Assessment

Contents

	Page
1. Introduction.....	7
1.1 Project Background	7
1.2 Scope of Flood Risk Assessment.....	8
2. Planning Context	9
2.1 National Planning Policy Framework.....	9
2.2 Chichester District Local Plan.....	11
2.2.1 1999 Saved Policies	11
2.2.2 Key Policies 2014-2029 Proposed Modifications	11
2.3 Arun District Local Plan	13
2.3.1 2003 Saved Policies	13
2.3.2 2011-2029.....	14
2.4 Beachy Head to Selsey Bill Shoreline Management Plan.....	14
2.5 Pagham to East Head Coastal Defence Strategy	15
2.6 Other Plans.....	15
2.7 Strategic Flood Risk Assessment.....	16
3. Sources of Flood Risk.....	17
4. Proposed Community Project and Its Objectives	20
5. Key Benefits of Proposed Project.....	22
5.1 Adaptive Management Approach	23
6. Impact on Flood Risk.....	25
6.1 Pagham Beach (Erosion to the South-West of Groyne 3)	26
6.2 Pagham Beach (Erosion Between Groyne 3 and the Yacht Club).....	29
6.3 Pagham Beach (Erosion Between Yacht Club Area and End of East Front Road)	31
6.4 Pagham Beach (Flooding of the Beach and Sandy Road Area).....	32
6.5 Pagham Harbour	34
6.6 Summary and Cost Implications	37
7. Climate Change	39
8. Sequential and Exception Tests	40
8.1 Vulnerability and Use.....	40
8.2 Sequential Test.....	41
8.3 Exception Test.....	41
9. Flood Risk Assessment Checklist.....	42
10. Conclusions	45
11. References	46
12. Abbreviations	49



Tables

1.	Predictions for sea level rise	39
2.	Site-specific flood risk assessment checklist	42

Images

1.	Proposed project showing preferred breach design and location of infill	7
2.	Plan of key local features at Pagham	9
3.	Church Norton Spit at Pagham and existing rock revetment (27 February 2015).....	17
4.	Exposure of the geotextile bags within the inlet channel	18
5.	End of Church Norton Spit and properties behind on a high tide	26
6.	Beach volume changes (2003 to 2014) along Pagham Beach (centre and west, 4dSU23).....	27
7.	Beach volume changes 2013 to 2014 along Pagham Beach (centre and west, 4dSU23).....	27
8.	Properties that are vulnerable to erosion and flooding risk.....	28
9.	Beach volume changes (2003 to 2014) along Pagham Beach (east, 4dSU22)	30
10.	Beach Volume changes 2013 to 2014 along Pagham Beach (east, 4dSU22).....	30
11.	Areas of flood risk along the Pagham frontage	33
12.	Land elevations around Pagham Harbour equating to projected extreme water levels	34
13.	Time series plots of water levels at three points within the harbour before and after scheme implementation.....	36
14.	Environment Agency defence improvement areas in Pagham Harbour	37
15.	Environment Agency works on eastern side of Pagham Harbour.....	37
16.	Flood zone map along Pagham frontage	40

1. Introduction

1.1 Project Background

On behalf of the local community at Pagham (West Sussex), the Pagham Parish Council (PPC), and its working group the Pagham Flood Defence Steering Group (PFDSG), are proposing to undertake a managed breach of the shingle spit at the mouth of Pagham Harbour, West Sussex (Image 1). The main aims of this shoreline adjustment (hereafter referred to as either 'the [proposed] project' or the 'community project') are to move the coastline towards a more sustainable morphology¹ and address the coastal erosion, amenity and human health problems that are presently being experienced along the adjacent Pagham Beach.

The location of the proposed breach is shown on Image 1. The proposed breach, as excavated, will have the following design characteristics:

- A central 40 m channel at a depth of -1.80 mODN, which is equivalent to the Mean Low Water (MLW) level and is comparable to the channel bed level of the existing harbour inlet channel;
- Side slopes on each side of the breach that will be set at approximately a 1:4 gradient;
- A width of 80 m at tidal elevation of +3.0 mODN level which is approximately at the Highest Astronomical Tide (HAT) level; and
- An excavated volume of around 42,000 m³ (below +3.0 mODN) with an expected additional 10,500 m³ needing to be excavated above the +3.0 mODN elevation.

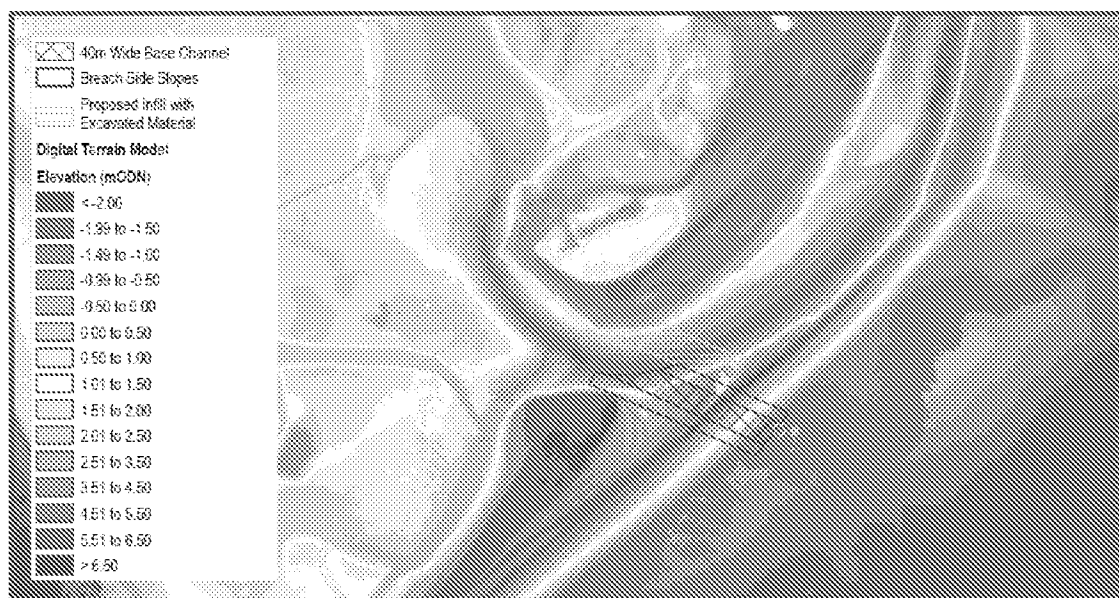


Image 1. Proposed project showing preferred breach design and location of infill

¹ i.e. one that is more natural, self-maintaining, requires less frequent and costly intervention and has a wider range of social ecological and economic benefits than alternatives (in keeping with the principles of sustainable development as directed by the National Planning Policy Framework (NPPF)).

The material excavated from this breach will be used to infill the existing channel which is adjacent and just to the north-east of the breach (Image 1). Once the breach is created and the existing channel is closed, natural processes will take over and no ongoing management of the site (e.g. maintaining the breach position) is proposed. However, one subsequent breach intervention has been included as part of the proposal as a contingency in the unlikely event that the breach should close.

1.2 Scope of Flood Risk Assessment

This Flood Risk assessment (FRA) has been prepared to accompany the planning application for the proposed project in fulfilment of the validation requirements cited by the Local Planning Authorities (Chichester District Council (CDC) and Arun District Council (ADC)) and at the request of the Environment Agency. It is noted that the main aim of this project is to alleviate flood risk and has been a material consideration in preparing this FRA.

The methodology of this FRA follows guidance provided by Department for Environment, Food & Rural Affairs (Defra) and Environment Agency (2015). Furthermore, it has been prepared in accordance with the requirements of the National Planning Policy Framework (NPPF) (DCLG, 2012; para 103) and provides an assessment of the flood risk as a consequence of the proposed project.

In accordance with the guidance, this FRA covers the following:

- Planning context (Section 2);
- The sources of flood risk and coastal erosion pressures (Section 3);
- A brief description of the proposed project and its objectives (Section 4);
- The key benefits of the project, and whether the project is considered appropriate for the proposed location (Section 5);
- The impact of the proposed project on the existing coastal erosion, and in turn, flood risk along Pagham Beach and inside Pagham Harbour (Section 6);
- Climate change (Section 7);
- The sequential test and exception test (Section 8); and
- A completed site-specific FRA checklist (Section 9).

2. Planning Context

The proposed project is situated across the border of two Local Planning Authorities. The Local Planning Authorities are ADC and CDC. The principal settlement affected by the project is Pagham (see Image 2).

Relevant planning documents to this FRA are reviewed in the following sections to set the proposed project in the context of national, regional and local policy.

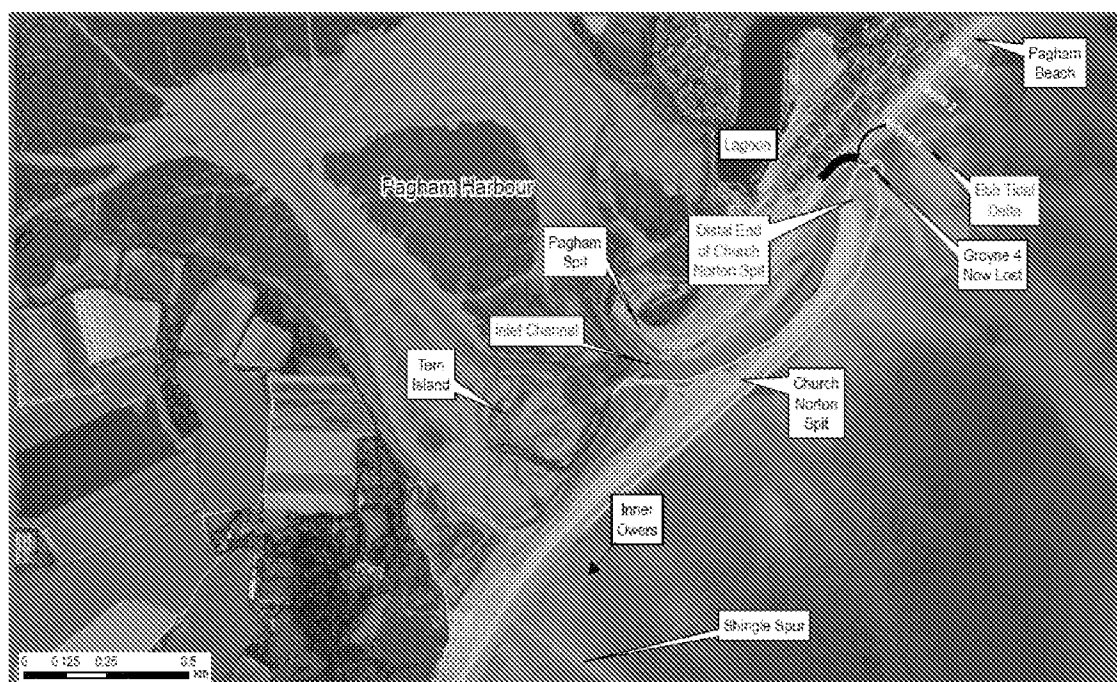


Image 2. Plan of key local features at Pagham

2.1 National Planning Policy Framework

The NPPF sets out the Government's planning policies for England and how these are expected to be applied (DCLG, 2012). The NPPF replaces previous national planning policy guidance which was primarily contained within a series of Planning Policy Guidance notes (PPGs) and Planning Policy Statements (PPSs). The framework is a key part of Government reforms to make the planning system less complex and more accessible, to protect the environment and to promote sustainable growth.

