

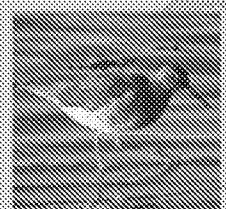
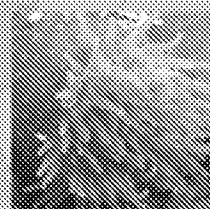
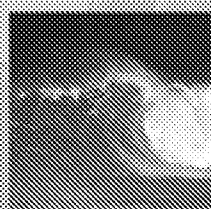
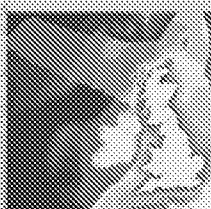
Managed Breach of Shingle Spit at Pagham

Further Information for Planning Application
and Marine Licence

Pagham Parish Council

May 2016

Creating sustainable solutions for the marine environment



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This report has been prepared to address questions raised by Natural England and other parties about planning application to Arun District Council. To assist with this report Natural England has provided specific advice on the reports content.

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Executive Summary

Report background

This report provides selected further information to accompany the planning and marine licence applications for a proposed managed breach of the shingle spit at Pagham Harbour. This further information is presented, on behalf of Pagham Parish Council (PPC), to address outstanding issues identified by Arun District Council (ADC) (in letter dated 7 March 2016) following the consultation processes for these two applications.

The main areas that ADC has asked for clarification for relate to marine ecology interests following issues raised by Natural England. To assist with addressing these, Natural England has separately provided further advice at meetings and through letters issued on 25/26 April 2016. The other key issue addressed within this report relates to the preparation of a cultural heritage assessment. This was requested by Historic England through the Marine Management Organisation (MMO) marine licencing process (though this topic was previously scoped out during the planning process).

In addition, ADC has asked (email dated 18 April 2016) that this report consider the physical changes that have taken place on the proposed managed breach site since the applications were validated. This area has seen some distinct changes (especially during February and March 2016) and ADC has requested that the implications of these changes for the proposal are addressed within this report.

Recent changes on site and the implications

Since the planning application was validated (December 2015), the Pagham Harbour frontage and Pagham Beach have continued to change (as expected within such a dynamic system). Over the 2015/16 winter the beach continued to erode and both emergency and planned protection measures had to be put in place by ADC to protect houses. Then during February/March 2016, the spit's central section lowered and subsequently breached naturally (following a process that the proposed managed breach is aiming to mimic but in a manner that achieves greater benefits). A channel has then evolved through this breach to become the dominant tidal inlet/outlet (again, as per the proposed managed breach).

This natural breach has demonstrated, in part, what the proposed managed breach is seeking to achieve. It has partially reduced the scour/erosion stress from the tidal inlet channel on the beach and may well have unlocked a portion of shingle in the distal end of the spit (i.e. in separated end) so that it can naturally migrate towards (and 'feed') the eroding beach to the east. The area is, however, presently in a state of particularly rapid flux and there are still many uncertainties over its future evolution and the extent to which such gains have been achieved or will be persistent.

What is immediately clear however is that the natural breach, given its current position, has created a large 'S-shaped' tidal channel that is continuing to meander and, in doing so, is eroding into both the remaining spit and the western end of Pagham Beach. This new configuration has created a shoreline evolution condition that the proposed managed breach fits even more clearly into. This is because the proposed managed breach¹ will be placed in the area where the channel is now trying to erode

¹ Which, following recent changes, will now involve moving the new breach/inlet to the south-west by around 350 m rather than by 950 m (as would have been the case from the pre-March configuration)

the spit (while also shortening the channel directing the flows away from the coast) and in doing so will help to stabilise the morphology.

The community, therefore, still wishes to realise the objectives of the original proposal to achieve the more sustainable outcome/morphology and help to manage the uncertainties that exist over how the site will develop. Also, the adoption of the original proposal still represents an important opportunity to deliver the broader vision of achieving multiple win-win benefits for the community and the environment. In fact, some environmental benefits are more evident than they were before.

Project objectives

One key coastal processes gain from the proposed managed breach is that it will block the long-shore scour (from the tidal channel) completely while also unlocking greater shingle volumes for easterly transport. It will therefore have larger benefits over longer timeframes for coastal protection, human health and site amenity. It also moves the tidal inlet further to the west to achieve a straight inlet shape that will have greater stability than the existing tidal channel shape. As described above, this existing tidal channel has a convoluted shape and is continuing to evolve and is currently causing further progressive erosion of the spit itself and at the end of Pagham Beach/Spit.

The further distinct benefit of this project which still applies is that it helps the community have more ownership of, and become more actively re-engaged in, the management of the environment on their doorsteps. In doing so, it also helps to move away from the historically perceived conflict between ecology and people. The proposed project will also inherently broaden the concepts of what adaptive management means for this part of the shoreline and move away from the idea that such measures can only be reactive actions on the immediate frontages of the houses. Instead it will show how adaptive management can include more proactive and sensitive measures which help both the communities and the conservation interests of the harbour.

The project will also have environmental benefits in its own right especially as it will be accompanied by management, mitigation and compensation measures which will help to provide assurances as to the tidal functioning of the harbour and measures to manage damage to Little Tern breeding habitat. The impacts to breeding Little Terns from the latest changes are yet to be established, but certainly the present shoreline shape is making it more difficult for the RSPB to manage the site for this species (by simultaneously making it more difficult for their staff to access it while also making it easier for predators to reach it). The changes observed have also demonstrated how there is no certainty in the persistence of the spit and how the compensation works can be valuable for protecting very vulnerable Little Tern nesting habitat in that context.

Costs, methods and funding for the project

In making this judgement to progress the original proposal, the community/PPC has continued to evaluate the costs, benefits, funding sources and methods associated with the project implementation and management. This has been done in part as a response to comments from ADC and Natural England but also, crucially, in order to be prepared for implementation this autumn (subject to securing the appropriate permissions).

As part of this review process, PPC has obtained a second opinion on the methods for the work (in addition to that obtained for the Environmental Statement (ES)). This was provided by a specialist with a high level of local knowledge and was informed by the natural breaching processes that have just been witnessed on site. This natural breach has illustrated how the managed breach could potentially be more sensitively implemented without the need for sheet-steel piling but instead would involve more closely replicating the natural process of: opening one channel at the preferred location;

allowing two channels to operate for a period before then closing the old channel. Adopting this approach would probably take less time than that proposed in the ES (estimated as 8 weeks) and would reduce any impacts during the construction phase.

PPC will not however be able to provide a full and final construction methodology and schedule until a formal procurement process has been pursued. However, the key principles for work (e.g. construction working areas and timings etc.) that will need to be adhered to have been further defined in this report in response to the ADC letter (and Natural England's comments). Also, it is anticipated that provision of the final post-procurement method statement will be made a planning condition.

Since the application was submitted, the community has also continued to review funding sources. In this case it is seen as necessary to have the permissions in place in the first instance in order to then drive the funding process.

Response to key issues highlighted by ADC

In response to the requests from ADC and in light of the advice from Natural England and Historic England, the required further information is presented in this report under the following headings:

- Additional Information for Appropriate Assessment (AA);
- Additional information for the ES and Marine Conservation Zone Assessment (MCZ); and
- Archaeological impact assessment

Appropriate Assessment

As set out in the ADC letter of 7 March 2016, an AA under the Habitats Regulations is required for this project. This was anticipated within the application documentation and relevant information for an AA provided (Appendix C of the ES). In addition to that information, extra details in response to the ADC correspondence are presented in this report. These details include confirmation that:

- the management of the compensation and breach sites will be overseen by a stakeholder group working with local voluntary organisations (and a flexible/adaptive approach to this management will be required);
- the RSPB will continue to manage (in collaboration with the local community and stakeholder group) the Little Tern habitats;
- the methods used by the RSPB (including fencing and wardening) will be as per their ongoing work under their reserve management plan;
- there will be extra summer fencing and signage to limit human access to the remaining section of spit (for as long as it remains viable habitat for terns);
- the recent natural breach has meant that there are more uncertainties than before as to the value of the spit as Little Tern habitat (in advance of the project being implemented); the new value of the habitat will need to be understood as part of the ongoing monitoring and management of the compensation site especially;
- the risk of breach closure is deemed to be low as set out in the application documents but further details about the measures to maintain the breach are presented in the form of an outline 'Traffic Light' system (or 'What If' matrix);
- this 'What If' matrix cannot be based on quantitative criteria but will need the inherent application of judgment from the stakeholder group;
- Natural England's advice on timing of construction to avoid sensitive breeding seasons will be followed;

- the RSPB will provide a watching brief for Little Terns to ensure that this species is unaffected by construction and no work is started on the site (outside of development compound at Pagham Car Park) until the last bird has fledged;
- the majority (possibly even all) of the work should be carried out before the overwintering bird period, but any work after 1 November will be accompanied by certain restrictions to minimise the risks of disturbance to overwintering birds;

As set out in the ADC letter, where a project is deemed to affect the integrity of a designated site (or such an effect cannot be excluded), then there are certain 'derogation tests' that apply under the Habitats Regulations/Directive. These tests were recognised within the application documentation and are further considered within this report as required. In summary, it is concluded that

- **Consideration of Alternatives.** No alternative approaches are identified which meet the range of project objectives, but also have less environmental effects;
- **Imperative reasons of overriding public interest (IROPI).** The objectives of the proposal are tested against the IROPI test and the project is deemed to meet the relevant criteria;
- **New Tern Island Compensation:** Further details about the design and management of the New Tern Island site are presented within this report (following further consultations with the RSPB and Natural England).

This information on the derogation test will be required by Chichester District Council (CDC) to prepare the AA under the Habitats Regulations.

Environmental Statement and MCZ Assessment

As requested within the ADC letter, further details about the impacts to the Pagham Harbour Site of Special Scientific Interest (SSSI) and MCZ are presented within this report in addition to the details already set out in the ES. Once again, the advice provided by Natural England on these issues has been used to inform this review.

Archaeology Impact Assessment

Within the ADC letter it is indicated an archaeology assessment is required in response to a request from Historic England. This assessment was not requested within the CDC scoping opinion that informed the Environmental Impact Assessment (EIA) process and it was not included in the ES for that reason. In response to this request this assessment has been conducted. It has been concluded that there will be no significant impacts to features of archaeological interest. There are no known features of interest at the breach site (which is a transient, recent and mobile environment) and the redundant and fractured concrete training wall/revetment at the compensation site will not be removed but instead be buried under the site's landscaping materials.

Updated Design and Plan Details

Finally, as also requested by ADC, further design details are included within this report. These details include:

- Clarification of the cut and fill volumes with allowances for loss and settlement during construction;
- Updated plans which illustrate the full 'as-designed' cut area for the breach and the design of the infill and the compensation site; and
- Updated red line boundary plans which were developed following further discussions with ADC and CDC on this issue. These plans have mainly been adjusted on the ADC side of the area and this has been done to provide a necessary degree of flexibility in the construction routing (and on the basis that the area defined by the red line does not then affect the planning fee).

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1 Introduction

1.1 Report background

This report has been prepared by ABP Marine Environmental Research Ltd (ABPmer) on behalf of Pagham Parish Council (PPC) and in response to the letter issued by Arun District Council (ADC) on 7 March 2016 (included as Appendix A). That ADC letter identified a selection of issues to be addressed in order to progress the planning and marine licence applications for the following proposal:

*Managed breach of shingle spit & blocking of adjacent tidal inlet channel with shingle barrier.
Formation of shingle island within Harbour following excavation of adjacent area of spit.*

The planning application for this proposal was submitted by PPC jointly to ADC and Chichester District Council (CDC) on 9 September 2015 and the application for a marine licence was submitted to the Marine Management Organisation (MMO) on 10 September 2015. Following subsequent requests for further information, the planning applications were validated by ADC and CDC respectively on 3 and 7 December 2015. The marine licence was accepted by the MMO on 29 September 2015.

Under the Coastal Concordat² ADC, CDC and the MMO are working jointly on this application with the following reference numbers and roles applying for each authority:

- ✧ **ADC (P/97/15/PL):** Leading the planning application and also the lead contact for submitting information;
- ✧ **CDC (SY/15/03053/FULEIA):** Leading on the Appropriate Assessment as required under the Habitats Regulations;
- ✧ **MMO (MLA/2015/003390):** Leading on the Marine Licence and Marine Conservation Zone (MCZ) Assessment.

This document now provides the further information needed by these parties to complete these tasks.

1.2 Report structure and approach

The further information requested by ADC is presented here under the following three topic headings:

- ✧ **Section 2:** Additional information to assist with the preparation of an Appropriate Assessment (AA), including derogation tests;
- ✧ **Section 3:** Additional information to clarify impacts to SSSI features and assist with the MCZ assessment;
- ✧ **Section 4 (and Appendix B):** An archaeological impact assessment in response to a request from Historic England.

In each case, these sections present further detail, as requested, with references being made back to pertinent sections of the original planning documents (within which the majority of information exists) where it is necessary to refer to, or draw upon, previously-prepared and relevant information. This has been done to try to minimise repetition and ensure that this 'Further Information Report' presents a focussed but thorough response to the outstanding enquiries from the regulators. These preceding documents include:

² <https://www.gov.uk/government/publications/a-coastal-concordat-for-england>

- **September 2015:** Environmental Statement (ES) Volume 1 Main Report (ABPmer 2015a);
- **September 2015:** ES Volume 2 Appendices (including AA Information Signposting Document and MCZ Assessment Information) (ABPmer 2015b);
- **October 2015:** Flood Risk Assessment (ABPmer 2015c); and
- **November 2015:** Design and Access Statement (DAS) and other Planning Documentation (ABPmer 2015d).

To inform the preparation of this text, a consultation meeting was held between PPC, ABPmer and the regulators on 11 February 2016 (prior to receipt of the ADC letter). There were also further meetings between ABPmer and Natural England on 18 March 2016 and with the RSPB on 28 April 2016. There have also been several extra meetings and discussions between PPC and key stakeholders throughout this five-month post-validation period (including a meeting and site visit with Natural England on 5 May 2016).

These discussions were held to ensure that the key issues are addressed within this document and, where required, that extra information was obtained (from consultees including Natural England, RSPB, ADC, CDC and Historic England) to inform this review. In particular Natural England has provided specific written details to help with addressing their own concerns on the potential ecological impacts. These details are mainly set out in two letters dated 25 April 2016 dealing with issues associated with the Special Protection Area (SPA) and Ramsar site and the proposed New Tern Island compensation area, and a follow up letter dated 26 April 2016 addressing Site of Special Scientific Interest (SSSI) and MCZ issues.

In addition to the letter of 7 March 2016, ADC has also asked that this report consider the changes that have taken place on the site over recent months and the implications of these changes for the proposal. This request was made by Simon Davies (ADC Case Officer) in an email dated 18 April 2016 and was prompted particularly by the fact that a new breach developed through the spit from early February 2016 onwards. These and other changes and relevant interventions are reviewed below in Section 1.3.

1.3 Site update (changes and interventions)

This section summarises the changes that have taken place to the Church Norton spit and to Pagham Beach since the application for the intervention works was submitted. This information is presented both in response to the ADC email dated 18 April 2016 (as noted above), but also because it is important to keep the changing conditions on this site under review. This need for ongoing re-examination is in-keeping with the principles of 'adaptive management'³ which applies to this dynamic and changeable section of the coastline.

In keeping with these principles, this section outlines not only the changes at the site (based on relatively recent monitoring results and observations) but also the intervention actions that have been carried out in response. Section 1.3.1 considers the changes up to January 2016 based on new monitoring data that was not available when the ES was prepared. Then the interventions that were carried out in response to these changes are described in Section 1.3.2. In Section 1.3.3, the emergence and evolution of the natural spit breach (since February 2016) is described. Then, the implications of these changes for the proposal are reviewed in Section 1.4.

³ As described at the end of Section 1.1 in the ES (ABPmer, 2015a) adaptive management is defined as a process involving an iterative sequence of monitoring studies followed by informed intervention actions. It is also described in the RSPB letter to ADC (4/1/16) as "Managing complex coastal areas by monitoring changes and acting on them in a planned but flexible way, increasing our understanding over time".

1.3.1 Spit growth and beach erosion up to January 2016

The physical conditions along the spit and on Pagham Beach are surveyed regularly (and with a high degree of topographic resolution) under the continuing Channel Coastal Observatory (CCO) monitoring programme. These surveys are very valuable for understanding the changes taking place. Data from CCO surveys were reviewed in the ES for the period up to January 2015 (see Section 6.1.1 of the ES for full list of data sources used within the ES).

For this Further Information Report, additional unpublished data were provided by Adur and Worthing Councils (AWC) (James Bovington, AWC, Pers. Comm.). This data describes the beach volume changes up to 29 January 2016, and includes as yet unpublished spatial maps illustrating these changes up to January last year (2015). The most recently created maps, which describe the beach volume changes for the Pagham Harbour and western beach frontages (Coastal Unit 4dSU23) for the period from February 2014 to the start of last year (January 2015), are shown in Image 1. These maps illustrate how the end of the spit extended in a north east direction from September 2014 to January 2015 while beach material continued to be lost to the east of Groyne 3.



As yet unpublished maps from AWC

Image 1. Changes to beach and spit volumes in 2014⁴

The measured beach volume calculations based on the latest survey on 29 January 2016 also indicated that the spit continued to grow throughout 2015 and that there was continued beach loss along the Pagham Beach frontage. The data shows that since February 2014 the western section of Pagham Beach has lost 40,283 m³ and the spit has exhibited a net growth of 11,583 m³. Over just the last winter alone (September 2015 to January 2016) the beach lost a further 7,438 m³ and the volume of spit growth was 29,069 m³. A chart describing the relative volume changes from 2003 to early 2016 is shown as Image 2.

⁴ These mapped outputs can be compared against equivalent maps covering periods from March 2003 to February 2014 and February 2013 to February 2014 and as shown in Images 6.16 and 6.27 of the Environmental Statement.

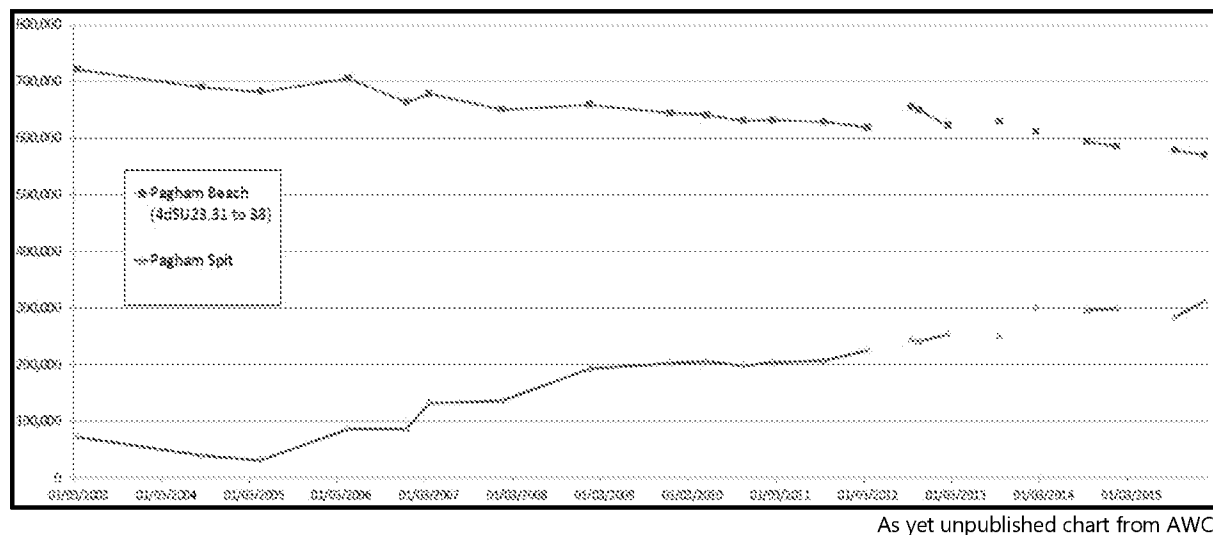


Image 2. Changes to Pagham beach and spit volumes (y axis/m³) over time (x axis/year)

1.3.2 Recent interventions (shingle recycling and rock armour)

The reductions in beach shingle volume described in the preceding section have also been visually apparent in recent months. In addition, there was a distinct change during early March this year when the long-shore tidal inlet (as formed by the growing spit) cut a channel through the timber-framed Groyne 3. In response to the preceding and ongoing changes, ADC carried out a sequence of emergency and planned beach restoration and protection measures during the 2015/16 winter.

- ✧ **29 October 2015 to 6 November 2015:** shingle recycling/importation as well as the placement of Purbeck rock armour between Groynes 3 and 4 and the bolstering of Groyne 3 with geotextile membrane;
- ✧ **2 to 9 December 2015:** recycling shingle to the area between Groynes 3 and 4 following a storm event;
- ✧ **17 and 18 December 2015:** recycling material to the area between Groynes 3 and 4 with some minor remedial works to the Groyne 3 rock and geotextile membrane structure;
- ✧ **4 and 5 January 2016:** further recycling of shingle taking materials from ebb delta and building up beach between Groynes 3 and 4 as well as adjusting the position of the Purbeck rock (which had been pushed back up against the newly formed beach crest);
- ✧ **11 and 12 March 2016:** further shingle recycling and reinforcement of Groyne 3; and
- ✧ **March to April to 2016:** recycling 15,000 m³ of shingle from the ebb delta and placing it to the east of Groyne 1 with some minor remedial work also undertaken to Groyne 3.

The movement ('recycling') of 15,000 m³ of shingle in April/March was a planned protection measure that was undertaken to protect the beach section to the east of Groyne 1 (with a temporary stockpile also formed between Groynes 2 and 3). This was part of ADC's ongoing and anticipated works on site. This element was funded by drawing down Governmental Flood Defence Grant in Aid (FDGiA). For this FDGiA funding the 10 houses between rock Groynes 3 and 4 were identified as the ones afforded protection, and for which relevant Governmental funds and community/partnership funds could be drawn down. This means that the 25 houses on the western side of Pagham Beach (those coloured pale blue and green in Image 3) have been claimed under FDGiA.

The recycling of 15,000 m³ involved transporting shingle (at a cost of just over £50 k) from the inshore banks onto the vulnerable and eroding sections of the upper beach. In the first week of such work it is understood that around 5,000 m³ was transported in this manner. This material was understood to have been largely removed from its site of deposition (and the crest retreated) during the storm event ('Storm Katie') that occurred on 28 March 2016. This illustrates the processes taking place and the

challenges of this work in this environment. In response, further remedial measures were then undertaken the following week. Therefore, while the plan had been to move 10,000 m³, this was increased to 15,000 m³ in response to the effects of Storm Katie (Roger Spencer ADC Pers. Comm.). Further details about the costs of protection measures over the last 6 years are presented in Section 6.2.6.3 of the ES (ABPmer 2015a).

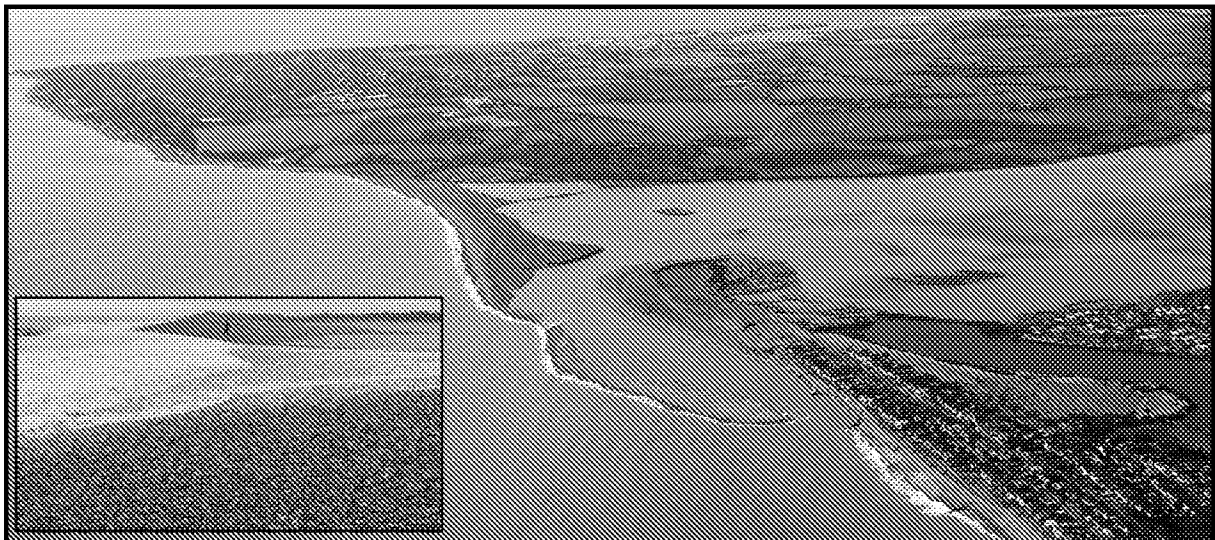


Partial image from Figure 6.6 from ES (ABPmer 2015a)

Image 3. Location of houses vulnerable to erosion or flooding (West Pagham Beach only)

1.3.3 Development of the spit breach

Towards the very end of January, there were early signs of a change to the spit morphology with signs of some roll back occurring along a central section. This presaged a process of change which then occurred over the course of February and March. By early February 2016 the central section of the spit 'slumped' along approximately a 90-100 m wide section and high-water exchange began to occur across this section (see Image 4).



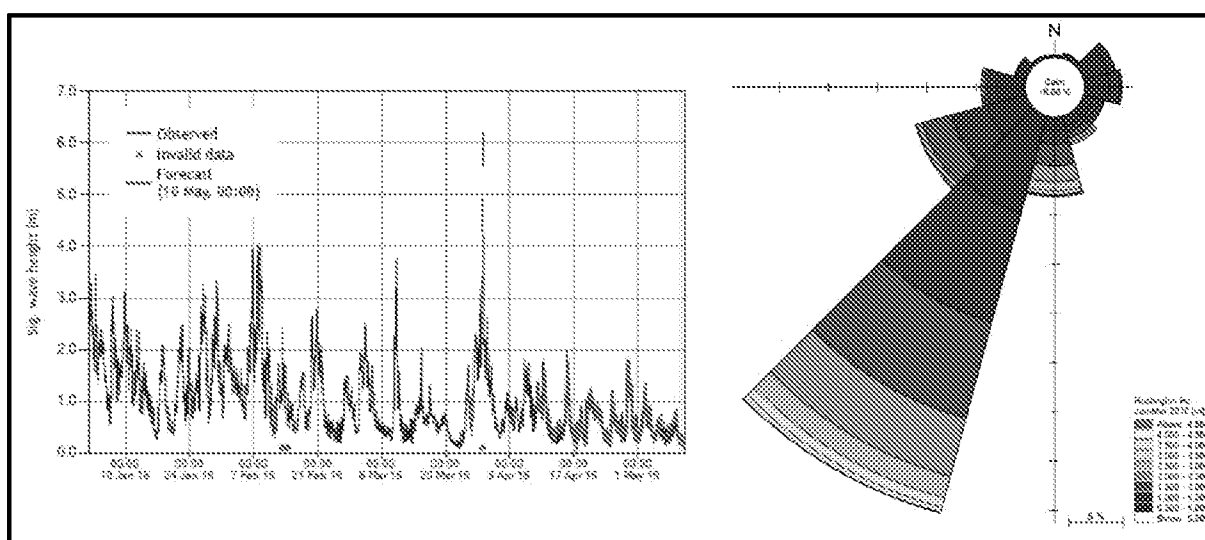
Source: Aerial John Akerman 23 February 2016; inset ABPmer 20 February 2016