The NPPF acts as guidance for local planning authorities and decision-takers, both in drawing up plans and making decisions about planning applications. The framework incorporates policies relating to climate change, flooding and coastal change that are of direct relevance to the proposed project. These include the following:

- Development should be planned to avoid increased vulnerability to the range of impacts arising from climate change (DCLG, 2012; para 99);
- Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere (DCLG, 2012; para 100);
- When determining planning applications, local planning authorities should ensure flood risk is not increased elsewhere and only consider development appropriate in areas at risk of flooding where, informed by a site-specific flood risk assessment² following the Sequential Test, and if required the Exception Test, it can be demonstrated that:
 - Within the site, the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; and
 - Development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed, including by emergency planning; and it gives priority to the use of sustainable drainage systems (DCLG, 2012; para 103).
- Local planning authorities should apply Integrated Coastal Zone Management to integrate terrestrial and marine planning regimes (DCLG, 2012; para 105);
- Local planning authorities should reduce risk from coastal change by avoiding inappropriate development in vulnerable areas or adding to the impacts of physical changes to the coast. Local planning authorities should identify Coastal Change Management Areas³ likely to be affected by physical changes to the coast (DCLG, 2012; para 106);
- Local planning authorities are expected to be clear what development will be appropriate in Coastal Change Management Areas⁴ and make provision for development and infrastructure that needs to be relocated away from Coastal Change Management Areas; and

In addition, as set out in paragraph 168 of the NPPF, Shoreline Management Plans (SMPs) should inform the evidence base for planning in coastal areas. The prediction of future impacts should include the longer term nature and inherent uncertainty of coastal processes (including coastal landslip), and take account of climate change.

² A site-specific flood risk assessment is required for proposals of 1 hectare (ha) or greater in Flood Zone 1; all proposals for new development (including minor development and change of use) in Flood Zones 2 and 3, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

³ This is an area identified in Local Plans as likely to be affected by coastal change (physical change to the shoreline through erosion, coastal landslip, permanent inundation or coastal accretion).

⁴ Essential infrastructure may be permitted in a coastal change management area, provided there are clear plans to manage the impacts of coastal change on it, and it will not have an adverse impact on rates of coastal change elsewhere.

2.2 Chichester District Local Plan

2.2.1 1999 Saved Policies

The Local Plan for Chichester District (CDC, 1999) consists of the Saved Policies in the Chichester District Local Plan (adopted April 1999). These policies guide development in this district and are used to make decisions on planning applications. Until the new Local Plan 2014-2029 has been adopted (see Section 2.2.2), the following policies, which have been identified as being particularly relevant to the proposed project, remain current:

Policy C3: Managed Realignment states that ‘Proposals for the managed realignment of sea defences or coast protection structures which provide nature conservation and/or landscape benefits will be permitted providing there is no loss of the best and most versatile agricultural land or danger to buildings and provision is made for diversion of the coastal path or other affected public rights of way’.

Policy C9: Sea Defence and Coast Protection Works states that ‘proposal for the construction of new or replacement sea defence and coast protection works... will be permitted provided that: the District Planning Authority can be satisfied that the technical requirements of the coast protection authority have been met; in the rural area they are not visually obtrusive or damaging to the open appearance or character of the shoreline...; they would not be damaging to features of ecological or archaeological significance to the locality; they do not involve the visible use of waste material; they are of a design... which, where technically feasible, will attract accretion of silt and plants to reduce the visual impact of works;... they maintain access for commercial and leisure fishing activities’.

2.2.2 Key Policies 2014-2029 Proposed Modifications

On 30 May 2014, the Chichester Local Plan: Key Policies 2014-2029 and supporting documents were submitted for independent examination to the Secretary of State for Communities and Local Government via the Planning Inspectorate (CDC, 2014). The Secretary of State has appointed an independent Inspector to conduct the Examination.

The Local Plan provides the broad policy framework and a long-term strategy to manage development, protect the environment, deliver infrastructure and promote sustainable communities within Chichester District (excluding the area within the South Downs National Park) to 2029. Once adopted, all planning applications will be assessed against the policies in the Local Plan.

The final scheduled session on the examination of the Chichester Local Plan: Key Policies Pre-submission 2014-2029 was held on 3 December 2014 and the Council has consulted on the Proposed Modifications it considered were required to make the Plan sound. Any minor changes required on the basis of accuracy, clarity or for updating purposes will be included in the adopted version of the Chichester Local Plan.

The Proposed Modifications consultation ran for six weeks from 8 January 2015 to 19 February 2015. The Inspector has carefully considered all the representations submitted in response to the Council's proposed modifications and will take account of these in writing the report which was unavailable at the time of writing.

Particularly pertinent policies in the pre-submission document (CDC, 2014) are now listed.

The proposed Policy 22 on 'Integrated Coastal Zone Management for the Manhood Peninsula' could be viewed as pertinent, as the Church Norton Spit is essentially part of the Peninsula, even though the affected community at Pagham is not on the Peninsula, nor is it within the boundaries of CDC. For the Manhood Peninsula, CDC pledges to 'prepare plans, strategies, projects and other measures, in partnership with other organisations and local communities, to ensure that the Manhood Peninsula is planned for in a coordinated and integrated manner, whilst recognising the individual needs of the communities within the area'. 'Proposals and initiatives will be supported that promote the following general objectives:

1. Facilitate the economic, environmental and social well-being of the area;
2. Address proposals for the coastline and coastal communities set out in Coastal Defence Strategies and Shoreline Management Plans;
3. Contribute to greater safeguarding of property from flooding or erosion and/or enable the area and pattern of development to adapt to change, including the relocation of current settlement areas, and vulnerable facilities and infrastructure that might be directly affected by the consequences of climate change;
4. Provide resources to improve the process of harbour and coastal management, incorporating and integrating social, recreational, economic, physical and environmental issues and actions;
5. Improve infrastructure to support sustainable modes of transport, especially cycle ways, bridleways and footpaths, including the National Coastal Footpath; and
6. Provide the means of supporting regeneration on the Manhood Peninsula."

Proposed Policy 44, Development around the Coast, states that 'planning permission will be granted for development in the coastal area, outside of Settlement Boundaries, where it can be demonstrated that all the following criteria have been considered:

1. There are no harmful effects on or net loss of nature conservation or areas of geological importance within the Chichester and Pagham Harbours and Medmerry Realignment;
2. The development provides recreational opportunities that do not adversely affect the character, environment and appearance of the coast and Chichester Harbour Area of Outstanding Natural Beauty;
3. Regard has been shown to the high quality and inclusive design of new buildings in coastal locations in accordance with other relevant design and historic environment policies;
4. There are measures for mitigation of any detrimental effects including where appropriate the improvement of existing landscapes relating to the proposal;

5. Where appropriate, opportunities have been taken to upgrade existing footpaths and cycle paths, enhance and protect the National Coastal Footpath and ensure that public access is retained and provided to connect existing paths along the waterfront;
6. The development would result in improvements to or redistribution of moorings, marine berths or launch on demand facilities (dry berths) in the harbours; and
7. The development would not be detrimental to infrastructure for, and quality of, water-based recreation, or be detrimental to the safety of navigation.”

Proposed Policy 48 Natural Environment states that “planning permission will be granted where it can be demonstrated that all the following criteria have been met:

1. There is no adverse impact on:
 - The openness of the views in and around the coast, designated environmental areas and the setting of the South Downs National Park;
 - The tranquil and rural character of the area; and
 - Development recognises distinctive local landscape character and sensitively contributes to its setting and quality;
2. Proposals respect and enhance the landscape character of the surrounding area and site, public amenity and detailed design;
3. Development of poorer quality agricultural land has been fully considered in preference to best and most versatile land; and
4. The individual identity of settlements, actual or perceived, is maintained and the integrity of predominantly open and undeveloped land between settlements is not diminished.”

2.3 Arun District Local Plan

2.3.1 2003 Saved Policies

The current Local Plan for Arun District was created in 2003 (ADC, 2003) and the Council is currently in the process of producing a new one (Section 2.3.2). The following policies are of particular relevance to the proposed project:

Policy GEN10: Tidal Flooding and Coastal Defence states that “The risk to development in areas subject to flooding and coastal erosion is set out in the Coastal Defence Strategy. The Coastal Defence Strategy identifies standards of defence and future management”.

Policy GEN19: Coast Protection and Sea Defence Works states that “Proposals for coast protection and sea defence works or improvements to existing works will be considered in the light of the following: (i) the recommendations of the shoreline management plan and the coastal defence strategies in respect of the physical maintenance of the coastline and coastal defences; (ii) their impact on the visual character of the open, undeveloped coast and on the appearance and use of the coastline in the built-up areas; and (iii) that the proposed method of coastal defence is technically sound and appropriate to the task”. The main aim of the policy is to maintain sea defences and protect the coast where necessary through the use of the best technically, economically and environmentally appropriate solutions.

2.3.2 2011-2029

The Arun District Local Plan 2011-2031 and supporting documents were submitted on 30 January 2015 for independent examination to the Secretary of State for Communities and Local Government via the Planning Inspectorate.

The Local Plan sets out a vision for the future of Arun up to 2031. This Local Plan sets the planning framework for the district and will detail planning policy and identify the amount of development proposed and where it should be located. It will also be used in the consideration of planning applications. The Plan covers the Arun Local Planning Authority Area. The Local Planning Authority is ADC administrative area excluding land within the South Downs National Park Authority boundary.

Particularly pertinent policies in the pre-submission document (ADC, 2014) are now listed.

Policy W DM4 Coastal protection states that ‘Proposals for coast protection and sea defence works will be permitted if they:

- a. Have been considered in light of their impact on the visual character and value of the open, undeveloped coast, protection and enhancement of coastal habitats and the provision of opportunities to complete the coastal footpath and improve the appearance and use of the coastline in the built-up areas.
- b. Use methods of coastal defence that are technically sound and appropriate to the task and do not have a detrimental effect on other parts of the coastline; and
- c. Are in accordance with the Shoreline Management Plan or Strategy for the particular frontage.

Proposals for development in coastal locations, including for example, sea defence works, will be permitted providing they protect and enhance coastal habitats such as vegetated shingle. Where habitats are lost through the provision of sea defence works, replacement habitats must be provided in a suitable location. Any works under this policy should take account of any local and/or interest features. Developments shall also be consistent with all other Local Plan policies.’”

2.4 Beachy Head to Selsey Bill Shoreline Management Plan

Pagham Harbour falls within the Shoreline Management Plan 2 (SMP2) Policy Unit PU4d25 (South East Coastal Group, 2006). The SMP2 indicates a policy of Managed Realignment at this location given the very dynamic and heavily environmentally designated nature of the area. Pagham Beach falls within the SMP2 Policy Unit PU4d24 and has a policy to ‘Hold the Line’. There has been a change in the policy options for this part of the coast (including SMP2 Policy Units PU4d25 and PU4d24) as a result of newer and more detailed Pagham to East Head Coastal Defence Strategy (Environment Agency, 2013) which has adopted a policy of ‘Adaptive Management’ at Pagham (Section 2.5).

2.5 Pagham to East Head Coastal Defence Strategy

The Pagham to East Head Coastal Defence Strategy has been produced by the Environment Agency in partnership with CDC and ADC. The Strategy looks at ways to manage the risk of flooding and erosion to 5,300 properties on the West Sussex coastline, between Pagham Beach and West Wittering, over the next 100 years. This Strategy updates the SMP2 policies provided in the Beach Head to Selsey Bill SMP (Section 2.4).

The strategy covers the main population centres around Pagham, Selsey and the Witterings. There are 20,000 permanent residents, and thousands of people visit the area each year, many staying in local caravan parks. Land is generally low but many of the area's properties are on higher ground, resulting in the need to manage the risks from both flooding and erosion.

The Environment Agency, CDC and ADC worked together to produce the strategy. All three organisations approved the final version in 2008 and 2009. The Strategy area is split into six management frontages. Chichester District Council (CDC) manages four frontages. The Environment Agency manages the Medmerry frontage, with joint responsibility for the Pagham frontage shared with ADC and CDC.

The recommended management option for Pagham is Adaptive Management⁵ (Environment Agency, 2009). Urgent work is required to manage erosion at Pagham Beach. Given the level of uncertainty in this rapidly changing system, a flexible response is needed that can manage flood and erosion risk, as well as the internationally designated nature conservation site. For this reason Adaptive Management has been recommended for this frontage. An adaptive management plan is to be produced and a management group set up to implement the plan subject to funding availability.

2.6 Other Plans

Pagham Parish Council has produced a Neighbourhood Development Plan (Pagham Parish Council, 2014). Such plans set out specific policy proposals for a given parish and involve detailed consultation with statutory stakeholders and the local community. The Neighbourhood Plan is awaiting final approval from ADC, pending some further work on associated assessments. With respect to policies and proposals contained within, the following are particularly pertinent:

Proposal 1: Coastal Protection states that "The Parish Council will support proposals for coast protection and sea defence works, in the area shown on the Proposals Map, to reduce flood risk and to protect against the loss of homes, businesses, tourism attractions and habitats in Pagham, in pursuit of the adopted Pagham to East Head Coastal Defence Strategy 2010, together with its associated Strategy Approval Report 2009 and its Decision Framework for Adaptive Management at Pagham Harbour. The detailed design of the works will be to the

⁵ Defined as "Managing complex coastal areas by monitoring changes and acting on them in a planned but flexible way, increasing our understanding over time".

satisfaction of the regulatory authorities and should ensure that any significant impact on the Designated Nature Sites within the vicinity of the works is avoided."

2.7 Strategic Flood Risk Assessment

The proposed project is situated across the border of two Local Planning Authorities: CDC and ADC. Both Local Planning Authorities have prepared Strategic Flood Risk Assessments (SFRAs) (Capita Symonds, 2008a; b). The Chichester District SFRA and the Arun District SFRA include maps showing recorded historic flood incidents from a large range of sources (fluvial, tidal, groundwater, sewer, surface water)⁶.

The SFRAs indicate that Pagham Beach, Pagham Harbour and Church Norton are mainly protected by large shingle banks (i.e. the shingle spits and beaches either side of the tidal inlet entrance to Pagham Harbour). It should be noted that due to the highly dynamic nature of this coastline, the morphology of the spits and tidal inlet entrance and the level of protection afforded by defences that existed at the time that these SFRAs were undertaken (2008) will be different to the current (2015) situation (see Section 3).

The SFRAs predicted tidal (surge) flooding from a coastal event with a 0.5% Annual Exceedance Probability (AEP) to result in the 2008 sea defences in Pagham Harbour to be overtopped, causing tidal flooding in the lower areas of Sidlesham, Pagham and Church Norton.

For the extreme event⁷, tidal flooding was predicted to occur in Sidlesham, Church Norton and Pagham due to the overtopping of sea defences in Pagham Harbour. The climate change scenarios modelled in the SFRA were also used to indicate residual risk. For the 2056 event, the defences along Pagham Harbour were predicted to be overtopped causing flooding throughout the land north of Selsey.

⁶ These maps are not available on the online published versions of these SFRAs and have therefore not been taken account of as part of this FRA.

⁷ Residual risk is the flooding caused by an event bigger than an event for which the flood defences were designed.

3. Sources of Flood Risk

The source of flooding to the proposed project site is from the sea. This coastline is at risk of periodic flooding from extreme high tides, storm surges and waves. Maintaining adequate beach levels provides protection from flooding. The existing coastal defences in the wider study area along Church Norton, Pagham Harbour and Pagham Beach consist of shingle spits and beaches, in some areas stabilised by rock and timber groynes. Recent rock revetment works along a short section at the rear of the shingle beach at Pagham has provided remedial measures to arrest recent coastal erosion pressures on the local beach, and as a consequence offer flood protection (Image 3).



(Photograph courtesy of John Akerman)

Image 3. Church Norton Spit at Pagham and existing rock revetment (27 February 2015)

In most instances, existing sea defences are constructed (or recharged and re-profiled if necessary in the case of shingle beaches) to offer protection from the 0.5% AEP storm surge (Capita Symmonds, 2008b). However, there exists a residual risk of flooding behind these defences from the chance that extreme high tides and tidal surges, coupled with wave action, could produce water levels exceeding the height of the frontage and therefore causing them to be overtopped. There also exists a risk of flooding due to flood defences breaching.

Coastal erosion can exacerbate the potential flood risk to properties along this coastline. The main erosion problems at Pagham Beach are largely being caused by the 'Church Norton Spit' in front of Pagham Harbour which has grown substantially over the last decade. In recent years, the spit and the Pagham Harbour tidal inlet channel have extended and migrated

northwards along Pagham Beach; and this has caused/allowed a tidal inlet channel to cut into the beach leading to rapid localised shoreline retreat (Image 3).

The existing coastal morphology is resulting in erosion, and in turn, flood risk to residential properties at the south-western side of Pagham Beach which are currently being afforded protection by recent rock revetment work. This revetment, however, is vulnerable to failure. In the near future, the spit and channel are also likely to outflank the existing structures on the shoreline (revetment and groynes) to further exacerbate erosion along the central part of the beach further to the east.

The current morphology is also posing a problem for the remainder of the beach. The central part of the Pagham Beach area is in an eroding/deteriorating condition, and in this present state has a substantially reduced amenity and reactional value. This is because not enough shingle is being allowed to move north-eastward through normal long-shore sediment transport pathways into this part of the beach. Instead, the shingle is largely being stored or 'locked up' within the spit and its fronting ebb delta feature⁸. Material is not being moved ashore in large part because of the strong flows that occur through the elongated tidal inlet channel. This reduction in the shingle supply is exacerbating beach erosion problems along Pagham Beach and increasing flooding risk to residential properties.

The Church Norton Spit is also now responsible for beach erosion on the northern bank of the Pagham Harbour inlet channel. This is driven by high current velocities within the channel, which are sufficient to expose the filled geotextile bags (and rock revetment) currently being used for coastal protection (Image 4).



(Photograph courtesy of ABPmer, 2015)

Image 4. Exposure of the geotextile bags within the inlet channel

⁸ The ebb delta is the area of deposited shingle that lies in front of (on the seaward side of) the inlet and is where shingle is deposited due to the nature of the tides draining Pagham Harbour.

Man-made features or fixed structures have also influenced the evolution of the spit, harbour entrance and inlet channel and, in recent years, are also partly responsible for the erosion issue presently experienced along Pagham Beach. For instance, whilst the migration of the Church Norton Spit is predominantly controlled by the balance in longshore drift and the influence of the tidal inlet channel, the channel itself has become artificially impinged by the training wall that was built in 1963 and reconstructed in the 1980s to provide stability to the harbour entrance. Without the training wall, the channel would have been able to erode the distal end of the northern (Pagham) spit in order to follow a more natural sinusoidal (meandering) shape, possibly taking it away from the properties situated along Pagham Beach.

The groynes in place on Pagham Beach are designed to stabilise the beach during periods of erosion and to enhance deposition/retention when the sediment supply is sufficient. Presently, however, the most south-westerly groynes are constraining the Pagham Harbour inlet channel, which has been forced northwards towards Pagham Beach by the migrating Church Norton Spit. This has been aggravating the erosive pressure at this part of the beach.

4. Proposed Community Project and Its Objectives

The current morphology of the spit is resulting in immediate coastal erosion, and in turn, flood risk to residential properties at the eastern side of Pagham Beach and is also posing an erosion threat to the remainder of the beach which is in a deteriorating condition and has reduced in amenity and recreational value. In addition, it is causing distress and concern to the local community given that the current management of the foreshore and comparatively short term reactive initiatives are leaving the beach at risk of sudden unpredictable effects from future storm events.

Following a review of alternative management options for the spit feature at Pagham Harbour (ABPmer, 2015), it was concluded that the most appropriate sustainable solution for the long term is to create a managed breach through the spit feature. This preferred option has been informed by past case examples and underpinned by the large amount of research and management work that has been carried out on Pagham Harbour and Pagham Beach over many years. This past work included reviews of possible intervention options such as closing the tidal channel and protecting the Pagham Beach foreshore (Royal Haskoning, 2014a; b). Other options considered were a combined approach of breaching the spit and constructing a new stabilising cross-shore training wall. These alternative options together with the “do nothing” option are reviewed in greater detail in Section 2.2 of the Environmental Statement.

The proposed community project will involve excavating a breach directly in front of Pagham Harbour aligned to the existing 1963-installed steel sheet training wall (i.e. where the tidal inlet entrance was previously located throughout the latter half of the 20th Century) (Image 1). The material excavated from this breach will then be used to locally infill the existing channel to the north-east of the breach. This will create a new straight and relatively short tidal inlet channel immediately in front of Pagham Harbour.

Once the existing channel is closed and the new breach is created, natural processes will take over and no regular ongoing management of the site (e.g. maintaining the breach position) is anticipated. However, as a contingency, the option for one subsequent breach intervention is included as part of the proposal. A more detailed description of the proposed project is presented in Section 3 of the Environmental Statement.

A summary of the main objectives of the proposed community project are as follows:

- Achieves spatially larger and longer-term coastal defence benefits for the Pagham Beach foreshore;
- Brings other gains that are linked to having an improved beach structure and better coastal protection including improvements for the site’s amenity value and for the ‘human health’ of the local community in this vulnerable coastal location;
- Represents a more cost-effective use of public money (with local community funding support);
- Involves the application of a ‘soft’ solution that works with natural processes at the coast, rather than fighting against them with hard engineering;



- Mimics a process (i.e. breaching of the spit) that will occur naturally in the much longer-term future (as well as being one that has happened in the past) but exerts a degree of sensitive control over this process rather than waiting for it to happen naturally in the future in an unknown form and location over unknown timescales;
- Helps the community to actively re-engage with the environment on their doorstep including by using their voluntary support to assist with site management; and
- Provides greater assurance that the tidal functioning of Pagham Harbour will be maintained.

5. Key Benefits of Proposed Project

The proposed breach has been designed to be at its most stable position compared to other locations (including the current inlet condition). The proposed project is also predicted to allow for a marginally improved tidal exchange in the harbour. In addition, it will remove the tidal scouring effect away from Pagham Beach and allow the separated northern end of the Church Norton Spit to integrate back into the north-eastward transport pathways. This will allow material to be supplied to the currently impoverished Pagham Beach through natural processes. All of these changes will effectively remove the existing coastal erosion pressure along Pagham Beach and in turn alleviate flood risk to properties in this area.

The project represents a 'soft' solution to the coastal erosion and flood risk problems along this frontage because it seeks to mimic a process (i.e. breaching of the spit) that has happened naturally in the past and is likely to occur in the longer-term future (though probably not within the next decade). However, it does this in a predictable and controlled way that addresses immediate problems, anticipates future needs, and also buys time for the ongoing adaptive management of this coastline.

The proposed managed breach of the Church Norton Spit is designed to alleviate the problems arising in a proactive manner that works with natural coastal processes and also then allows these processes to subsequently continue being the dominant factor influencing the coastline. Compared to alternatives, this approach can achieve more natural, and spatially extensive, coastal protection improvements as well as benefits to human health and site amenity.