Image 4. View of the spit and high water at Pagham in February 2016

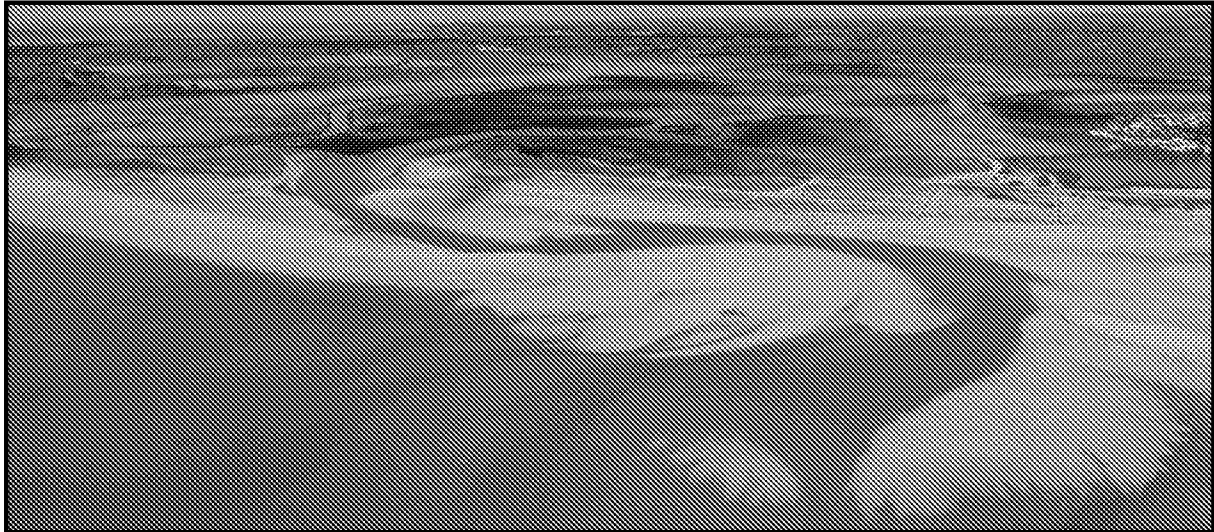
This high-water 'breach' occurred in a location near to where overtopping occurred back in 2011 (see Section 6.2.8 of the ES) and was accompanied by a distinct landward movement of the whole central part of the spit (see Image 4). In contrast to the 2011 event (which was followed by a reformation of the spit in the following summer) the changes in 2016 were more substantial and persistent.

In the weeks following the initial 2016 overtopping this breach matured, i.e. widened and deepened. Towards the end of February (site visit 20 February 2016) there were early signs of this deeper channel beginning to form on the landward side of the spit but the major breach development changes occurred particularly after two major storm events in March.

To illustrate the frequency and nature of the storms over this period, significant wave height data from the Rustington buoy is shown in Image 5. This data indicates that while most waves approach from the south west (as is typical) over the last few months, the wave directions have been highly variable during the storms and some of the largest ones (e.g. during Storm Katie) came from the south.



All potential outcomes are dependent upon factors such as the weather/storm conditions and the supply of shingle. However, as things currently stand in early May 2016, the S-shaped channel is maturing and 'seeking' a more sinusoidal shape. In doing so, this is causing further cliffing and erosion on the Pagham Beach/Spit foreshore and on the spit immediately fronting the training wall and Little Lagoon. This erosion is expected to continue during summer 2016 and possibly much longer depending on the way in which the site develops.



Source: Sussex by Air, 30 April 2016

Image 6. View of the new breach and channel at low water in late April 2016

This new configuration has created a condition for future shoreline evolution that the proposed managed breach fits even more clearly into. This is because the proposed managed breach will be placed in the area where the channel is now trying to erode the spit (while also shortening the channel directing the flows away from the coast) and in doing so will help to stabilise the morphology.

1.4 Implications of breach and project objectives

1.4.1 Implications of breach

The breach that has formed within the spit has helped to illustrate (in part) what the community proposal for a managed breach is designed to achieve. As explained within the application documents (including the ES and the DAS (ABPmer 2015 a, b and d)), the proposal is designed to replicate/mimic such a 'natural breach' formation but with wider benefits. It is designed to remove the scouring pressure that was being caused by the long-shore channel and create a morphology that allows the shingle in the separated end of the spit to winnow into, and resupply, the Pagham foreshore.

These key beneficial changes are now, in part, being observed on site and certainly the scouring pressure on the breach has been lowered. Also, the change may well have unlocked a portion of shingle in the spit (i.e. in the separated end) so that it can naturally migrate towards (and 'feed') the eroding beach to the east. However, the site is so complex in its existing morphology that the extent of this 'feeding' effect is as yet uncertain. The breach has though started to illustrate how the proposed scheme is designed to function as 'a soft solution that works with natural processes at the coast, rather than fighting against them with hard engineering' (see Section 2.1.3 of the ES (ABPmer 2015a) and Section 2.5.3 of the DAS (ABPmer 2015d)). However, the proposal is still required in order to achieve (in addition to its other socio-economic benefits) a better, more sustainable, morphology and help manage the uncertainties that exist over how the site will develop from its current state of flux.

In addition to demonstrating the reason why this work was being promoted in the first place, the changes that have taken place have provided further confidence that such a breach is self-maintaining. What exists on site now is another distinct configuration (in addition to the many that have existed, and been recorded, over the past 400 years⁵) which has not closed up either in this new morphology or in any of the intermediate configurations that took place as it adjusted towards it over the last three months. Instead, throughout this period tidal, exchange between the harbour and coast has been maintained.



Source: John Akerman; Sussex by Air (30 April 2016); CCO (4 May 2016)

Image 7. Views of the spit and breach over the 2015 to 2016 period

The evolution of the new 'natural' breach has also provided some valuable lessons about the way in which this process might be replicated to create the proposed managed breach at the preferred location. It has helped to illustrate some of the design principles that will be relevant for the ongoing maintenance of the proposed breach (see Section 1.5 for further details on the scheme design and implementation).

While the changes to the breach site (following recent changes) will have delivered some of the anticipated benefits of the proposal, PPC wishes to progress with the project as it has been proposed. This is because it is still considered to be the most sustainable option and the one which reduces ongoing uncertainties and will be accompanied by the greatest range of benefits. These project objectives are revisited in the following section in the context of the existing morphological conditions on site.

1.4.2 Project objectives and benefits

The key drivers for the work were set out in Section 2.1.3 of the ES (ABPmer 2015a) and Section 2.5.3 of the DAS (ABPmer 2015d) and these remain valid in light of the changes observed on site. The individual reasons relate, as before, to the need for protecting homes, improving human health and enhancing the amenity value of Pagham Beach, but they also include a number of ecological and environmental benefits that were identified in the ES. Indeed, the changes on site over the last three months have meant that, on balance, the role of the project in achieving ecological and environmental benefits is more evident than before. The key sustainable objectives, in the context of the existing situation on site, can be summarised as follows:

⁵ Informed in large part by the historical evidence, as well as inlet stability analyses, it was concluded in Section 6.3.1.6 of the ES (ABPmer 2015a) that there can be a high level of confidence that the breach created for this proposal will not close. The changes that have occurred on site have helped add confidence to this conclusion.

- ⌘ **To achieve larger and longer-term benefits for coastal protection, human health and for the amenity value of Pagham Beach:** In its current configuration, with a new breach having formed and the dominant channel having moved westwards, the tidal energies and potential for scour effects on Pagham Beach (or for further damage to groyne structures) from the long-shore channel, have reduced. Continuing with the proposed breach will create a more robust blockage to the long-shore tidal flows (as water still flows through this channel during higher states of the tide). Also by breaching further to the west and directing the tidal flows more directly away from the coast, the project will facilitate the migration of greater volumes shingle ('unlocked' from the severed spit and allowed to migrate more easily within the easterly littoral drift due to the blocked channel) towards the beach over a longer timeframe. This will achieve inherently larger and longer term benefits. The proposed project will, additionally, slow/halt the erosion presently occurring on the Pagham Beach/Spit (from the evolving S-shaped channel). It will also reduce the risk of the spit building up quickly along its existing, and shortened, configuration to further exacerbate this presently observed Pagham Beach/Spit erosion. It will also reduce the risk of, or delay the re-occurrence of, a replication of the damaging pre-February 2016 morphology;
- ⌘ **To provide the community with the opportunity for exerting a degree of sensitive control over the management of the beach and the wider shoreline and broaden the options available for the ongoing adaptive management of this coastline.** The project remains a proactive solution which is preferred to relying solely on the existing situation of responding to change at the beach in front of houses. This proposal therefore inherently broadens the options that are available for the ongoing adaptive management of the coastline which is typically viewed (at this location at least) as a set of reactive actions that can only be done on the immediate frontages of the houses along the shoreline;
- ⌘ **To allow the community to become more actively re-engaged with the management of the environment on their doorsteps.** This project will be accompanied by community voluntary support and oversight (site management procedures are described further in the sections following) and will also present new opportunities for community engagement activities. This will allow the community to be actively re-engaged in the environment and move away from a situation where there is a perceived conflict between ecology and people, or where the community view themselves as bystanders unable to undertake measures due to perceived constraints and issues of uncertainty;
- ⌘ **To secure ecological and environmental benefits.** Within the original planning application and subsequent consultations, the opportunities for ecological and environmental gains that come with this project were noted⁶. In particular it was considered (by ABPmer) that the project provides 'greater assurance of Pagham Harbour tidal functioning'. In light of the current morphological conditions on site and also the requirements that exists as part of this proposal to secure compensatory habitats for Little Tern (discussed further in Section 1.5.6) and introduce breach management measures (to ensure no breach closure, as discussed further in Section 1.5.4), these ecological and environmental benefits are in many ways more evident than before. These can now be seen as including:

 - **Reducing the risk of further damage to the appearance and ecology on the beach.** The coastal protection measures in front of the properties (which includes areas within the SSSI/SPA/Ramsar boundary) have involved introducing imported rock

⁶ The initial prompt for the work was the desire to improve protection to homes and restore Pagham Beach as much as possible. However, it is considered that this should not mean wider environmental benefits are ignored. Instead, such benefits are seen as fundamental to the more sustainable approach that was developed and is proposed.

armouring and translocating shingle. These have protected homes but have also inherently damaged the naturalness and appearance of shoreline. The need for such measures will be reduced by the project and this will reduce the potential for further damage (this benefit still applies following the recent changes on site);

- **Providing extra management of potential Little Tern nesting habitat in an environment that is in a state of flux.** The recent changes on site have highlighted that there is a great deal of existing uncertainty about the duration of Little Tern habitats. Much of the potential Little Tern habitat may well have been damaged by the recent breach and certainly much of it has been opened up to visitors and predators. There are also signs of progressive erosive change of the residual spit and greater uncertainty as to the future evolution of the breach and spit features. In this context, the proposed project will create a more stable breach and will be accompanied by ongoing site management and new seasonal visitor exclusion and education measures. This offers the opportunity for greater certainty that Little Tern habitat can be managed (and, indeed, benefited) across Pagham Harbour than is provided by relying solely on nature and natural processes. In this context it is also pertinent that the success of Little Terns on the spit in recent years has been due to the management, care and oversight provided by the RSPB staff during the breeding season. This management has been made more difficult by the recent changes.
- **Reduce the risk of breach closure.** As set out in the ES, ABPmer considers the risk of breach closure following a managed intervention to be very low. It is also considered to be low under a natural/existing breach condition. However, to the extent that such a risk exists from a managed breach, it will be reduced by the fact that a management measure has been requested by Natural England to ensure it does not close. With its inclusion, the risk of closure is inherently reduced.

Further information about how these benefits compare against those provided by any relevant alternatives, is presented in Section 2.3.

1.5 Design and methods for breach and compensation site

In response to requests for further information from ADC and Natural England, this section clarifies some details about the design, the methods of construction and the monitoring work associated with the proposed breach and the proposed New Tern Island compensation site. Further details about the management of the breach, spit and compensation area are also presented in Section 2 as part of the AA information review.

1.5.1 Managed breach – Design, cut and fill volumes and plans

As requested by ADC, further clarifying details about the cut and fill volumes and the design of the proposed infill are provided here. Updated plans of the design are also included as Figures 1 to 5. These plans update and replace the plans that were presented in Figures 1 to 4 of the DAS report (ABPmer 2015d). They also include an extra plan (Figure 5) which describes the shape and design of the New Tern Island compensation site.

The proposed managed breach (located 350 m to the south west of the newly formed breach location) will require the excavation and translocation of around 54,545 m³ of shingle. Of this volume 52,500 m³ will be excavated within the central 80 m-wide section of the breach cut. As highlighted by ADC, there will be a need for a further cut at the crest of the spit to ensure that the breach ties in at the highest elevations. This extra zone has also been illustrated on the plan drawing (Figure 2) as triangular-shaped side extension to the breach. The inclusion of this extra cut will provide around a

further 1,954 m³. In total therefore the excavation volume is around 54,454 m³ (a rounded value of 55,000 m³ is recommended for use as part of budgeting and planning purposes).

The fill had originally been designed (in the ES) with a flattened surface that was set at HAT (3 m Ordnance Datum (ODN)). It was designed to ensure there was plenty of extra shingle volume with which to make appropriate design adjustments in the field. In response to requests from ADC, however, these relevant further details adjustments are presented here to better describe what the final infill design might look like and provide all regulators and advisors with necessary confidence in the efficacy of the design.

For this clarified design the crest level of the infill area has been raised to around 4.8 m ODN. This will allow for some settlement of the deposited material and ensure that it remains above the height of the highest tides. The infill has also been shaped with 1:8 side slopes (in keeping with, but slightly shallower than, the existing channel side-slopes under the existing morphology).

This infill design shape will be much more in keeping with the shape and side slopes of the existing spit and will allow the crest of the infill to be 'tied into' the crest of the remaining spit feature. This will maximise the visual and morphological integration of the infill and the spit. This design also has a widened based to further enhance the stability (and channel blockage value) of the infill area.