These benefits are not all realised by other alternatives which typically seek to 'fight against' natural processes often in a more reactive and localised manner (e.g. by introducing rock armouring or gravel-filled bags, shingle recycling, installing training walls or groyne, fixing the breach closed). The proposed approach is also more cost-efficient in terms of the gains achieved for the money spent.

A further benefit of this project arises from the fact that it is very much a 'community project'. It was the local community who originally emphasised the need for it and have continued to be supportive of it as the design has been developed. This proposal will inherently help the community to re-engage with the environment on their doorstep rather than viewing it as a threat to homes on the beach. Members of the community have also volunteered to play an active role in the management of the environment following the implementation of such a measure. Thus the potential exists for greater coherence between the needs of the environment and the community. Given the multiple benefits associated with the project, it is considered to be in keeping with the principles of sustainable development as directed by the National Planning Policy Framework (NPPF).

Also, in the event that the new breach closed, it is likely to be more easily re-opened than if the current spit and inlet closed up. Thus, while environment effects will occur, that are reviewed in detail within the Environmental Statement, there will be inherent long term environmental benefits associated with the proposed scheme (e.g. for water quality and ecology) in terms of greater assurances that the tidal functioning of Pagham Harbour will be maintained.

The proposed project is also considered to be an appropriate ‘Adaptive Management’ measure and, as such, is in-keeping with the strategic coastal defence objectives as set out in the Pagham to East Head Coastal Defence Strategy (Section 5.1). Adaptive management is a process that is adopted for complex coastlines and essentially involves an iterative sequence of monitoring and action. In this case the intention of the proposed project is to adjust the morphology of the environment in as natural a manner as possible and then to allow the environment to naturally readjust. This process of adjustment will be monitored and the results will feed back into ongoing strategic decisions.

5.1 Adaptive Management Approach

The Pagham to East Head Coastal Defence Strategy requires that an Adaptive Management⁹ approach needs to be taken (Environment Agency, 2009) and that Pagham Beach and the mouth of Pagham Harbour should be viewed as one frontage. The primary goals for this project in this context are to:

- Alleviate the pressure being placed by the tidal channel; and
- Allow a flux of shingle into the Pagham Beach shoreline to reverse recent beach erosion trends.

Along the shoreline in front of the harbour, the dominant activity is one of longshore and offshore transport of shingle with periods of natural breaching, breach movements and man-made closures. In this context, and given the need to work with natural processes, any measure that seeks to halt this longshore transport process should be discouraged. For example introducing training walls or trying to fix the environment in place on such a dynamic coastline is likely to cause problems later. The use of such cross-shore structures may solve the short term critical erosion problems in times when the shingle supply is in surplus, as is seen presently, but they are likely to also cause longer-term erosion pressures over possibly a larger area of the shoreline when the shingle becomes scarce. This is because such structures could then effectively inhibit longshore sediment transport.

The problems and challenges of using long-shore and/or cross-shore fixed revetments are already in evidence on this site because these techniques have already been employed. The emergency revetment work that has been undertaken on Pagham Beach has protected a short section of the western end of Pagham Beach from the effects of erosion by the migrating tidal channel. However, this has not created a stable coastal defence structure but one that has required regular subsequent intervention (with associated costs) to maintain its functionality. The construction of the initial emergency rock revetment in the 2013 winter cost approximately £500,000. The subsequent beach recycling efforts and urgent remedial works to the rock revetment and groyne which were being undermined by scour cost a further approximately £360,000 the following year.

⁹ Defined as ‘Managing complex coastal areas by monitoring changes and acting on them in a planned but flexible way, increasing our understanding over time’.

Whilst the revetment works address the problems being experienced where the tidal channel is cutting in currently, they do not address the fact that the spit will grow and continue to cause further tidal channel incursions along the beach. Thus, it is deferring the problem to the eastern parts of the beach as the spit continues to grow.

The idea has been proposed that the existing rock armour on the beach could be moved when such pressure is placed further down the beach. For example in the Defra (2015) review it is stated that “a key reason for the use of rock in the revetments was that it could be moved to other areas of the beach when necessary”. This is highly unlikely to be a realistic situation. This is because once the armouring is removed from one part of the beach it will then simply leave the area of their original placement exposed to the strong tidal flows being caused by the attempted migration of a tidal channel. Therefore moving rock armouring from one previously protected location (whether the existing position or from any future location in which it needs to be placed) would simply re-expose that formerly protected beach section to tidal pressure.

The only realistic way to protect the beach over the longer-term using revetment work will be to continue extending the armouring along the foreshore. This would incur substantial costs (for installation as well as for regular management) and would ultimately also become a ‘Hold the Line’ strategy rather than Adaptive Management (thus not in keeping with the management strategy for this section of the coast). In addition, it is worth noting that any such further work may well have to be undertaken at very short notice in response to sudden storm events. This would leave little time for the relevant consenting and procurement works to be carried out (Dornbusch, 2014) and would increase the flood risk the Pagham frontage.

The problems with using groynes is clear from conditions on site where the channel has broken through Groyne 4 and is continuing to pro-grade and exert further pressure on Groyne 3 and on the beach behind. Groynes 3 and 4 have helped to stall the passage of the spit by causing a diversion of the tidal channel away from the shore but, in doing so, have placed further pressure on the beach locally by helping to force the spit into the shore (i.e. along its ‘preferred’ north-easterly alignment).

Where the groynes not present, a progressive extension to the long-shore revetment would still be needed given the pressure exerted by the channel. However, the spit would also be more likely to progress rapidly in a parallel alignment to the shoreline and ultimately would be more likely to weaken and breach naturally at some point along its length. The existing groynes are thus effectively slowing these processes from occurring.

Overall, the proposed project is the preferred coastal erosion and flood risk management option for this frontage as it is considered to be the only longer-term ‘soft solution’ for this particular site in view of its history and the dynamics of the environment. This approach is considered to be an appropriate Adaptive Management measure for the entire frontage and, as such, is in keeping with the objectives of the Pagham to East Head Coastal Defence Strategy.

6. Impact on Flood Risk

This section presents the changes in coastal erosion pressures and indirect flood risk alleviation that the proposed project will bring to the Pagham Beach foreshore. The changes in high water levels as a result of the proposed project within Pagham Harbour and the consequences in the context of existing flood risk are also considered in this section.

This assessment has been informed by historical reviews of the harbour conditions alongside estimations and predictions of the future evolution of the beach and spit both with and without the proposed project (as presented above). The review of issues within Pagham Harbour has also been informed by the numerical modelling analysis conducted by ABPmer (see Section 6.3.2 and Appendix A of the Environmental Statement) as well as using expert analysis of the evidence and an understanding about the proposed coastal improvement measures that are underway and proposed within the harbour.

Where the benefits provided to Pagham Beach are considered, these are presented in a way which will allow for informed judgments to be made about the flood defence costs and benefits. This is designed to assist with developing funding calculations using the Government's FDGiA (Flood Defence Grant-in-Aid) cost calculations (Defra, 2011). These calculations are based on an understanding of the proposal costs, the number of properties at risk and the duration of the coastal protection benefits that is afforded by the scheme.

These FDGiA cost metrics are often more easily applied to projects that enhance defined sections of sea walls and thus protect discrete coastal areas for definable periods of time. By contrast, the soft-solution approach that is being adopted for this proposed project (which is designed to ensure natural processes have a dominant influence on the foreshore) will benefit properties across a relatively large and unconstrained area over varying timescales. Therefore, there are some inherent uncertainties associated with making predictions about the precise duration and scale of coastal protection benefits.

The FDGiA process can address these uncertainties as long as the predictions remain realistic in the context of the available evidence. Therefore, care has been taken to make realistic but not 'high-end' 'over optimistic' estimates of the duration of future benefits (in general a value of around 8 years has been used) even though the benefits may well extend over a longer period (predictions for the decline of the separated end of the spit are in the region of 8 to 12 years and the benefits of this in terms of sediment supply to Pagham Beach is likely to have value well beyond this timeframe).

The relatively distinct nature of this project, and its coastal protection benefits, will be recognised in the application of any future detailed cost:benefit analysis, along with a consideration of the wider benefits that the project will have for the amenity value of the beach and the economics of the town. The following section considers the key issues that will be relevant for different sections of the Pagham Beach shoreline as well as Pagham Harbour.

6.1 Pagham Beach (Erosion to the South-West of Groyne 3)

Once implemented, the project will have an immediate coastal protection benefit for this south-western section of the beach (see Image 5) which has been rapidly eroding in recent years with large scale reductions in beach volumes. This erosion has been evident for the 11 years between 2003 and 2014 (see Image 6) and more so for the latest full annual period between February 2013 and 2014 period (see Image 7).

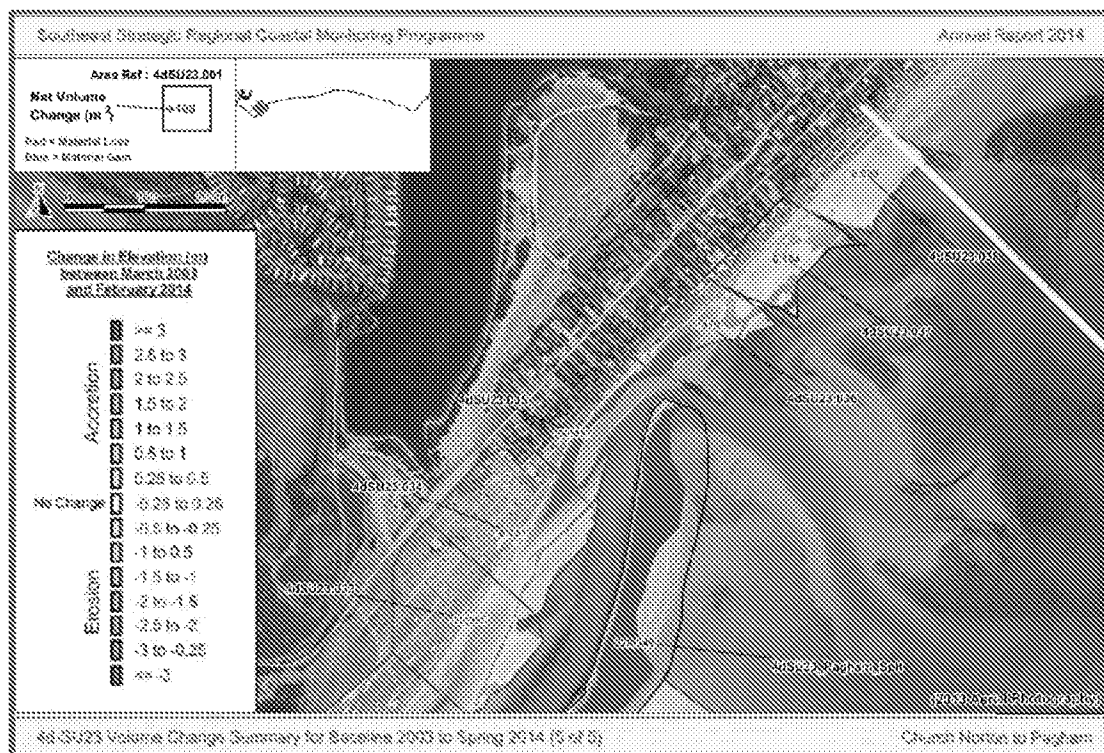


(Photograph courtesy of John Akerman, April 2014)

Image 5. End of Church Norton Spit and properties behind on a high tide

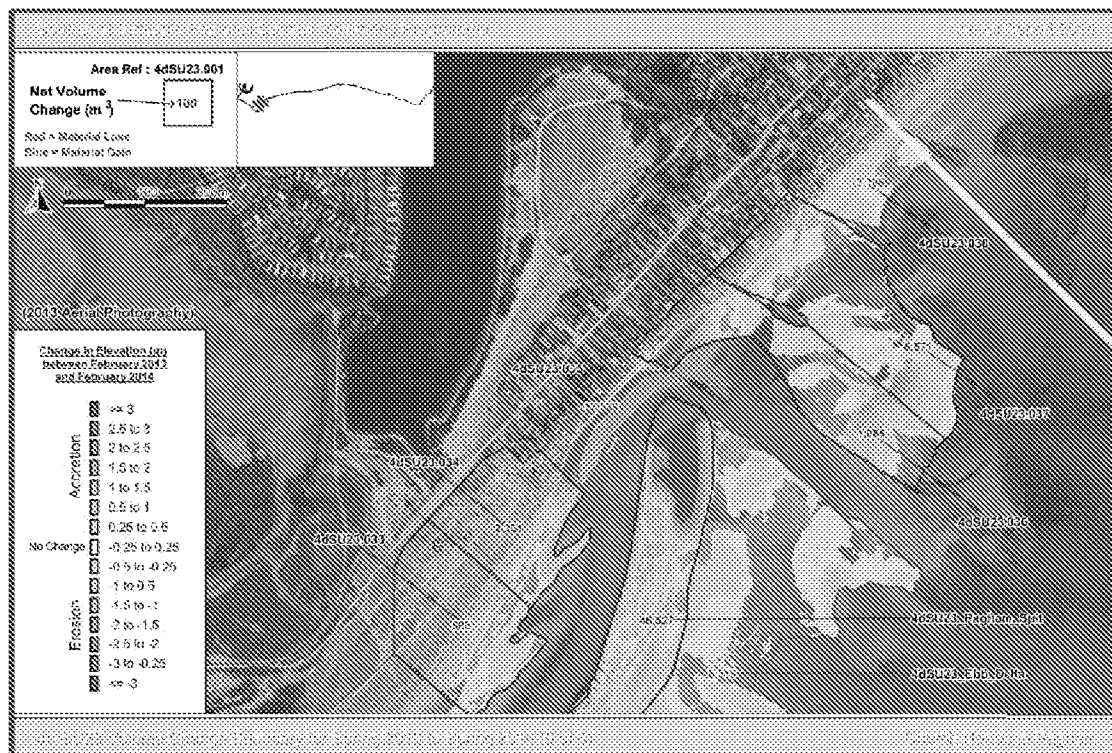
In this area, the beach crest has substantially narrowed by around 30 m and reduced in elevation including reaching emergency levels that have triggered the coastal defence interventions on the western side. The proposed managed breach of the spit will provide rapid coastal protection benefit here because, once undertaken, there will no longer be strong erosive flows through the tidal channel and this will ease the erosive pressure.

Following implementation of the proposed managed breach the model predicts local peak flow speeds on a mean spring of 0.30 m/s, whilst neap flows will not exceed 0.15 m/s. These flow speeds will be insufficient to erode gravel sized material; requiring approximately 0.8 m/s and greater (for coarser fractions). As such, the considerable erosion pressure currently placed on the Pagham frontage by the spit and inlet channel will rapidly ease.



(Source: SRCMP, 2014)

Image 6. Beach volume changes (2003 to 2014) along Pagham Beach (centre and west, 4dSU23)



(Source: SRCMP, 2014)

Image 7. Beach volume changes 2013 to 2014 along Pagham Beach (centre and west, 4dSU23)

This change will rapidly benefit the south-western end of this area (south-west of Groyne 4). Here, the 15 properties fronting the beach have already been protected through the recent placement of revetment work¹⁰. In the future, however, the proposed managed breach is expected to ease the pressure on these defences (as the spit joins to the beach and extends it) and reduce the need for this existing revetment to be maintained (for an estimated period of 8 years) and this will have an ongoing cost benefit.

The bay between Groynes 4 and 3 already has some revetment and bags but this area may still be vulnerable to erosion (under existing conditions) given the nature of the defences (Dornbusch, 2014). These defences protect 10 properties whose benefit has not yet been formally claimed under FDGiA (Image 8). These properties will receive benefit for the estimated 8 year period (from reduced tidal erosion pressure and increased shingle supply) and there will also be reduced maintenance costs (i.e. there is expected to be no need to maintain the revetments and recycle shingle) over this period.



Image 8. Properties that are vulnerable to erosion and flooding risk

¹⁰ Funding for these works was claimed under FDGiA and were part funded with contributions from the local community on the basis of the protection is afforded.

There is no intention as part of this project to remove the existing rock armour, or other protective features, from this area. Instead it is valuable that they remain in place to ensure they provide continuing protection along this part of the shoreline and to avoid incurring costs associated with such removal work.

In terms of the future protection, this not thought to be needed for 8 years at least (i.e. the duration of the benefit of the proposed managed breach and the length of time it would take for the distal end of the spit to winnow into the wider shoreline). However, on such a dynamic foreshore there is always a risk that the shoreline will become vulnerable and it will be the best, and most cost-effective, solution to keep this protection in place in case there is an unforeseen re-exposure of this location in the short term and to provide a basis for protection over the longer-term.

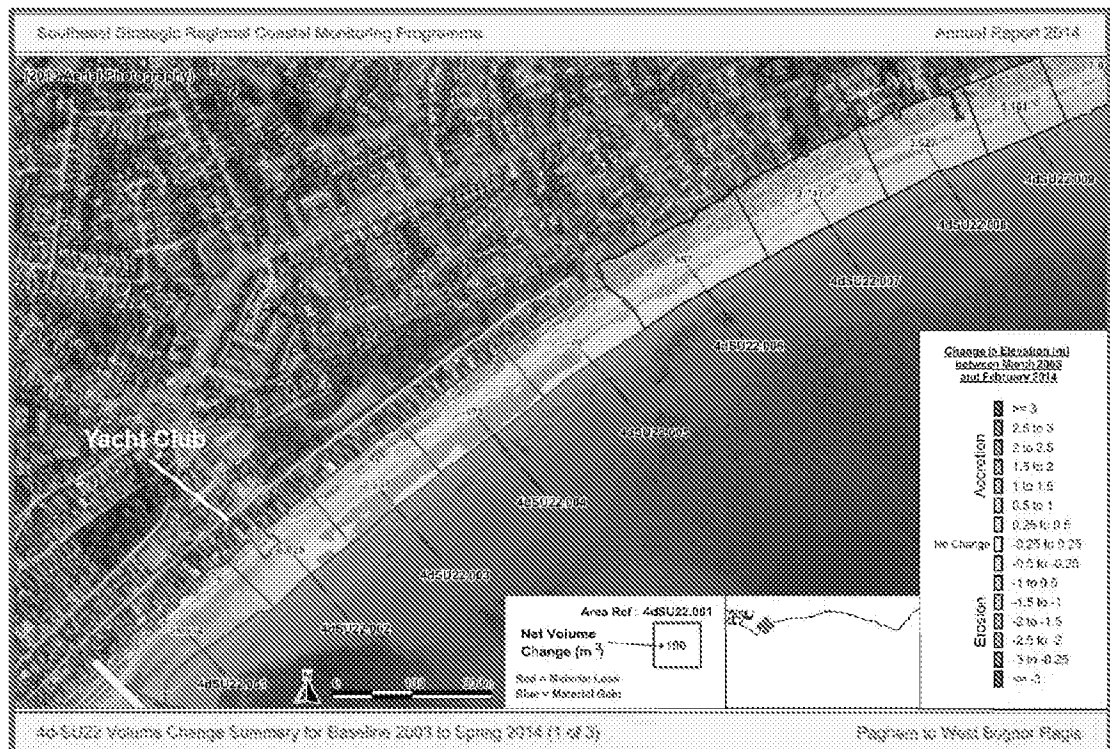
6.2 Pagham Beach (Erosion Between Groyne 3 and the Yacht Club)

Once implemented, the project will have an immediate coastal protection benefit by removing the risk of erosion from a future encroachment of the spit and tidal channel. It will also, in the short to medium term, reverse the trend of erosion and beach loss by re-introducing long-shore shingle transport to the beach.

The ongoing process of erosion is evident along the section of the beach between Groyne 3 and the Yacht Club where beach volumes have substantially reduced over time. This is evident for the 11 years between 2003 and 2014 (see Images 6 and 9) and for the latest annual period between February 2013 to 2014 period (see Images 7 and 10). There has, however, been a small amount of local accretion of the beach (between Groynes 2 and 3) which may in part be due to artificial shingle recycling measures or the trapping of eroded sediment on the up-drift section of the beach.

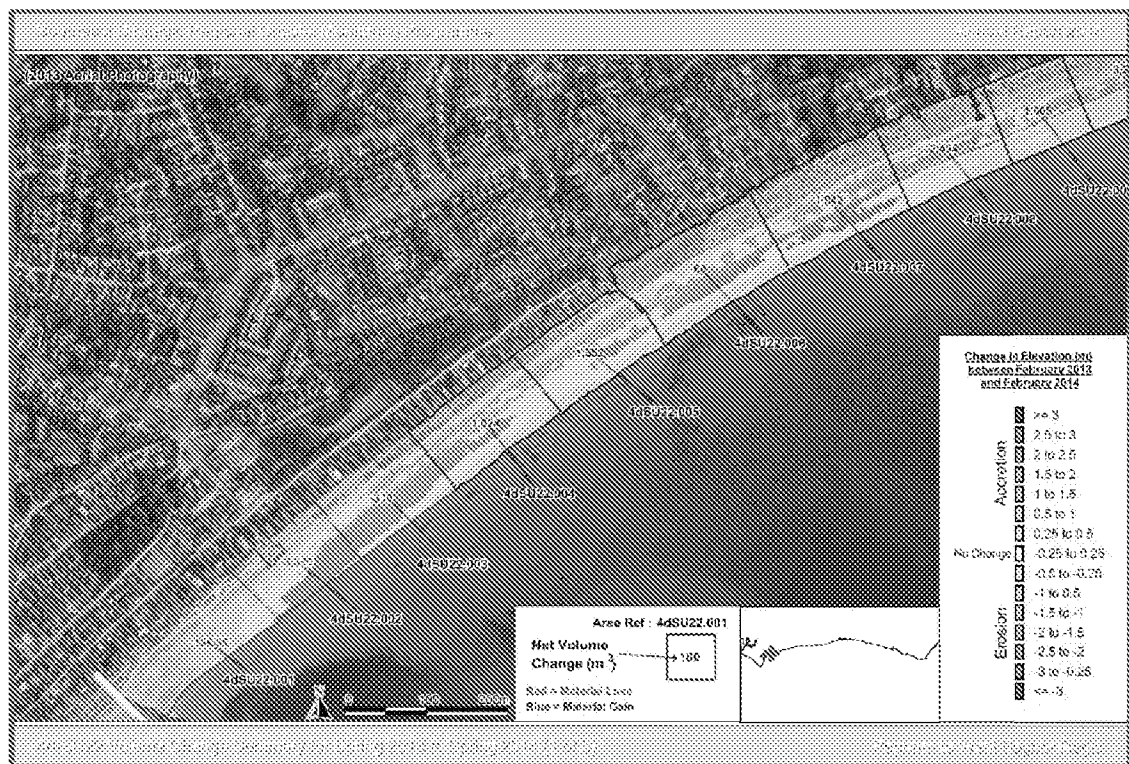
In general, there has been an approximate retreat of the upper shoreline by between 10 and 30 m over the last decade but also retreat of the lower shore by 5 to 10 m over the 2013 to 2014 period alone. The greatest retreat is occurring just to the north-east of Groyne 1 where the beach is being starved of sediment. Currently the beach crest immediately in front of the properties has remained at a high elevation of around 5.6 to 6 m ODN (possibly with some man-made intervention) but it has narrowed (by around 16 m) in areas to the north-east of Groyne 1 and as the lower beach continues to reduce in elevation this will increasingly compromise the beach crest over time.