The volume of this infill design is around 45,000 m³. This leaves a positive cut:fill balance of 10,000 m³ which represents a 'contingency volume' that is available for use at the compensation site, the infill or the adjacent spit as required. These volumes are based on the Environment Agency's January 2015 LiDAR data and should be reviewed in advance of the work based on the latest morphological data on the site.

In Figure 1 an updated version of the red line boundary plans is shown which was developed following further discussions with ADC and CDC on this issue. This boundary has been adjusted mainly on the ADC side of the area to provide a necessary degree of flexibility in the construction routing (and on the basis that the area defined by the red line does not then affect the planning fee)⁷.

1.5.2 Managed breach - Construction plan

Details of the proposed construction, based on advice from a potential contractor, were described in Section 3.2 of the ES and further details, including a map of the access routes, were included in Appendix D. In response to a request from ADC and Natural England, further details about the methods and timings of the construction work and the routes to be taken by plant on site are presented here.

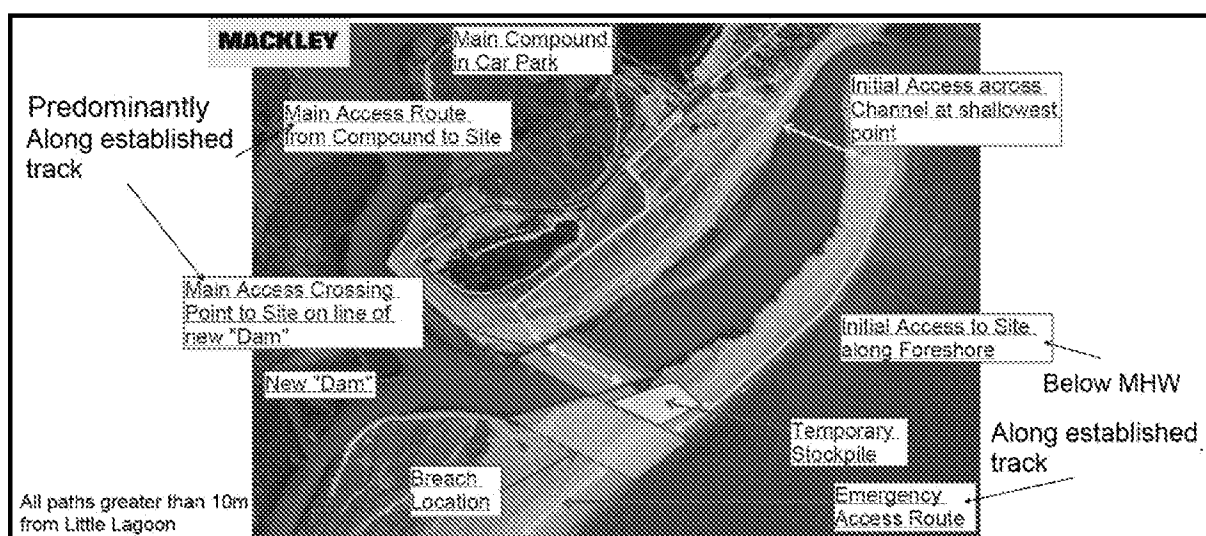
Using the advice from Natural England and the information within the ES, this information is presented as a set of key construction principles. This is because it is not possible, at this stage, to provide a final detailed construction plan. This can only really be prepared once the procurement process has been progressed and a preferred contractor commissioned⁸. The key principles of any work that will have to feed into such a plan are as follows:

⁷ The previous understanding (in 2015 submission) had been that the fee was related to the planning area and this had led to a small red line area being developed which might constrain project flexibility.

⁸ It is anticipated that the need to submit a construction plan will become a planning and marine licensing condition, which would be submitted once the complete procurement process has been progressed. This plan will also need to take account of the specific conditions that exist on site (especially the morphology of the spit) which may be different from the conditions as they are currently known.

- ✱ **Plant Routes:** The proposed plant route map shown in Appendix D of the ES is reproduced as Image 8. For this plan the routes were aligned along existing paths or along the un-vegetated sections of the spit below mean high water to ensure that there is minimum damage to areas with vegetation. Adopting this approach will also keep plant away from newly formed shingle ridges (except at the construction areas) which are of geological interest and will keep plant more than 10 m away from the Little Lagoon (see Image 8). This basic plan still applies following the recent physical changes on site. For instance it has been confirmed (following recent advice received from a second expert contractor) that plant access can still be from the distal end of the separated spit and then through the new breach at low water (over the ebb delta). Adoption of this route will avoid damaging vegetated shingle areas and locations of geological interest.
- ✱ **Avoiding the Bird Breeding Season:** As proposed in the ES, construction work on the spit will be avoided during the breeding bird season but it is recognised that further details of the timings and nature of the activities are warranted to provide Natural England with greater assurances as to the absence of any effect on breeding birds. To provide this it can be confirmed that Natural England's advice on timing to avoid sensitive breeding seasons will be followed and that:

 - the mobilisation of plant will start in August but all such works will be confined to the works compound (which will be in the Pagham Harbour Road car park) and access roads;
 - no plant movements will occur outside of the car park until the last Little Tern (or other breeding bird species) on the spit has fledged. This is expected to be late August to early September. The timing of this last fledging and construction commencement will be agreed in consultation with the RSPB who will be providing the required 'watching brief'. At that time Natural England and the contractors will be jointly notified;
 - as part of all phases of this work (i.e. during the procurement process and then when preferred contractor mobilises on site), construction staff will be briefed to ensure they are aware of the need to keep away from breeding bird sites during the summer (and also to avoid unnecessary activities (e.g. walking across the site) that may cause disturbance to overwintering birds during the winter and to adopt access routes/movements that minimise potential effects on vegetated shingle);



Source: Mackley Construction Proposals, Appendix D, ABPmer 2015a

Image 8. Construction access route map based on site morphology before March 2016

- * **Construction Plant and other details:** Following the selection of the preferred contractor, a finalised construction plan (including plant route map) will be forwarded to ADC, RSPB and Natural England for agreement and sign off. The plan will include:
 - o Type and number of vehicles;
 - o Access route maps for plant;
 - o Access route maps for personnel which will be predominantly confined to the compound, the area of the new infill and the breach location;

For now the number of plant is expected to be around 8 on site (2 teams each with 1 excavator, 1 dozer and 2 dump trucks plus 4-wheel drive support as described in Section 3.2.6 of the ES). For this Further Information Report, a second opinion on this issue was sought from another specialist contractor and they have confirmed that around this number of plant would be required.
- * **Work during the Bird Overwintering Season:** Work at the breach will only start after the departure of breeding birds and then the majority (if not all) of the work is expected to be carried out before the overwintering bird period (start of November 2016). Where work extends into November it is likely to be for around three weeks. During this early part of the overwintering period, cold/freezing weather working restrictions for the work will apply⁹ and personnel walking movement outside of the plant will be kept to a minimum and confined to areas of work at the breach and compensation site cut and infill areas (subject to issues of safety).

1.5.3 Managed breach - Ongoing Tern habitat management

Further details about the ongoing management of the breach site and tern habitat are presented in Section 2.2.1 below in the context of response related to the AA. In summary though, this process will involve the setting up of a stakeholder group to oversee the project. The RSPB and PPC are expected to play lead roles in the group (jointly chairing) and RSPB staff will continue to manage the breach and spit area for Little Tern and other breeding birds.

The RSPB's work on the ground (to be done in collaboration with a local voluntary body) will include fencing and wardening work in the summer. This will incorporate installing reactive fencing around nesting sites on the spit areas to minimise the impacts of predator disturbance. This reactive fencing and wardening will follow the methods that the RSPB has adopted for its current work under the reserve management plan. In addition, there will be extra proactively-placed seasonal fencing and informative signage to limit human access to the remaining section of spit (for as long as it remains viable habitat for terns) during the summer breeding season). The group will not only advise on the efficacy of, and funding for, the fencing and wardening work, but will also have a remit to identify and develop community and schools engagement initiatives over the 8-year period of its operation.

It is proposed that the stakeholder group meets on a biannual basis for the first 2 years and then annually for a further 6 years¹⁰. It is not considered appropriate for commitments specifically related to this proposal to be extended much beyond this timeframe given that the process works with natural processes and that, over time, there will be an increasing inability to distinguish between the shoreline morphology that would have existed with and without the proposed intervention. However, this shoreline will require ongoing adaptive management (lead by ADC) over the longer-term.

⁹ Drawing on wildfowling approach (<http://jncc.defra.gov.uk/page-2894>), running from 9 November, a period of optional/voluntary development restraint would apply when more than half UK meteorological stations have recorded frozen conditions for 7 consecutive days. A cessation of activities would occur from the 13th day of such conditions. Any response should be based on advice from NE and RSPB in the light of the project status and the risks to waterbirds based on observations made during the work.

¹⁰ It may also need to meet outside of these periods to address breach maintenance issues (see Section 1.5.4).

1.5.4 Managed breach - Ongoing breach maintenance

The stakeholder group will also advise on whether there is a need for any post-construction shingle excavation/recycling work to maintain the breach open¹¹. In particular, Natural England has asked that a management plan for such measures be put in place to be assured that the harbour will not close and that effective tidal exchange between the harbour and coast is maintained. Equally, Natural England also supports the concept of the project which is to let natural processes operate post breach and for the new breach to not become heavily managed. The stakeholder group must, therefore, balance these two considerations when applying its advice.

The group will also need to consider timescales of change and recognise that conditions can change in a distinct and directional manner over periods of a few weeks to months (as evidenced by the recent breach opening). The minimum time for making any judgements would be based around the fortnightly neap-spring tidal cycles. For instance, the breach may appear to partially close (become shallow) over a neap tide but may well then re-open (deepen) on subsequent spring tides. More rapid change can occur over hours/days particularly during stormy periods and, as we have seen from the recent breach, storms can play a key role in changes taking place. However, a spit's responses to storms can either be in line with the broad direction of an observed trend or can prompt a reversal of it.

Therefore making shorter-term reactive management responses to changes that have taken place over a few days or one or two weeks only should be avoided. In this respect, there were valuable lessons from the recent breach in which the trend of change was clear and occurred over several weeks but the key shifts occurred after storm events (see Section 1.3).

Bearing these considerations in mind, the stakeholder group will need to be aware of trends and changes over weekly/monthly timeframes, while also being cognisant of how these trends might be accelerated over periods of a few days during storms. Time of year is also important because the ecological need for intervention will be greater during the winter (because limited tidal exchange will restrict the intertidal area for bird foraging), but equally the potential for a storm event will be greater and these issues will need to be considered. On this basis, a 'Traffic Light System' warning system (to meet the 'What If' matrix requirement requested by ADC), might be applied which would be as follows:

- **Green Light:** The breach remains open and/or the morphology of the coastline is allowing efficient drainage of the harbour on neap and spring tides. **Action** no active intervention is required but ongoing monitoring and oversight (see Section 1.5.5) continues.
- **Amber Warning.** The depth of the breach is raised to, or just above, MSL (at which point the extent of harbour intertidal area will start to become marginally reduced¹²) for a period of up to 4 weeks (i.e. 2 full spring neap cycles), leading to a distinct/measurable restriction in tide drainage over this period. Additional considerations would be that there is no sign of a deepening central channel emerging at the channel base to indicate that the high water overtopping is beginning to reverse this trend and re-establish a deeper cutting or there is no immediate prospect of storms occurring that would presage a distinct morphological shift. **Action** a judgement should be made about the extent to which this is a response to the broader trends in the evolution of the spit and the breach (based on available monitoring) and contractors should be alerted as they may well be required to intervene within a few days/weeks;

¹¹ Recognising, as stated in Section 6.3.1.6 the ES and again in Section 1.4.2 above, that the risk of such closure is anticipated to be very small.

¹² As described in Section 8.2.5.2 of the ES - 4.2 ha of low intertidal (4.5% of harbour intertidal) is inundated by shallow water when tides in the harbour are retained at MSL.

- * **Red Light:** The depth of the breach is raised closer towards Mean High Water Neap levels (at which time the intertidal area within the harbour will be significantly reduced) for a period of more than 4 weeks leading to a distinct/measurable restriction on spring tide drainage over this period. There is still no sign of a central channel to indicate that the high water overtopping is beginning to reverse this trend and re-establish a deeper cutting and no immediate prospect of storms occurring in the near future that would presage a distinct morphological shift. **Action** The breach needs to be re-excavated in a manner that is appropriate to the morphological conditions on site.

In summary, intervention should only be required when the status of the breach has developed to a point where the scale of change is no longer likely to be reversible by natural processes alone. The nature of interventions will also need to be considered. They do not necessarily need to involve returning the breach dimensions to the 'as-designed' condition. Instead the dimension may only need to be returned to a level where subsequent desired changes can be achieved by natural processes.

The location for the placement of newly excavated shingle also warrants consideration under such circumstances. It is likely to be preferable to place shingle at a location alongside the breach which helps maintain the breach location and/or also provides an area which may become valuable for breeding Little Terns. With these issues, as with all aspects of this management plan, an element of judgement will be required.

1.5.5 Managed breach - Ongoing monitoring

This proposed breach site and the New Tern Island compensation location will be subject to ongoing physical and ecological monitoring to ensure that the post-implementation developments, and interactions with the nature conservation interest of the protected SSSI/Ramsar site, are understood. The vast majority of such work will be carried out as part of established programmes of work, including especially the Southeast Strategic Regional Coastal Monitoring Programme which involves beach monitoring survey led by AWC and the Environment Agency Light Detection and Ranging (LiDAR) surveys.