This progressive shingle loss may cause erosion damage to properties in the next few years. However, there is a further risk of more rapid damage in the likely event that the spit extends towards the maturing ebb delta area in front of this part of the beach. In that event the encroaching tidal channel could extend into the beach and cause rapid erosion from high flow speeds.



(Source: SRCMP, 2014)

Image 9. Beach volume changes (2003 to 2014) along Pagham Beach (east, 4dSU22)



(Source: SRCMP, 2014)

Image 10. Beach Volume changes 2013 to 2014 along Pagham Beach (east, 4dSU22)

Such an event is expected to occur within 1 to 2 years and especially after a winter storm period. However, as discussed previously, the location for such a future effect will be dependent upon the alignment that the tidal channel takes and that, in turn, will be strongly dependent upon whether Groyne 3 stays in situ. If this groyne does stay in place the spit may move offshore but if the groyne fails (as Groyne 4 has done) then the spit is likely to move inshore, pass the end of Groyne 2 and contribute to erosion in the vicinity of this groyne. Whilst the precise location and timing of this tidal channel effect are difficult to predict, the proposed spit breach will provide an immediate alleviation of this impending risk. Then, within a few weeks and months, the area will begin to benefit from the import of shingle as the spit feature begins to integrate into the Pagham shoreline.

These processes will benefit the 43 properties that lie along the foreshore from Groyne 3 to the Yacht Club area (see Image 8). These properties are expected to be adversely affected within 2 to 3 years with no intervention. They will be benefited for at least 8 years, thereafter. This 8 year period is based on the time that it is likely to take the separated end of the Church Norton Spit to decline at a rate of 15-20,000 m³/year. However, as described previously, use of the spit decline rate as a measure for how the beach might respond is indicative only. It is not anticipated that there will be simple unidirectional export of the materials from the spit that then move into and along the beach to the north-east and the pattern of shingle movement and the manner in which it reshapes Pagham Beach will be influenced by the nature and frequency of storm events that are observed during the years after the project's implementation.

This 8 years period is considered to be as a realistic period for the duration of benefit arising from the work. Indeed, this value is considered to be relatively low (and precautionary) when it is noted that this part of the beach has lost in the region of 65,000 m³ of sediment/shingle over the period from 2003 to 2014 (35,000 m³ as shown in Image 9 plus around a further 30,000 m³ imported or recycled in 2009 and 2010) including during the severe storm periods of the 2013/14 winter. The proposed breach of the spit and the unlocking of the retained shingle is likely to resupply at a rate of around 15-20,000 m³/year and would potentially offset the observed losses within 4 years. Ultimately the re-supply could substantially stabilise or reverse the past trend of sediment loss for perhaps more than 10 years.

6.3 Pagham Beach (Erosion Between Yacht Club Area and End of East Front Road)

The benefits of the proposed project further along the eastern side of Pagham Beach will occur over a longer timeframe than those predicted for the rest of the foreshore (under the present condition). This area of the beach is eroding but at a slower rate than other up-drift sections of the shoreline. This is because any shingle that is exported to the east is re-supplied by sediment imported from the immediate west (supply which will include material that was introduced as part of previous beach nourishment campaigns). Ultimately, and with no intervention, as the supply to the west decreases then the rate of erosion in this area will increase.

In this area, it is notable that the top of the beach is typically eroding while the lower areas appear to be more stable and preferentially receiving shingle through littoral drift (see Image 8). The beach crest in this area has retreated by around 6 or 7 m over the last decade and a

continuation (and anticipated acceleration) of this rate will result in damage to properties within 10 to 15 years. Added to this, there is the risk that if the spit and its associated tidal channel continue along its potential meander path that there will be a future encroachment of the spit into this part of the beach in a decade or so. In this event there may be more rapid localised losses to the beach through tidal scouring.

In the years after the implementation of the proposed breach, this area will begin to receive an increased supply of shingle from the redistribution of the spit and ebb delta that will stabilise or reverse the ongoing erosional trend. The net benefits, in terms of avoiding erosion to properties, may well not be observed for a decade however, in keeping with the benefits projected for other areas of the beach the benefit when it arrives can be expected to last for at least around 8 years. There are 34 properties fronting this section of the beach that will be benefited (Image 8).

As described previously for the section of coast to the west, this 8-year duration of benefit is expected to be a minimum duration and may well be longer. This area has lost in the region of 3,000 m³ of sediment/shingle over the period from 2003 to 2014 but the proposed breach of the spit and the unlocking of the retained shingle is likely to resupply at a rate of around 15-20,000 m³/year for around 8 years. This could substantially stabilise or reverse the past trend of sediment loss for perhaps for up to 20 years.

6.4 Pagham Beach (Flooding of the Beach and Sandy Road Area)

The benefits that the proposal will provide for the section of shoreline between Groyne 3 and the Yacht Club area (as described in the preceding section) will reduce the risk of a possible future flood event behind the beach. This poses a risk to the low elevation areas around Beach Road and Sandy Road (areas that were also subject to flooding in the 1933). In this area, there are 23 properties and a vacuum pumping station (Image 8).

Flooding of this area could occur as a result of localised wave overtopping along the frontage in the event that the existing beach height and width is no longer sufficient to protect the properties from breaking waves. This is the issue presently seen along the south-eastern section of the frontage where the rock armouring has been placed to address the risk.

As described above, the beach between Groyne 3 and the Yacht Club area is continuing to retreat and reduce in volume (especially in its low shore elevation) although the crest has remained relatively stable. With continued loss of beach material the residential properties are expected to be adversely affected within 2 to 3 years and this could also introduce the risk of wave overtopping under storm conditions. This has the potential to affect 23 properties within the flood zone.

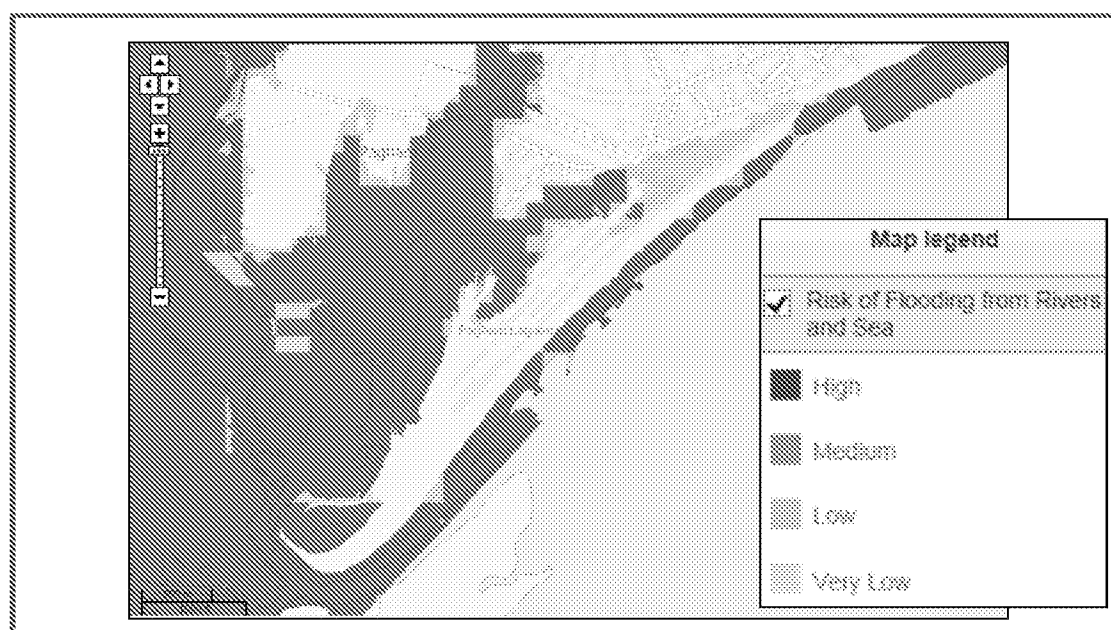
The flood zone in this case is illustrated as the pale blue triangular area around Beach and Sandy Road, as shown in Image 11, but also in the equivalent area illustrated in Image 12. Image 11 describes the flood risk zones identified by the Environment Agency based on the standard of existing defences; currently it identifies a low risk of flooding to this area but this risk is increasing over time as shingle depletion occurs in the fronting beach. Image 12 shows an equivalent triangle zone at risk of flooding for around a 1:10 to 1:200 year period. This plot

describes the results of ABPmer analysis which compares the existing land elevation (from 2014 LiDAR data) around the harbour and at Pagham against the extreme water levels that are predicted for a range of return events (3.17 mODN water level for a 1:1 return event to 3.93 mODN at a 1:1000 return event).

This analysis indicates that there is a low likelihood of any flooding occurring outside of this Beach and Sandy Road area because of the topography of the land. There is also unlikely to be sufficient water in the overtopping events to cause any issues beyond this zone, particularly considering that most of the gardens/roads are constructed from a gravel/sand sub-base which will act somewhat as natural drainage.

The western end of Pagham around Lagoon Road is within a flood zone (as shown in dark blue in Image 11) but that is due to the risk of flooding via Pagham Harbour. That risk will be reduced because the Environment Agency is carrying out defence improvements along this frontage.

In other areas much of Pagham is highly elevated (above present and future sea levels). As such, flooding through tidal inundation is unlikely (i.e. above a 1 in 1,000 year event) at present and into the near future. This is also illustrated by both the Environment Agency flood map¹¹ (see Image 11) and the extreme water levels map (see Image 12).



(Source: Environment Agency, 2015a)

Image 11. Areas of flood risk along the Pagham frontage

¹¹ <http://watermaps.environment-agency.gov.uk>
R/4282/01



Image 12. Land elevations around Pagham Harbour equating to projected extreme water levels

6.5 Pagham Harbour

After the introduction of the breach, water levels in the nearshore region, seaward of the proposed harbour inlet are not expected to be noticeably affected through the tidal cycle. Also there is not expected to be any increase in wave penetration into the harbour.

Some minor changes in water levels are expected within Pagham Harbour. During the initial period of breach adjustment there is likely to be a small reduction in high water levels across the harbour: in the order of 0.05 to 0.06 m (5 to 6 cm) over a mean spring tide and less than 0.02 m (2 cm) over neap tides (see Image 13). This effect would only occur in the period where the breach self-adjusts. Once the breach has self-adjusted (especially following an initial a sequence of larger spring tides), it will deepen and allow greater volumes of water through thus restoring the baseline tidal patterns. Critically, this work indicates that there will be no adverse effect during this initial and temporary adjustment period and that the potentially reduced high water levels will technically have a beneficial effect in terms of flood risk.

The consideration of a surge tide shows that peak water levels within the harbour have a minor reduction during the period of self-adjustment in breach dimensions, but thereafter the flood risk levels remain unchanged.

The initial self-adjustment of the breach to a new morphological equilibrium is expected to be achieved over the course of a few spring tidal cycles. Any subsequent natural readjustment of the breach and inlet channel is likely to either increase (if the breach widened/deepened to a greater degree) or decrease high water (if it narrowed). Such changes will be in keeping with the range of conditions experienced previously (given the range of morphologies that previously existed at the site) and will continue to be an inherent function of the natural dynamic environment in the future.