As noted within the ES, the Pagham Harbour frontage has been subject to detailed study over many years. This is because of its ecological value as well as the dynamism and research potential associated with this location. This level of interest, and regularity of survey, is expected to continue into the future so that monitoring results will be available to inform management decisions. Since the ES was completed, the following surveys have been undertaken:

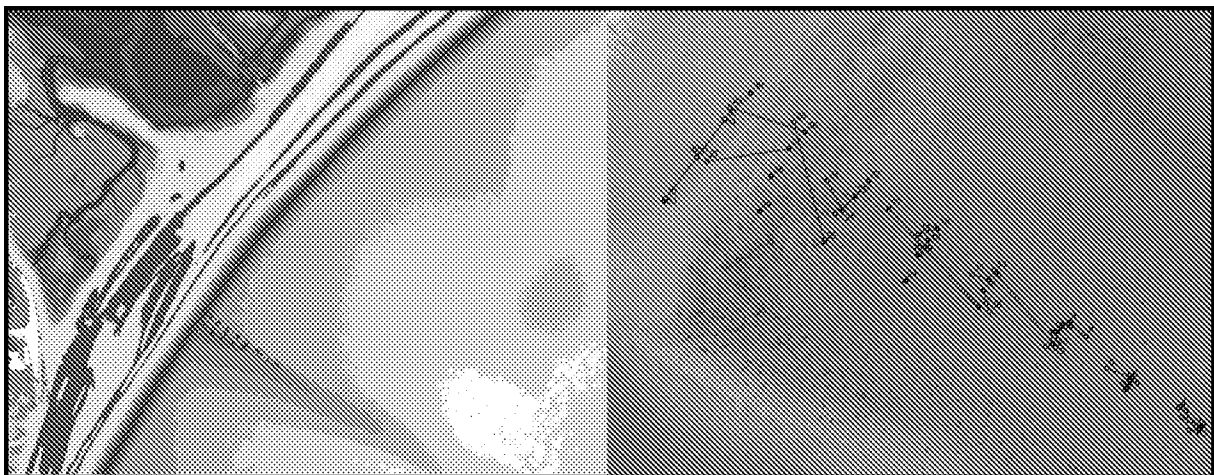
- * The regular topographic shoreline **laser-scanning surveys** under the CCO programme (undertaken using All-Terrain Vehicle (ATV)) have been continued and were carried on 29 January 2016 (see also Section 1.3 above) and again on 13 April 2016 just before the major phase of new breach evolution (James Bovington, AWC, Pers. Comm.). These provide detailed full topographic coverage of the spit and shoreline at low water (as opposed to individual cross-section profile lines only which were the historical survey methodology) and provide a detailed description of the spit and shoreline morphologies. The results of this work will be reviewed and reported within the annual reports (e.g. SRCMP, 2014).
- * Under the CCO programme a new **multi-beam ('swath') bathymetric survey** was conducted from the Wessex Explorer survey vessel at the end of April/start of May 2016. The results of this survey will be used to update the admiralty chart maps (Andrew Colenutt, CCO, Pers. Comm.) and fill gaps in existing understanding about subtidal conditions (seabed morphology and substratum composition);

- A further Environment Agency **LiDAR survey** as part of their ongoing monitoring work. This was carried out in March 2016 and will be used, alongside the ATV laser-scanning work, to map and understand coastal morphology and changes taking place to the spit and the wider coastline.

The intertidal morphology work (laser-scan and LiDAR) is expected to continue over the coming years. The programme for these surveys is being reviewed currently, so it is not possible to confirm the frequency and number of surveys at this time. However the indications currently are that the Selsey, Pagham Harbour and Pagham frontages (i.e. including the spit) are likely to continue to have at least two laser-scan surveys each year, with potential for separate post-storm or interim surveys (Andrew Colenutt, CCO, Pers. Comm.). The next formally-scheduled laser-scan survey will be in September 2016 (James Bovington, AWC, Pers. Comm.). This would essentially represent a continuation of the current programme. As for the Environment Agency LiDAR surveys, these may begin to reduce in frequency after the 2017/18 winter period. Instead of being annual surveys each winter, they may be carried out every two or three years (Andrew Colenutt, CCO, Pers. Comm.).

Added to these established survey programmes, this is a location which is closely watched by locals and coastal managers alike and is an area where there has always been an intense level of interest and research work. There have been numerous additional survey and research studies as well as regular Unmanned Aerial Vehicle (UAV) and manned flights undertaken by locals to obtain aerial photography.

One example of other research which may provide valuable insights includes a study by the University of Sussex. It is currently conducting shingle/pebble tracking work under a SCOPAC (Standing Conference on Problems Associated with the Coastline) R&D project initiated by the Environment Agency, CDC and ADC. Recent results have shown how rapidly pebbles can move landward (Prof. Cherith Moses, Pers. Comm.). This is illustrated in Image 9, which demonstrates results of a recent (24/25 April 2016) tracking exercise conducted along a spur feature. Hypotheses on the relationships between wave energy conditions, shoreline location and pebble size are being evaluated through this investigation.



Source: Environment Agency LiDAR 2015 with University of Sussex Shingle tracking data 2016

Image 9. Location of shingle tracking work on a shingle 'spur feature'

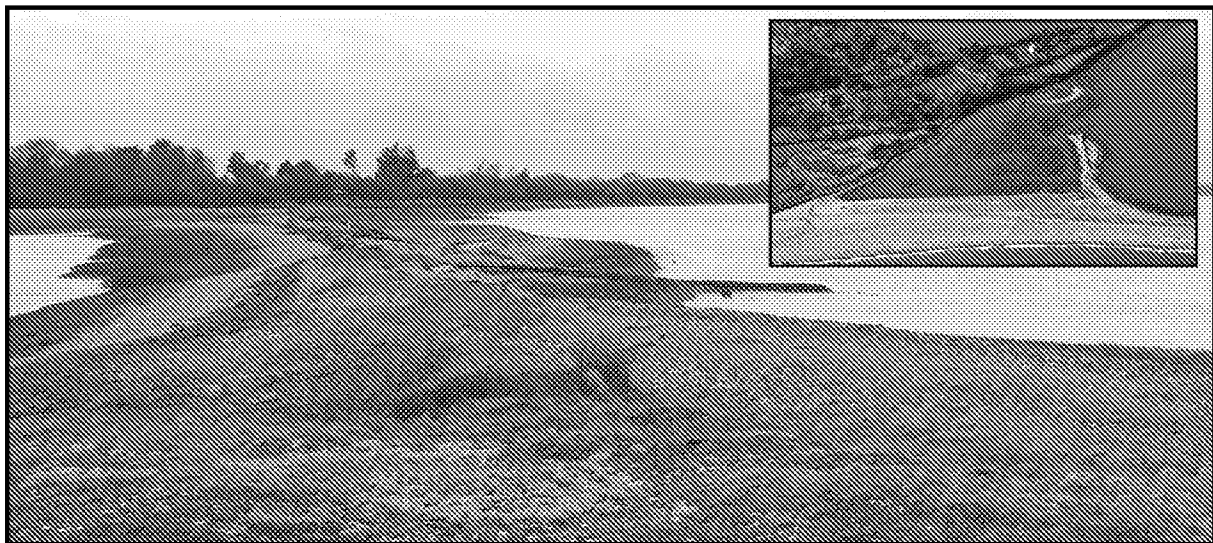
In addition to the above there will be ongoing bird monitoring as part of the WeBS (Wetland Bird Survey) programmes. The only notable gap in information relates to tidal behaviour in the middle of the harbour and as a result it is recommended that a tide gauge is deployed within the harbour for the purpose of monitoring and managing the project. The stakeholder group can advise on the need for this, the duration of its placement, and/or the location for its deployment.

1.5.6 'New Tern Island' compensation site – Scheme design

ADC requested further details on the design of the New Tern Island that would be created as compensation for losses of suitable habitat at the spit. This compensation was identified to account for the uncertainty about the effects on Little Terns and was described in Section 11.2.2 of the ES (ABPmer 2015a). Further evidence about the effectiveness and adaptability of such a measure was also set out in Appendix L of the ES. This included past case examples and reviews of their effectiveness as well as details of the management measures that can be applied to enhance the value of a site for terns.

Natural England has requested further information (in their letter dated 25 April 2016) to secure sufficient certainty about the effectiveness of the 'New Tern Island' compensation site. To assist with this process, extra information on the design issues and requirements was provided by Natural England. This information was informed by discussions with the RSPB who have produced a clear note on this issue (as included with the Natural England letter).

In addition ABPmer visited the compensation site with the RSPB on 28 April 2016 to review the conditions and agree the design detail. Following these written exchanges and subsequent discussions, updated scheme designs for this compensation site have been prepared. Illustrations of the design are shown in Figures 3 and 5. Further details about the location in which this work would be carried out and the design are presented below and Images 10 and 11.



Source: ABPmer 20 February 2016; inset/aerial John Akerman 7 February 2007

Image 10. View from the south east (seaward) end of the proposed New Tern Island

The proposed compensation site enhancement work will be carried out at the same time as the breach excavation work. As requested by Natural England/RSPB, the design has been made as elongated and narrow as possible because that has been found to be the preferred shape for nesting Little Terns (as opposed to square/round islands for example).

Natural England has also asked whether the island can be made slightly larger and efforts have been made to do that, although on site there is very little room for horizontal adjustment. To try to achieve this, the channel (to be excavated on the south-east side of the island) has been moved very slightly further to the south-east.



Source: ABPmer 28 April 2016

Image 11. View from the north west (landward) end of the proposed New Tern Island

Further movement of this channel and extension of the island has been considered but is not proposed. This is because it is considered important to form a straight-line connection between the channels on either side and create the most direct flows. Also, any further shifting of its position in this direction would create a more sinuous or widened channel shape that would be more likely to silt up subsequently. Furthermore, any such changes to the channel would widen the area of excavation and require more of the existing shingle and mudflat habitats to be affected/translocated and would result in damage to areas of vegetated shingle.

There is also very little room for adjustment of the other island boundaries with the area in which the work can be done. This area is being relatively well defined by the existing zone of damaged concrete training wall and shingle above the Mean High Water level (see Images 10 and 11). To expand the area any further outside this boundary would result in change/damage to habitats lower down the shore and would not be of any greater value in terms of achieving the aims of the project (i.e. creating suitable nesting habitat which is only irregularly inundated).

Although there are considered to be no further opportunities for increasing the spatial extent of the proposed compensation area, the side-slopes have been made as steep as feasible to maximise the extent of the island's crest. This change has been undertaken to maximise the extent of the highest shingle habitats and enhance the potential value of the site for Little Terns. The resulting implementation and design details are:

- * All the landscaping material will be laid above the 1.9 m ODN level (Mean High Water (MHW)) raising a total area of 0.36 ha above this MHW level¹³;
- * The top/crest of the island is set at around 3.8 m ODN (approximately 75 cm above the level of Highest Astronomical Tide covering the uppermost exposed concrete on site) and will cover an area of 0.15 ha;
- * The side slope on the sheltered (northern) side would be set at 1 in 1 slope while it would be 1 in 5 on the exposed (southern) side; and

¹³ The tidal elevations used here are for Pagham. Within Pagham Harbour they will be slightly lower (and the areas here expressed will be larger) but for consistency it was considered appropriate to use the same elevations for the compensation site analysis as for the breach design analysis

- * The volume of landscaping material would be 1,900 m³ of which around 1,000 m³ can be derived if needed from the excavated channel. This means that at least a further 900 m³ of shingle will need to be translocated from the managed breach site to contribute to the formation of the island. However the option also exists for all the 1,900 m³ to be derived from the managed breach and the channel then excavated (and material set-aside locally) as the plant retreat from the site.

1.5.7 'New Tern Island' compensation site - Evidence of effectiveness

Natural England has also asked for further information to provide confidence in the habitat being used by Little Terns. The application documents reference a body of evidence on this issue and this was presented within Appendix L of the ES. This appendix was prepared because it was recognised that there was a need to have a high level of certainty as to the effectiveness of the proposed compensation measures under the Habitats Regulations.

On the basis of this evidence and in light of the proposed measures that will be put in place to manage the site (see next section), there can be a high level of confidence that the measures will work. The deteriorating condition of the spit feature in its current morphology lends an extra level of urgency to these measures, but also further confidence in their effectiveness, as discussed previously.

Natural England identified particular questions regarding the differences in the aspect and situation in which the works would be carried out when compared to the site of the breach (e.g. the latter is a more exposed coastal location while the former is sheltered and closer inshore). To allay any concerns on this issue, the RSPB has highlighted that the conditions at the New Tern island site are very similar to those prevalent at the Hayling Oysterbeds (Langstone Harbour) where the Little Tern enhancement work was initially very successful (as also indicated in the Natural England letter). Both have relatively sheltered inshore conditions in relatively close proximity to a treeline. The sheltered conditions will also help to keep the shingle stable.

It is also notable that one of the reasons why the existing spit is successfully used by Little Terns is that the RSPB take great care to fence off suitable areas and manage the site for predation¹⁴. The recent changes will make it much more difficult for the RSPB to manage much of the site (i.e. the separated end of the spit) for Little Terns by simultaneously making it more difficult for RSPB staff, but easier for predators, to access it. The recent changes on the site will, therefore, make this oversight much more difficult as well as potentially reducing the general stability of the habitat. Therefore, the compensation work to offset losses of Little Tern nesting habitat (measures which were important and necessary as part of this project under the legislation) are now more valuable for providing assurances as to the persistence of appropriate, accessible and manageable Little Tern habitat into the future.

The effectiveness of the New Tern Island and the management of it will need to be judged in the context of the recent natural changes that have taken place on the spit. These will become more evident after the end of the 2016 summer period when the effects of the new morphology for Little Terns will be more clearly understood. It is recognised that Natural England require certainty as to the outcome of the compensation measures but that will need to be viewed, assessed and in future, managed in the context of the high level of uncertainty that currently exists. Further details about the management of this New Tern Island are presented in the following section.

¹⁴ The works on the New Tern Island will have a further ecological value in that will cover fox hides on the island (they are believed to be using the areas under the broken concrete revetment) and that will help to reduce predation levels in this part of the harbour.

2 Appropriate Assessment Information

2.1 Background

As the proposed managed breach will take place within a designated Special Protection Area (SPA) and Ramsar Wetland site (see Section 8.1.2 and Figure 8.1 of the ES) there is a need to evaluate the impacts through a Habitats Regulations Appraisal (HRA) process. This HRA process was outlined in Section 4.4 of the ES (ABPmer 2015a) and also in the RSPB planning response (letter dated 4 January 2016).

This process requires an initial judgement to be made as to whether the project will have a 'likely significant effect' (LSE) on the designated sites. If there is a LSE (or such an effect cannot be excluded) then there is a need to produce an Appropriate Assessment (AA) to determine whether the integrity of the designated site will be affected¹⁵. If there will be an effect on the integrity (or the potential for such an effect cannot be excluded) the project can only go ahead if the following three tests are applied:

- * Test 1: there are no alternative solutions that would have a less damaging effect;
- * Test 2: there are imperative reasons of overriding public interest (IROPI) for the project; and
- * Test 3: suitable compensation measures are carried out to offset negative effects.

Defra (2012) provides guidance on how the above tests should be applied in England and UK offshore waters.

This HRA process was followed within the impact assessment documents submitted with the planning application. These documents included a review of the project's effects on nature conservation interests (see Section 8 of ES) as well as an 'AA signposting document' which highlighted the information required to produce an AA and which assessed the projects' effects against the site's conservation objectives (see Appendix C of ES Volume 2).

During the planning process and scoping consultations, a LSE judgement was confirmed (as advised by ADC, CDC, MMO and Natural England)¹⁶. During the subsequent assessment process (Section 2.1.1 of the ES), there was then an early recognition that an effect on integrity could not be excluded in the context of the Conservation Objectives (see Section 11.2.2 and Appendix C (Table C2 Row 2) of the ES). In the assessment documentation this was attributed to uncertainty about whether, and to what degree, breeding Little Terns (which are an interest feature of Pagham Harbour SPA) will be affected by the proposed project. This early conclusion about the effect on integrity was based on past UK experience and on the fact that, because this project works with natural processes, there was an inherent lack of certainty as to the absence of an adverse effect (ABPmer 2015a).

It was therefore concluded within the assessment documentation that there would be a need to further consider the alternatives in the context of the Habitats Regulations, to conduct an IROPI test, and identify compensation measures as required. As part of the assessment process, the alternatives were reviewed (Section 2.2 and Table 2.1 of the ES) in the context of the project objectives (Section 2.1.3 of the ES) and the IROPI criteria (Section 2.1.4 of the ES Volume 1 and Section C.14 in Appendix C Volume 2). Following the impact assessment, a proposal for compensation measures was included (Section 11.2.2 of the ES) to address the uncertainties of effects on Little Tern breeding habitats.

¹⁵ The final AA (including a judgement about the effects of the project on the integrity of the protected sites) needs to be made by the lead competent authority which in this case is CDC.

¹⁶ This was then also further confirmed within the ADC letter dated 7 March 2016 (Appendix A)

In response to requests by Natural England and the RSPB, ADC has requested further information to clarify certain technical and policy aspects relating to the ecological effects, project implementation, processes and mitigation measures as well as the three derogation tests under the HRA process. This information is provided here to complete the information needed by CDC to undertake an AA. The topics covered here are:

- **Section 2.2 Further Information for Appropriate Assessment**
 - the effects on Little Tern populations and the management of these;
 - the risks of the harbour inlet closing and the management of this; and
 - the impacts to overwintering SPA/Ramsar bird populations during construction.
- **Section 2.3 Appropriate Assessment (AA) Derogation Tests**
 - Test 1 Objectives and Alternatives;
 - Test 2 IROPI; and
 - Test 3 Compensation Measures.

The further information requested on these topics is presented below (with references back to earlier sections of this report that are also relevant).

The Information for an Appropriate Assessment (AA) Signposting Document (Appendix D of the Environmental Statement) concluded that it was not possible to demonstrate with the required certainty that the proposed project will not have an adverse effect on the integrity (AEOI) of the Pagham Harbour SPA and Ramsar site. Article 6(4) of the Habitats Directive provides a derogation which allows a plan or project to be approved in limited circumstances even though it would or may have an AEOI.

2.2 Further information for appropriate assessment

2.2.1 Impacts to Little Tern and their management

Details about the design of the 'New Tern Island' compensation site were presented in Section 1.5.6 of this report. The measures for managing Little Tern habitats/impacts at the breach area (i.e. site of construction) were also summarised in Section 1.5.3. In addition, Natural England has requested further details about the management measures that will be put in place to enhance the value of the compensation site (and provide requisite levels of certainty as to the success of these proposed compensation measures). This section, therefore, further reviews these relevant management measures (which will be appropriate to both the compensation and breach sites). These measures have been discussed and agreed with the RSPB and PPC.

Within the ES (Section 11.2.3 and 11.3 (ABPmer 2015a)) it was recognised that there would be a need for "ongoing oversight of the project" to address issues of impact "uncertainty especially in respect of the effects of the project on Little Terns" and that this technical oversight could be provided by a panel of stakeholders. The role of the stakeholder group has been reviewed in Section 1.5.3 above and it is expected to be composed of representatives from PPC, ADC, CDC, Natural England, the Environment Agency and the RSPB. It is also expected to meet on a half-yearly basis over the first 2 years and then annually for a further 6 years. It will be responsible for advising on:

- the management of the breach;
- the management of the residual spit (including fencing, signage and wardening) for Terns and other breeding bird species; as well as
- the management of the New Tern Island compensation site.

This group will consider these aspects in the context of the latest available monitoring results. It will also link up separately with a local group (possibly the Pagham Conservation Volunteers) who will

assist the RSPB on site. The stakeholder group will also be able to provide advice on more general initiatives for informing and engaging the community about the ecological development and management of the project areas and the wider Pagham Harbour. It is envisaged also that this group will be able to separately advise Natural England on implications associated with the proposed coastal access path through this section of the beach. It is anticipated that the RSPB will have a key (but not lead) role within this group, not least because its staff will be the on-site managers and will have the best understanding of the issues and the needs of Little Terns and other interest features of the harbour.

The considerations associated with the management of the breach itself were described in Section 1.5.4 but with respect to ongoing management of the distal end of the spit (the area separated off by the proposed breach but also joined to the shoreline by the infill) the RSPB has agreed that they will oversee this area. Their work on this site will be conducted in essentially the same manner as their current programme of works on the site. This will involve:

- regular wardening visits (with frequency at least as per current RSPB management measures but probably increased with voluntary support);
- seasonal visitor exclusion of the connected section between Pagham Beach and the infill area;
- seasonal placement and moving of reactive predator-exclusion fencing around nests;
- installing seasonal signage to explain to residents and visitors (and especially dog walkers) why this access exclusion fencing is in place and explain the need to be alert to the situation during the summer season (late April to the end of August); and
- monitoring nesting activities and breeding success (as well as feeding back results to the overseeing stakeholder group so that they can understand and review the effectiveness of the management measures).

The position of the seasonal visitor-exclusion fencing will depend on the morphology of the separated spit section. However, following the recent breach, much of the spit has already separated and the channel to landward has infilled. Therefore much of the old spit is now accessible (by visitors and predators) from a wide range of directions at low water. Based on this existing configuration it is anticipated that the visitor fencing will be confined to the western end of the beach to exclude people from directly accessing the discrete spit section that will be created following the breach excavation and channel closure. This aspect will be reviewed by the overseeing stakeholder group.

On the spit itself the RSPB will continue with the placement of 'reactive' predator-control fences around specific areas where birds have settled down to nest. This is expected to be mainly Little Tern nests but may also include other species such as Oystercatcher and Ringed Plover depending upon the conditions. As requested by Natural England, these measures will continue for as long as the habitats on the remaining distal end of the spit continue to be suitable for nesting terns.

Once the New Tern Island compensation site has been created then this will also be managed by the RSPB under their existing reserve site management plan. The range of different management options that are available were included in Appendix L of the ES and some or all of these will be used, as required, to maximise the value of the site and its attractiveness to Little Terns. To this list can be added the idea of using tape lures (recordings of bird calls), as suggested by Natural England, which could be used alongside decoys (creating decoys can also be a valuable community/school engagement activity).

Based on the RSPB's experience the key measures will include seasonal predator exclusion fencing (i.e. placed from April to August each year and not placed in the reactive way that is proposed for terns nesting on the separated spit end). It will also include raking the surface the shingle at regular intervals to keep the shingle bare and reduce lichen coverage and vegetation. See Appendix L of the ES for more of the available management measures.

2.2.2 Breach closure risk and maintenance/monitoring

As explained in Sections 8.1.9.1 and 11.2.1.4 of the ES there is considered to be low a likelihood potential for closure especially in the context of the historical evidence. However, in response to comments received from the regulators and Natural England, a process for more breach maintenance have been included as part of the project. These were set out Section 1.5.4 above. Further details about the monitoring associated with this management are also presented in Section 1.5.5.

2.2.3 Impacts to overwintering birds from construction activities

As set out in the ES (Section 3.2) the construction work will not take place over the summer (bird breeding period). The timescales for this and the way in which it will be assured, by having an ecological watching brief, were clarified in Section 1.5.2. The construction work is anticipated to have a 9 to 11-week construction window (it may be shorter at around 8 weeks if sheet-steel piling is deemed to be unnecessary) and therefore it may extend into the early phases of overwintering period (November to March).

Measures will be put in place to minimise any disturbance effects to birds after the 1 November and these measures are described in Section 1.5.2. This includes cold weather restrictions and minimising personnel movements. These are to provide further reassurances that there will be no significant disturbance effects in addition to the evidence presented and conclusion reached within the ES (see Section 8.2.6 and Appendix K).

2.3 Appropriate assessment (AA) derogations

With respect to the relevant derogation tests, ADC (and RSPB) have asked that those project benefits which are genuine public interest (and relevant to HRA derogations) be identified. It is then also requested that the alternative options are reviewed again to understand how the project can be confirmed as being the least damaging but appropriate option. This is because under the Habitats Regulations, as noted above, it is necessary to be assured that there are no other feasible ways to deliver the overall objective of a plan or project which will be less damaging to the integrity of the European site(s) affected (Defra, 2012).

These aspects and the IROPI considerations are presented below. The key tests of alternatives and IROPI need to be applied separately and sequentially, and the competent authority must decide whether there is an alternative solution before having lesser effect before (if necessary) it formally decides on the IROPI test (Defra 2012). The fundamental first step in this process (here treated as Test 1a), however, is to be clear on the project objectives/benefits (Defra 2012) and the extent to which they are of genuine public interest. This is required to then understand the consideration of alternatives.

2.3.1 Test 1a Project objectives

The overarching objective for this project is to achieve a sensitive and sustainable approach to the management of the Pagham Harbour and Pagham Beach shorelines. It involves a shoreline adjustment that moves the coastline towards a more sustainable morphology and addresses the coastal erosion, amenity and human health problems presently being experienced along the adjacent Pagham Beach. The project represents a 'soft' solution to these problems because it seeks to mimic a natural shingle breach process (as recently seen on site) but does so in a predictable and controlled way to address immediate problems and also buy time for the ongoing adaptive management of this coastline. It is also designed to reduce uncertainties about the future development of the shoreline. This uncertainty is particular evidenced by the recent breach change which has left the area in a distinct state of flux and ongoing change.

The proposed approach therefore achieves not only an improvement to coastal erosion protection along Pagham Beach but also delivers a range of other environmental and socio-economic benefits. These benefits are discussed in Section 2.1.3 of the ES and were further reviewed in Section 1.4 above in light of the recent changes on site. Due to these multiple benefits, and the proposed approach, the project is therefore in-keeping with the principles of sustainable development as directed by the National Planning Policy Framework (NPPF).

It needs to be strongly emphasised, therefore, that the aim of the project is not solely to protect homes from damage. Just focusing on that objective alone will lead to a misunderstanding about what is being proposed and, in particular, will miss the fact that this is accompanied by much broader societal benefits. It is the combination of these benefits that make this the best intervention in the ongoing adaptive management of the shoreline. As quoted in the ES, there are five main objectives of the proposed community project as follows:

1. Larger and longer-term coastal defence benefits for the Pagham Beach foreshore;
2. Improvements to the site's amenity value and 'human health' of the local community;
3. A more cost-effective use of public money¹⁷;
4. Application of a 'soft' solution that works with natural processes at the coast (and helps facilitate community engagement); and
5. Greater assurance that the tidal functioning of Pagham Harbour will be maintained.

There are also additional benefits that have been noted in this report and in the ES that should not be overlooked. For instance there is social value in having a project that facilitates greater community engagement in the environment. For this HRA review therefore this benefit has here been deemed to be an integral part of the benefit of working with natural processes component (as listed above).

In addition to these five objectives, the RSPB suggested (in their planning response) that an additional public interest objective which could be "the need to avoid the risk of further and uncontrolled damage to the SPA/Ramsar site through unmanaged breaches". This observation preceded/anticipated the unmanaged breach event which then occurred on site earlier this year (as reviewed in Section 1.3). As indicated in Section 1.4 above, one implication of the fact that this event has already happened is that damage to Little Tern breeding habitat has probably already occurred. Therefore, as discussed previously, there are now clearer benefits for Little Terns from the project because it may well create a more stable breach feature than the existing condition and also will include new seasonal visitor exclusion and education measures as part of its management. Bearing this in mind the sixth objective could perhaps now be framed as:

6. To minimise risk of further damage to breeding bird (Little Tern) habitat through the unmanaged and uncertain spit evolution.

These six listed key benefits are all considered to meet the appropriate public interest definition in the under the Habitats Regulations as set out in guidance. Therefore they all warrant consideration under the HRA process. For instance, Article 6.4 of the Habitats Directive states that public interests include aspects that are social or economic nature (European Commission 2007). Also, according to Defra (2012) IROPI for a project can relate to

1. Human health,
2. Public safety,
3. Beneficial consequences of primary importance to the environment and
4. Social or economic benefit¹⁸.

¹⁷ Better use of private/community money can be added to this.