As there will be no adverse effects within the harbour, the harbour's internal defences will also not be adversely affected. It is also noted that the Environment Agency already has measures in place to further enhance protection to vulnerable areas around the harbour. The defences protecting the western side of Pagham, for example, have been flooding from the eastern side of the harbour (Image 14). Improvement works on this section are ongoing and soon to be completed (Nick Gray, Environment Agency, Pers. Comm.), as shown in Image 15. Although these works were for flood risk alleviation, as is the case for the proposed project, contrastingly they did not require a FRA.

There are further proposals in the future for defence improvement works on the north-west side of the harbour between the Ferry Pumping Station and Sidlesham although these works are at the appraisal stage and have not been commissioned yet (see Image 14).

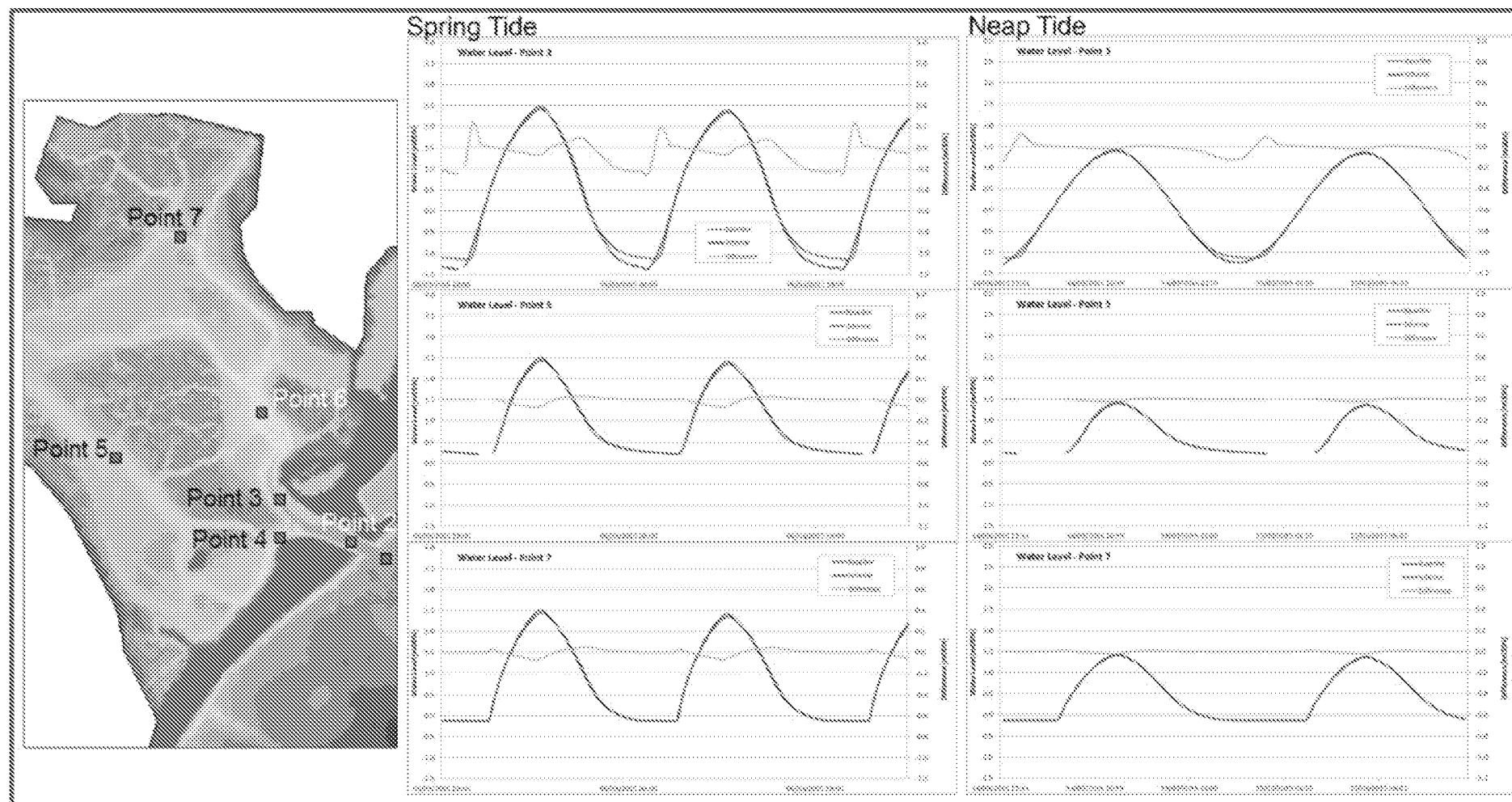
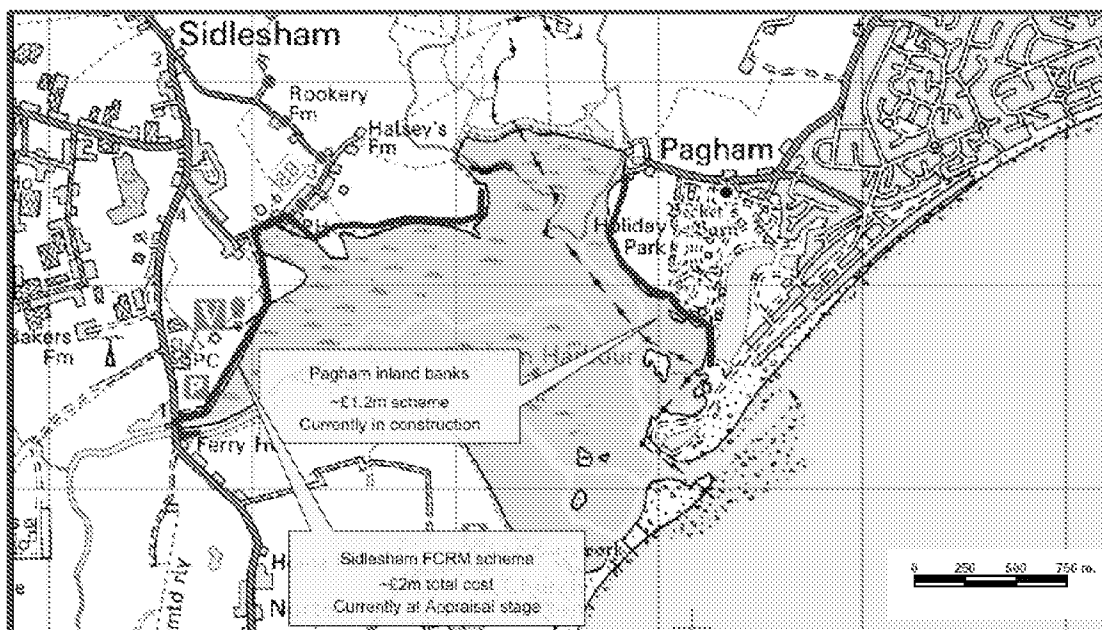


Image 13. Time series plots of water levels at three points within the harbour before and after scheme implementation



(Source: Environment Agency)

Image 14. Environment Agency defence improvement areas in Pagham Harbour



(Photograph courtesy of the Environment Agency, October 2015)

Image 15. Environment Agency works on eastern side of Pagham Harbour

6.6 Summary and Cost Implications

In summary, there will be substantial coastal erosion and therefore flood risk benefits to Pagham Beach and a low lying area behind from the proposed project. There is also not expected to be any adverse effects on the existing defences within Pagham Harbour. Along

the beach the benefits are largely from reduced erosion risk (Outcome Measure 3 (OM3); Defra, 2011) but also from a potentially reduced flood risk (Outcome Measure 2 (OM2); Defra, 2011).

In total there are up to around 110 properties that could be benefited over different timescales and which would otherwise be at risk imminently and certainly within the next 20 years. In summary the pressures on these properties and the benefits from the proposal are as follows:

- South-West of Groyne 3 (OM3 Erosion Risk Category): Immediately easing erosion pressure from tidal channel on this section of the breach and removing need for ongoing maintenance of existing revetment work. Estimated 10 properties benefiting that are unclaimed under FDGiA (plus further 15 that have been claimed) for 8 years from completion of the proposed scheme;
- Between Groyne 3 and Yacht Club area (OM3 Erosion Risk Category): Immediately reducing future risk of erosion from spit and tidal channel migration and then within weeks/months beginning to re-supply the beach with shingle to stabilise beach or reverse the past trends of sediment loss. Estimated 43 properties benefiting (all unclaimed under FDGiA) for at least 8 years from 1-2 years after project implementation;
- Between Yacht Club area the end of East Front Road (OM3 Erosion Risk Category): Within months and years the scheme will begin to re-supply the beach with shingle to stabilise beach or reverse the past trends of sediment loss. Estimated 34 properties benefiting (all unclaimed under FDGiA) for at least 8 years from 5-10 years after project implementation;
- Beach and Sandy Road Area (OM2 Flooding Risk Category): Reduced risk of wave overtopping in the future. Estimated 23 properties benefiting (all unclaimed under FDGiA) for at least 8 years from 2-3 years after project implementation;

Further analysis of the effects on these properties (and the cost: benefit of the work) will be needed as part of any submission of funding to the Environment Agency and this will need to consider the net value (Outcome Measure (OM1)) of these properties and other assets along the beach and the timings over which benefits will accrue.

The cost of implementing the work to protect up to 110 properties for a period of around 8 years (possibly longer) will be in the region of £1 million from the works themselves (estimated £700,000) along with further consenting work (estimated £100,000) and compensation measures (estimated £200,000). By contrast the costs of protecting the 15-25 properties on the western side of the beach also has already cost in the region of £1.5 million over the last 6 winters with the sum being incurred increasing over time with the growth of the Church Norton Spit¹².

¹² Over the last three winter periods these measures have cost around £900,000, including £500,000 for the 2012/13 revetment and £360,000 for later remedial/improvement measures. In the years preceding, there were fees incurred for shingle beach nourishment in 2010 (£600,000) and beach shingle recycling in 2009 (£43,000).

7. Climate Change

According to guidance provided by Defra and Environment Agency (2015), a site specific FRA needs to consider how flood risk at the site is likely to be affected by climate change and take account of the potential impacts of climate change over the development's lifetime.

United Kingdom NPPF guidance (DCLG, 2012) for the UK suggests that when preparing a SFRA or a site-specific FRA, the allowances for rates of relative sea level rise as provided by Defra (2006) should be used as "a starting point" for coastal (tidal) flooding considerations. In September 2011, however, the Environment Agency (2011) issued sea level rise and climate change adaptation advice. This guidance includes updated sea level rise allowances from UKCP09 (Lowe et al., 2009), based on the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report, which subsequently replaces the Defra (2006) predictions.

Environment Agency (2011) recommends that an upper confidence band of non-exceedance (95%ile) medium emission scenario is adopted from UKCP09 for future sea level rise predictions. The predictions for sea level rise for the south coast of England are provided in Table 1.

Table 1. Predictions for sea level rise

Sea Level Rise (m)	2010	2020	2030	2050	2070	2090	2110
UKCP09 (Medium Emissions/95%ile)	0	0.05	0.11	0.24	0.39	0.55	0.73

The proposed project seeks to address existing and anticipated coastal erosion problems (as well as post-breach benefits) over a period of around 10-20 years. This is because, for this highly dynamic coastline, making predictions about the future morphological evolution of the site beyond this timeframe is not possible. For this reason the longer-term issues associated with climate change and sea level rise have not been reviewed in detail. They will instead need to be considered on an ongoing basis as part of a continuing process of adaptive management that is recommended for this area by the Pagham to East Head Coastal Defence Strategy (see Section 2.5).

8. Sequential and Exception Tests

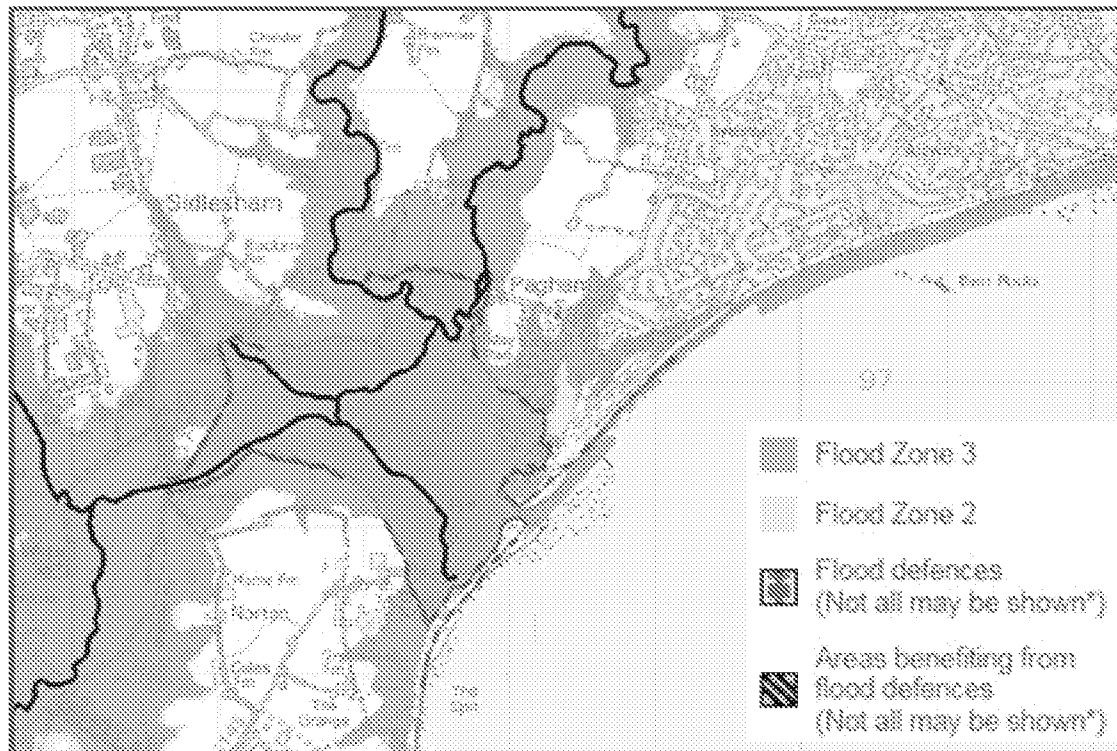
8.1 Vulnerability and Use

Flood Zone definitions are set out in the NPPF (DCLG, 2012):

- Flood Zone 1 - land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%);
- Flood Zone 2 - land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year;
- Flood Zone 3 - land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

Note these flood zones refer to the probability of river and sea flooding, ignoring the presence of defences.

The proposed project partly overlaps with Coastal Flood Zone 3 (Image 16). This indicates that the area could be affected by flooding, either from rivers or the sea, if there were no flood defences.



(Source: Environment Agency, 2015b)

Image 16. Flood zone map along Pagham frontage

The proposed project provides flood control infrastructure and involves sand and gravel working and is therefore classified as water compatible. Water compatible development is considered appropriate development within Flood Zone 3a and Flood Zone 3b according to the flood risk vulnerability and flood zone compatibility matrix provided in the Defra and Environment Agency guidance (2015).

8.2 Sequential Test

According to Defra and Environment Agency guidance¹³, a sequential test is required if both of the following apply:

- The development is in Flood Zone 2 or 3; and
- A sequential test has not already been done for a development of the type the applicant plans to carry out on their proposed site.

The sequential test ensures that a sequential approach is followed to steer new development to areas with the lowest probability of flooding. The proposed project is considered appropriate given that it is designed to reduce coastal erosion and flood risk and needs to be at the proposed location, in order for it to fulfil its purpose (Sections 3 and 4).

Water compatible development that occurs in Flood Zone 3b (functional floodplain), as is the case for the proposed project, should be designed and constructed to:

- Remain operational and safe for users in times of flood;
- Result in no net loss of floodplain storage; and
- Not impede water flows and not increase flood risk elsewhere.

8.3 Exception Test

According to Defra and Environment Agency guidance¹⁴, the exception test should be carried out for developments that are:

- Highly vulnerable in flood zone 2; and
- More vulnerable in flood zone 3a or essential infrastructure in flood zone 3a or 3b.

Neither of the above applies to the proposed project and therefore the exception test is not required.

¹³ <https://www.gov.uk/guidance/flood-risk-assessment-local-planning-authorities>

¹⁴ <https://www.gov.uk/guidance/flood-risk-assessment-local-planning-authorities>

9. Flood Risk Assessment Checklist

The site-specific FRA checklist provided in the Defra and Environment Agency guidance (2015) has been completed and is provided in Table 2.

Table 2. Site-specific flood risk assessment checklist

Item	Comment	Section in Report
1 Development Description and Location		
a. What type of development is proposed (e.g., new development, an extension to existing development, a change of use etc.) and where will it be located?	New development.	3
b. What is its flood risk vulnerability classification?	Water-compatible development.	8.1
c. Is the proposed development consistent with the Local Plan for the area?	Yes.	2
d. What evidence can be provided that the Sequential Test and where necessary the Exception Test has/have been applied in the selection of this site for this development type?	In terms of the sequential test, the proposed project is considered appropriate given that it is designed to reduce coastal erosion and flood risk and needs to be at the proposed location, in order for it to fulfil its purpose. The exception test has not been undertaken as the proposed project does not fulfil the necessary criteria.	8.2 and 8.3
e. Will your proposal increase overall the number of occupants and/or users of the building/land, or the nature or times of occupation or use, such that it may affect the degree of flood risk to these people? (Particularly relevant to minor developments (alterations & extensions) & changes of use).	No.	N/A
2. Definition of the Flood Hazard		
a. What sources of flooding could affect the site?	Tidal flooding	2.7
b. For each identified source in box 2a above, can you describe how flooding would occur, with reference to any historic records where these are available?	Overtopping of sea defences.	2.7
c. What are the existing surface water drainage arrangements for the site?	Unknown.	N/A
3. Probability		
a. Which flood zone is the site within?	Flood Zone 3	8.1
b. If there is a Strategic Flood Risk Assessment covering this site (check with the local planning authority). Does this show the same or a different flood zone compared with the Environment Agency's flood map? (If different you should seek advice from the local planning authority and, if necessary, the Environment Agency).	No flood zone maps are provided within the SFRAs available on CDC's or ADC's websites.	N/A

Item	Comment	Section in Report
c. What is the probability of the site flooding, taking account of the maps of flood risk from rivers and the sea and from surface water, on the Environment Agency's web site, and the Strategic Flood Risk Assessment, and of any further flood risk information for the site?	According to the Environment Agency Flood Map for Planning, the site has a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.	8.1
d. If known, what (approximately) are the existing rates and volumes of surface water run-off generated by the site?	Unknown.	N/A
4. Climate Change		
How is flood risk at the site likely to be affected by climate change? (The local planning authority's Strategic Flood Risk Assessment should have taken this into account. Further information on climate change and development and flood risk is available on the Environment Agency's web site.	Climate change scenarios were modelled in the SFRAs which showed that for the 2056 event, defences along Pagham Harbour (in 2008 at the time of the assessment) would be overtopped causing flooding throughout the land north of Selsey. The lifetime of the proposed project is only 10-20 years because predicting the future morphological evolution of the site beyond this timeframe is not possible. For this reason the longer-term issues associated with climate change and sea level rise have not been reviewed in this FRA in detail.	2.7 and 7
5. Detailed Development Proposals		
Where appropriate, are you able to demonstrate how land uses most sensitive to flood damage have been placed in areas within the site that are at least risk of flooding (including providing details of the development layout)?	Not applicable.	N/A
6. Flood Risk Management Measures		
How will the site/building be protected from flooding, including the potential impacts of climate change, over the development's lifetime?	The proposed project is a water compatible development located within the existing floodplain which does not itself require protection from flooding. The offsite flood risk benefits of the project are described below (see point 7c). The potential impacts of climate change over the lifetime of the proposed project (10-20 years) are not considered relevant.	7
7. Off Site Impacts		
a. How will you ensure that your proposed development and the measures to protect your site from flooding will not increase flood risk elsewhere?	The proposed project is considered appropriate given that it is designed to reduce coastal erosion and flood risk and needs to be at the proposed location, in order for it to fulfil its purpose.	8.2
b. How will you prevent run-off from the completed development causing an impact elsewhere?	Not applicable.	N/A

Item	Comment	Section in Report
c. Are there any opportunities offered by the development to reduce flood risk elsewhere?	Yes. There will be substantial coastal erosion and flood risk benefits to Pagham Beach and the low lying area behind from the proposed project. There is also not expected to be any adverse effects on the existing defences within Pagham Harbour.	6
8. Residual Risks		
a. What flood-related risks will remain after you have implemented the measures to protect the site from flooding?	None.	6
b. How, and by whom, will these risks be managed over the lifetime of the development? (e.g. flood warning and evacuation procedures).	Not applicable.	N/A

10. Conclusions

In view of the need for the project and its overall objectives, the proposed project is considered to be sustainable in flood risk terms. Overall, when compared to alternatives the proposed project can achieve more natural, cost-effective, and spatially extensive, coastal protection improvements, as well as benefits to human health and site amenity. Furthermore, it follows the principles of sustainable development as directed by the National Planning Policy Framework (NPPF)).

The proposed project is also a more appropriate 'soft' solution for this particular site that works with natural processes, in view of its history and the dynamics of the environment. This approach is considered to be an appropriate Adaptive Management¹⁵ measure for the whole foreshore (Pagham Harbour and Pagham Beach) and, as such, is in keeping with the objectives of the Pagham to East Head Coastal Defence Strategy.

If the proposed project does not take place, then Pagham Beach will face an increased risk of coastal erosion and flooding. With sea levels at this location predicted to increase by 0.05m and 0.73m in 2020 and 2090 respectively (Section 7), and changes to climate pattern resulting in increased frequency and severity of storms, this risk is very likely to increase further, especially as the conditions along the beach continue to deteriorate.

¹⁵ Defined as "Managing complex coastal areas by monitoring changes and acting on them in a planned but flexible way, increasing our understanding over time".

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12. Abbreviations

ABPmer	ABP Marine Environmental Research Ltd
ADC	Arun District Council
AEP	Annual Exceedance Probability
CDC	Chichester District Council
DCLG	Department of Communities and Local Government
Defra	Department for Environment, Food & Rural Affairs
FDGiA	Flood Defence Grant-in-Aid
FRA	Flood Risk Assessment
HAT	Highest Astronomical Tide
IPCC	Intergovernmental Panel on Climate Change
LIDAR	Light Detection And Ranging
MLW	Mean Low Water
NPPF	National Planning Policy Framework
ODN	Ordnance Datum Newlyn
OM(1,2,3)	Outcome Measure (1, 2, or 3)
PFD SG	Pagham Flood Defence Steering Group
PPC	Pagham Parish Council
PPG	Planning Policy Guidance
PPS	Planning Policy Statements
SFRA	Strategic Flood Risk Assessments
SMP	Shoreline Management Plan
SRCMP	Strategic Regional Coastal Monitoring Programme
UKCP09	UK Climate Projections

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.



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