The way in which these public interest reasons match the six key objectives cited above are outlined in Table 1. In making these evaluations of benefit it is considered that amenity does constitute a "genuine public interest objective". This is because it is linked to human health and also social and economic benefit which are acceptable public interest reasons in accordance with the guidance.

With respect to the 'greater assurance of tidal functioning', ABPmer consider this to be relevant because the new straighter breach configuration will inherently be more stable and easier to reopen than the previous or existing breach morphologies which have elongated and sinuous inlet/outlet channels. This benefit is reinforced by the fact that Natural England has requested breach management measures (see Section 1.4.2 and 1.5.4) and ABPmer's view would be that including such new management measures where none currently exist must inherently reduce closure risk.

Table 1. Public interest reasons relevant to each of the project objectives

Objective	Project Objective	Public Interest Reason(s)
1.	Larger and longer-term coastal defence benefits for the Pagham Beach foreshore.	Public safety
2.	Improvements to the site's amenity value and 'human health' of the local community.	Human health
3.	A more cost-effective use of public [and private/community] money	Economic benefit
4.	Application of a 'soft' solution that works with natural processes at the coast.	Social and economic benefit (inc. through community engagement)
5.	Greater assurance that the tidal functioning of Pagham Harbour will be maintained.	Beneficial consequences of primary importance to the environment
6.	To minimise further damage to breeding bird habitat	Beneficial consequences of primary importance to the environment

In conclusion, all the key project objectives listed in Table 1 are considered relevant for the alternatives test. This includes the project objective of cost-efficiency which is considered to fit under the economic benefit public interest motive (Table 1) and is not the sole consideration in the review of alternatives. As things stand however, while the community project is considered to be a cost-efficient approach for many reasons, the details of cost and monetary benefits are under review and are subject to a number of uncertainties. These cost:benefit uncertainties apply also to all the different alternatives including the do-nothing and 'extending existing protection' through revetment/shingle recycling along the shore (see next section). This means that it is difficult to make direct cost comparisons of different alternatives at this time. For the purposes of maintaining clarity of the HRA process therefore the issues of project cost and monetary benefit are not taken forward into the alternatives review.

2.3.2 Test 1b Alternatives review

The next step in the process is to identify alternative solutions which deliver the key objectives of the proposed project which will be less damaging than to the integrity of the European site(s). The Defra (2012) guidance states that consideration of alternatives should be limited to options which are financially, legally and technically feasible. In other words, an alternative should not be ruled out simply because it would cause greater inconvenience or cost to the applicant. However, there would

¹⁸ Social or economic benefit would not apply where the European site is a Special Area of Conservation (SAC) and a "priority" habitat or species will be affected. However, that is not the case at Pagham which is not designated as SAC.

come a point where an alternative is so very expensive or technically or legally difficult that it would be unreasonable to consider it a feasible option.

The five alternatives to the proposed project that were identified in Section 2.2 of the ES meet this requirement of the Defra (2012) guidance. These are as follows:

1. Installing/upgrading cross-shore groynes structures;
2. Excavating a breach in the spit and trying to fix it in place with a training wall;
3. Closing the existing breach;
4. Progressively extending existing revetment/protection/recycling on a reactive basis; and
5. Maintaining the new breach further along the spit further to the north-east and closing the existing tidal inlet. (prior to the recent breach this alternative involved excavating a breach at this location rather than 'maintaining' it).

These alternatives are illustrated in Image 12 (see also Figure 2.3 of the ES). The Environment Agency has also informally identified the option of installing a sheet piled wall along the Pagham Beach frontage. This option is deemed to be covered within alternative number 4 in the list above.

The "do nothing" option was not specifically considered in the ES as this was deemed not to be in keeping with the principles of adaptive management for the shoreline (under the Pagham to East Head Coastal Defence Strategy). For the HRA process, the scope of the alternative solutions should be connected to such an existing policy context. In this case an ongoing process of 'adaptive management' is required for the protection of this shoreline which means that there must always be some future oversight and, where required, intervention on this shoreline (see also Section 1.5 above).

The Defra (2012) guidance also indicates that a 'do nothing' option is not normally an acceptable solution because it won't deliver the objective. However, it also suggests that including a do nothing option in an alternatives review might help form a baseline from which to evaluate other alternatives. It can also help in understanding the need for the proposal to proceed, which will be relevant to any later consideration of the IROPI test (see Section 2.3.3). For this reason, a review of the do nothing option is included as follows.

6. Doing nothing and allowing the foreshore to evolve naturally.

These alternatives (with exception of do nothing) were all considered within the ES document. In that document they were compared on the basis of the benefits 1 to 5 as listed above. As these benefits are all deemed to be of genuine public interest for reasons noted above, this full review is not repeated again here. However, to underpin the AA, each of these alternatives is considered in outline below against the Objectives 1, 2, 4, 5 and 6 (cost-efficiency excluded) and including the 'do nothing' approach. The conclusions are also summarised, for ease of reference, in Table 2 which considers not only the extent to which the benefits are met by the alternatives and whether the effects on European/International Site(s).

As noted in Table 2, consideration of alternatives under the HRA process should be limited to options which would be less damaging to the affected site(s) or to any other site(s) that could be affected by a given alternative (Defra 2012). However, in summary the comparisons against all key alternatives (relevant to HRA or not) can be summarised as follows:

1. **Cross-shore groynes** (not applicable for HRA because more damaging than proposal): The use of large cross-shore groyne structures could help to trap shingle and have local benefits for coastal protection only at the site of their placement. In the very dynamic changeable environment near the breach and spit though they are unlikely to solve problems and would not help to unlock the remaining shingle in the spit in the shorter term. They are also likely to

create more coastal protection issues in future (especially when shingle supply might become limited). They would be inside the SPA/Ramsar (as per Option 1a in Image 12) and are likely to remove habitat and have greater impacts on naturalness and functioning of the European/International Sites than the proposed project. They will also not achieve the more sustainable multiple benefits offered by the community proposal (e.g. it will reduce amenity value or opportunities for community engagement).

2. **Breach and training wall** (not applicable for HRA because more damaging than proposal): As this would involve a managed breach (assumed here to be approximately at the location proposed for the community project (as per Option 2a in Image 12) it would deliver a number of the coastal protection benefits as well as some amenity value by supplying shingle and diverting inlet/outlet flows away from the coastline. However, the introduction of a large training wall to try and pin the breach in place will risk longer term problems along the shoreline and will damage the naturalness and functioning of the European/International Sites. This approach also not achieve the more sustainable multiple benefits approach offered by the community proposal.



(Source: Aerial Image Channel Coastal Observatory)

Image 12. Schematic view of alternative options which mainly involving some form of revetment (with published boundary of the SPA/Ramsar as hatched purple)

3. **Closing the breach(es)** (not applicable for HRA because more damaging than proposal): Blocking breaches under the current arrangements would be very difficult. In principle it would help achieve the large and longer term benefits by unlocking shingle but it is only likely to reopen in the near future and, while in place, would cause much greater damage to the European/International Sites than the proposed approach.
4. **Extending long-shore protection (revetment and shingle recycling)** (uncertain applicability for HRA): Continuing to work on a reactive basis by using rock armouring and shingle recycling along the shore helps to protect homes but does not help to realise the larger and longer term benefits that come with the proposed project (blocking tidal channel, unlocking more shingle and diverting tidal inlet flows away from the coast). It will also not bring human

health gains for the community or environmental benefits for the harbour. This approach has in the past been adopted without the need to adopt compensation measures and this indicates how the measures adopted have been perceived as less damaging to the integrity of the European/International Sites. However, these measures are inherently piecemeal in their nature and are undertaken in response to short term needs and while each intervention might be comparatively small in scale this approach has collectively involved multiple frequent interventions (note the several interventions costing £50,000 during 2015/16 winter alone (see Section 1.3.2) as well as £1.5 million of different works over the preceding 6 winters (see Section 6.2.6.3 of the ES). This approach inherently has adverse consequences for the appearance and ecology of the shoreline and by seeking to fix in place the shoreline on one side of the tidal channel it affects the naturalness of the shoreline and the extent to which the spit can evolve and behave naturally. Thus it is not definitively the case that the effects are less than the proposed approach just because they are not on the spit itself. Furthermore, the interventions have contributed to the current situation which has resulted in a major perturbation following the unmanaged breaching of the spit with potentially significant implications for Little Tern habitats. This approach also does not achieve the more sustainable multiple benefits approach offered by the community proposal.

5. **Maintaining new breach** (not applicable for HRA because more damaging than proposal): The approach of maintaining the breach at the location where it has recently formed can be viewed as being equivalent to the proposal cited within the assessment document of actively breaching at this location. Relative to the now existing conditions, it would not bring as many benefits for coastal protection. It will not address the continuing uncertainties that exist about how the site will change in the future. Compared to this approach, the proposed breach offers a more stable and less erosive breach configuration and is expected to be less damaging to the European/International Site. This approach also does not achieve the more sustainable multiple benefits approach offered by the community proposal.
6. **Doing nothing** (not applicable for HRA because not relevant under extant adaptive management policy and doesn't achieve any objectives also in the absence of management it could well be more damaging under HRA). Not actively intervening will exacerbate existing levels of uncertainty and ongoing patterns of change/erosion of the beach and is likely to have severe consequences for coastal protection and human health. This approach also does not, therefore, achieve any of the benefits approach offered by the community proposal.

In conclusion, there are considered to be no feasible alternative options to the proposed project that deliver the project objectives and are considered less damaging to the integrity of the European/Ramsar sites.

Table 2. Review of alternative options

Objective No./Alternative	1. Cross-shore Groynes	2. Breach with Training Wall	3. Closing the Breach(es)	4. Long-shore protection (rock/recycling)	5. Maintain New Breach	6. Do Nothing	7. Proposed Project
1. Larger and longer-term coastal defence	No	Yes	Yes	Yes	No	No	Yes
2. Improving amenity and 'human health'	No	Yes	Yes	No	No	No	Yes
4. Application of a 'soft' solution that works with nature	No	No	No	No	Yes	Yes	Yes
5. Greater assurance of tidal functioning.	No	Yes [■]	No	No	Yes	No	Yes [●]
6. Minimise breeding bird habitat damage	Yes [■]	Yes [■]	Yes [■]	No	Yes [■]	Uncertain	Yes [■]
Are impacts to European Site(s) lower than proposed approach	No (N/A to Test 1b)	No (N/A to Test 1b)	No (N/A to Test 1b)	Uncertain	No (N/A to Test 1b)	Uncertain (and not in keeping with Adaptive Management)	
Appropriate Assessment Alternatives Comparison with Community Project*	Doesn't achieve objectives; more damaging to SPA/Ramsar	Doesn't achieve all objectives; more damaging to SPA/Ramsar	Doesn't achieve all objectives; more damaging to SPA/Ramsar	Doesn't achieve all objectives; adverse effects on naturalness of SPA/Ramsar.	Doesn't achieve objectives; high level of ongoing uncertainty could well be damaging to SPA/Ramsar	Doesn't achieve any objectives; and potentially also damaging to SPA/Ramsar.	

★ NB The consideration of alternatives should be limited to options which would be less damaging to the affected site(s) or to any other site(s) that could be affected by a given alternative (Defra 2012). Therefore only Alternatives 4 and 6 are really relevant under the HRA process.

● On the assumption that these interventions would require a management plan to maintain the breach (as is the case for the proposed project).

■ On the assumption that these interventions would be of a scale that would require extra measures to manage the risks of further damage to Little Tern breeding habitat would be needed (as is the case for the proposed project).

2.3.3 Test 2 IROPI

The second test is to demonstrate that there are IROPI reasons for the project despite the fact that it may result in an AEOI. The public interest reasons which are relevant for making the evaluation of IROPI were described in Section 2.3.1 above. Also as set out in the guidance (Defra 2012) the IROPI judgement requires consideration of the following three elements (see also Section 2.1 and Appendix C of the main ES):

- **Imperative:** it must be essential (whether urgent or otherwise), weighed in the context of the other elements below, that the plan or project proceeds
- **Overriding:** the interest served by the plan or project outweighs the harm (or risk of harm) to the integrity of the site as identified in the AA ▪
- **Public interest:** a public benefit must be delivered rather than a solely private interest

As described in preceding sections, the project is deemed to be 'imperative' because it will provide larger and longer-term coastal defence benefits for the Pagham Beach foreshore that are urgently required and essential for public safety. The improved public access, safety, amenity and community engagement values provided will in turn result in human health benefits to the community. There will also be also gains for the environment.

The wide ranging benefits served by the proposed project are considered to greatly outweigh the potential risk of harm to the European/Ramsar site. Following the completion of the ES and this Further Information Report, the project impacts are negligible/minor in their significance and are accompanied by a number of extra benefits. Overall the project's benefits comprise improvements to public safety, human health, and social and economic benefits (as well as for ecology). It is also of note that the scale of the impacts, and the risk of damage, arising from the work are much smaller than those anticipated within the ES because the recent breach has evidently reduced the ecological value of the spit feature (i.e. for Little Terns and vegetated shingle).

In terms of public interest then this can be at a national, regional or local level. In this case the local need is manifest (as indicated by the project benefits that are cited above and in the assessment documents as well as by the widespread community support that accompanies this project). Public safety, human health, and social and economic benefits will be delivered to the residents of Pagham as well as the wider community. The project is also consistent with the principles of Adaptive Management for this coastline (under Pagham to East Head Coastal Defence Strategy) and with the principles of sustainably enshrined under the NPPF).

2.3.4 Test 3 Compensation measures

Details of the proposed compensation measures have been described elsewhere within this report (Section 1.5 and 2.2) and the assessment documentation. In light of the evidence assembled these measures are considered to meet the requirements under the guidance (Defra, 2012) of being: technically feasible, clearly planned, close to the site of potential impact, appropriately timed to achieve the required quality (within the context of the dynamism of the existing environment and the nature of the changes that have been and will be experienced on the site) and technically proven. They are also in-keeping with the requirements of important recent case-law guidance (Briels Case) as described in Section 11.2.2 of the ES.

3 Other EIA and MCZ Information

As the proposed managed breach will take place within a SSSI and MCZ (see Section 8.1.2 and Figure 8.1 of the ES), there was a need to assess impacts on the features protected by these national designations. The impacts on these features were assessed throughout Section 8.2 of the ES. However, clarification and assessment of additional aspects has been requested with regard to these designations. The details of these are now discussed below; first for MCZ features in Section 3.1 and then for SSSI features in Section 3.2.

3.1 MCZ features

3.1.1 Introduction

For MCZs, formal assessments need to be undertaken in order to determine whether there is a significant risk that an activity will hinder the conservation objectives of MCZ interest features. Potential impacts on the three features of the Pagham Harbour Marine Conservation Zone were assessed in Section 8.2 of the ES, and a separate MCZ Assessment Information Report was also prepared and presented as Appendix G.

As outlined in the ES, the three features for which the Pagham Harbour MCZ is designated for are:

- ✧ Seagrass beds;
- ✧ DeFolin's lagoon snail (*Caecum armoricum*); and
- ✧ Lagoon sand shrimp (*Gammarus insensibilis*).

Impacts on seagrass beds and DeFolin's lagoon snail were assessed in the ES. Impacts on the Lagoon sand shrimp had been screened out, due to it being found in an isolated lagoon only (the Ferry Pool). The assessments in the ES, and the summaries provided in the MCZ Assessment Information report, considered that there would not be any significant impacts on this shrimp species from either construction or operational activities. In response to the assessment documentation, the following additional concerns were raised by Natural England and ADC:

- ✧ Consequences for all MCZ features from harbour closure; this was highlighted as 'the main risk to the MCZ features' due to their requirement for saline influence;
- ✧ Consequences on DeFolin's lagoon snail from:
 - Shingle compaction due to construction vehicle movement near Little Lagoon;
 - Smothering due to construction of New Tern Island.

Natural England clarified that they have no concerns about the direct effects of the breach on DeFolin's snail, due to the snail being unlikely to be present in this breach and infill sections of the spit. The three additional potential impact pathways listed in the bullets above are now discussed in turn.

3.1.2 Risks to MCZ features due to harbour closure

In their letter dated 26 January 2016, Natural England raised a concern with regard to all the MCZ features which relates to the very low potential that exists for harbour closure due to the proposed works. The risks and proposed management options in relation to this closure are discussed in Section 1.5.4 of this Further Information Report. In summary, in order to further reduce the low closure risk, management measures to re-open the breach would be undertaken (should it close).

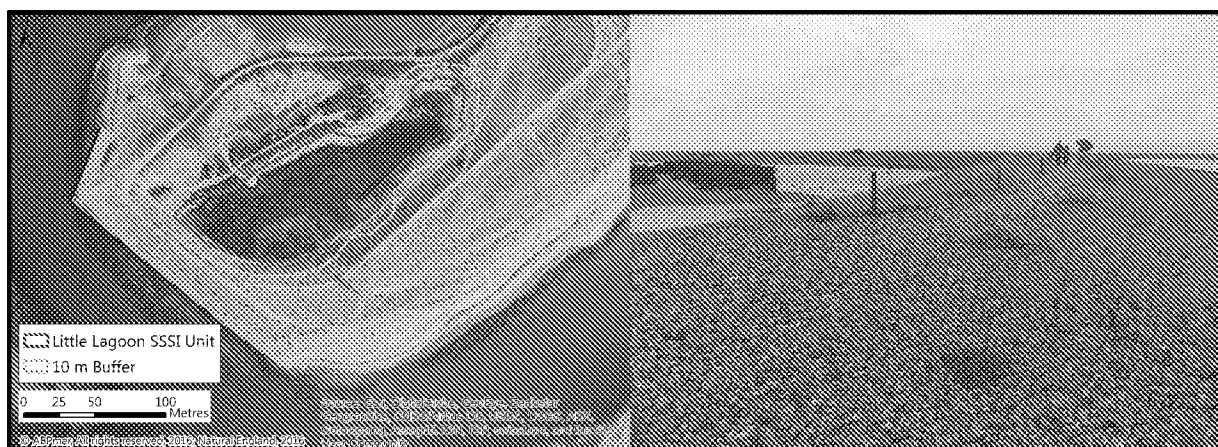
Thresholds for management action are determined using a 'Traffic Light System' which was outlined in Section 1.5.4; decisions on intervention will be made by a stakeholder group set up to oversee the project (see Section 1.5.3). It is considered that this commitment to manage and, if needed, re-open the breach addresses any uncertainties regarding risks to MCZ features (which ABPmer considers to be low see also Section 8.1.9.1 of the ES). Thus, no further action is considered to be required in addition to those already outlined in Section 1.5.4.

3.1.3 Risks to DeFolin's residing in Little Lagoon due to compaction

ADC and Natural England raised concerns that construction movement in close proximity to Little Lagoon could impact the DeFolin's snail populations which reside in Little Lagoon. As described in Section 8.1.4.2 of the ES (and associated Figure 8.5), a significant number of individuals of this snail were found on the shores of this lagoon during a 2013 survey in Pagham Harbour. Sixteen live DeFolin's lagoon snails were found at three of the seven sample locations at mid-shore level, with recently dead shells from five locations.

Natural England and ADC expressed concern that siting, and movement, of construction vehicles in close proximity to Little Lagoon could cause undue compaction of the shingle, which in turn could affect percolation through the shingle. This could affect DeFolin's Snail as this species prefers loose areas of shingle where water percolates through a shingle ridge or bund (slow flowing 'springs') (see draft MCZ objectives, and also Appendix J of the ES, which reviewed the ecology of this species).

In order to mitigate this risk, in its further advice issued on 26 April 2016, Natural England specified that 'this impact could be avoided by having a construction buffer zone of between 5 m to 10 m around Little Lagoon (there is a fence line already in place) and using existing track ways and paths, not turning vehicles on the shingle but reversing back along existing tracks.' The Little Lagoon already has an access exclusion fence around it (some 10-15 m from the lagoon edge) and it can be confirmed that plant will remain at least 15 m way from the Little Lagoon. Image 13 below shows that a minimum 10 m buffer will automatically be observed as all the tracks around the lagoon are at least that distance from the lagoon.



(Source: Photo ABPmer 13 Oct 2014)

Image 13. Existing exclusion fencing (right) and 10 m buffer zone around Little Lagoon (left)

It can also be confirmed, as set out in the ES and in Section 1.5.2 above, that plant will predominantly use existing trackways and areas below mean high water. Working in these areas will mitigate for any effects arising from the possible compaction of shingle. Turning of plant will also be avoided when they are moving along these established paths but will, instead, be confined to areas below mean high water, where tidal conditions permit. The turning points/areas will be agreed in advance with Natural

England. On any rare occasions when a plant moving along these routes needs to retreat and no suitable turning areas are available then this will be done by reversing along the agreed access track. It is advised that there should be no turning areas along the 160 m of track directly fronting Little Lagoon. The necessity of observing the minimum 10 m buffer, and not turning vehicles on the track fronting the Little Lagoon, will be set out in the construction plan.

3.1.4 Risks to DeFolin's due to Construction of New Tern Island

As outlined in Section 1.5.6 and in Section 11.2.2, the New Tern Island is to be created in the south-west of Pagham Harbour by covering an old concrete revetment/training wall with shingle above the Mean High Water mark and cutting a channel to isolate the new island from predators. Natural England has expressed concerns with regard to impacts on DeFolin's lagoon snail, as, during one of the surveys 'dead specimens of the snail were found on the revetment'.

As outlined in the ES (Appendix J and Section 8.1.4.2), this species is associated with the landward sides of shingle spits or bunds, just below the High Water Spring line. Thus, the placing of the shingle over the old training wall and extant shingle down to the Mean High Water line could affect (smother) DeFolin's snails if they were present.

Referring back to the ES, and Figure 8.5 in particular, the three survey stations along the revetment/shingle spur feature which are to be covered with shingle, yielded one dead shell and two shell fragments only. The revetment actually represents an old training wall which will extend a significant depth into the ground (exact depth unknown). Furthermore, it is a harbour-internal feature, which will not have a significant tidal height differential between the two sides of the feature. Both the deep wall in the middle of the narrow spur, and the harbour internal nature of the feature are factors which will inhibit percolation through the spur.

As noted above (and in Natural England's draft MCZ conservation advice), it has been found that DeFolin's lagoon snails prefer loose areas of shingle interstitial where water percolates through a shingle ridge. Due to the lack of percolation through the current feature, it is considered that the area where New Tern Island is to be created is not suitable for DeFolin's lagoon snail. The two shell fragments and one shell found during the 2013 survey could well have been washed onto the feature from a population on the nearby actual ridge where percolation does take place. Therefore, it is not thought to be necessary to reduce the size of the New Tern Island on the basis of risk to the DeFolin's lagoon snail, and the separate consideration of maximising the size of the island can be pursued (see Section 1.5.7).

3.2 SSSI features

3.2.1 Introduction

As outlined in Section 8.1.2 of the ES, the SSSI is designated for various reasons, including habitats and species which are found in, or frequent, the intertidal and shingle habitat zones where impacts could occur. These include:

- * **Habitats:** Vegetated shingle beach, coastal lagoons, dunes, saltmarsh/littoral sediment, shingle/supralittoral sediment and low islands;
- * **Species:** nationally important communities of plants and invertebrates; wintering wildfowl and waders as well as breeding birds (the mudflats were noted as providing food for a diverse breeding community, including Oystercatcher, Shelduck and Redshank); and

- **Geomorphology:** key site both as a classic shingle spit landform and for the links that have been demonstrated between the coastal nearshore and offshore forms and sediments.

Impacts on many of these features were assessed throughout Section 8.2 of the ES. The following additional concerns have been raised by Natural England and ADC:

- Impacts on SSSI overwintering and breeding birds (Pintail, Ringed Plover, Grey Plover, Oystercatcher and Black Tailed Godwit were highlighted by ADC in their letter), including in relation to construction impacts);
- Further information regarding mitigation of impacts on vegetated shingle; and
- Further information regarding mitigation of impacts on the geomorphology of the spit.

The additional impact pathway, and further mitigation clarification aspects are now discussed in turn.

3.2.2 Impacts on SSSI overwintering and breeding birds

Natural England and ADC, in their various letters dated 7 March 2016 (ADC), 26 January (Natural England) and 26 April (Natural England), raised concerns with regard to both overwintering and breeding birds considered to form part of the SSSI assemblage. The following three aspects are examined below:

- Temporary causeway construction;
- Increased disturbance during construction; and
- Loss of habitat at the breach.

Temporary causeway construction

ADC requested that 'impacts of stopping water flow during construction of the bund', should be considered. Firstly, it should be noted that water flow will not be stopped, but will only be reduced during the construction phase. The ecological impacts arising from the construction of the temporary causeway were considered under Section 8.2.5 (Impact Pathway 13) of the ES. This concluded that a small area of lower elevation mudflat within the Pagham Harbour SPA and Ramsar would become shallow subtidal habitat for the duration of the construction period. As stated in the ES, this area will measure 4.2 ha, which represents 4.5 % of this supporting habitat within the Pagham Harbour.

Impacts of this temporary reduction in intertidal were assessed for feeding overwintering waterbirds in Section 8.2.5, and assessed as potentially minor adverse. Mitigation is thus not considered to be required, and this issue is not addressed further in this document; although it should be noted that construction will largely avoid the overwintering period. Construction work will completely avoid the nesting period which, in response to advice from the RSPB, is understood to cover the period from April to August¹⁹. Thus, no impact from this temporary minor reduction in feeding habitat on breeding birds would be anticipated.

Increased disturbance during construction

In the ES, the effects from any increased disturbance on overwintering birds due to construction works were assessed as not requiring mitigation in Section 8.2.6 of the ES (Impact Pathway 14). To provide further assurances on this aspect, extra construction principles/measures will be included for any work after 1 November. These measures are described in Section 1.5.5. Breeding birds will not be

¹⁹ Furthermore, construction will only commence once the last Little Tern has fledged (see Section 1.5.2).

disturbed, as construction will not take place during the breeding bird season. The potential also exists for the construction work to not require sheet-steel piling which would reduce activities on site and would shorten the duration of the works. This would further lower the levels of potential bird disturbance. Based on these considerations there is not expected to be any significant disturbance effects on overwintering birds.

Loss of habitat at the breach

Impact Pathway 9 of the ES considered 'Effects of loss/change of shingle habitat during construction' for Tern species only. Natural England advised (in its letters dated 26 April 2016) that an assessment of impacts on Oystercatcher and Ringed Plover should also be carried out, as these species appear to 'nest almost exclusively in the breach area'. It was clarified that 'one of the reasons these birds nest on the spit is that it is relatively free of disturbance compared with other areas of the harbour'.

The ES specified in Section 8.1.5 that low numbers of Oystercatcher and Ringed Plover breed in Pagham Harbour, primarily on Church Norton Spit and Pagham Spit'. These areas were mapped in Figure 8.13, which shows that breeding is not restricted to only the breach area, but extends along the whole of the ridge frontage. It was also noted that Oystercatcher occasionally breed on nearby farmland.

Based on further discussions held with the on-site RSPB managing team, the footprint of the development is expected to support around 1 or 2 pairs of Oystercatcher and Ringed Plover (with perhaps 2 to 4 pairs in close proximity to the footprint). On the basis of these levels, and the broader availability of suitable habitats in the harbour, the changes to the breach area are not expected to have significant long-term effects on breeding birds during the operational phases. It should also be noted that the intended wardening and fencing measures targeted at Little Tern (see Section 1.5.3) would also benefit breeding Oystercatcher and Ringed Plover, and that these species might also use the New Tern Island compensation island.

3.2.3 Further information on mitigating impacts on vegetated shingle

In the ADC letter, the impact on vegetated shingle is indicated as an issue requiring further information. This topic was reviewed in Sections 8.2.1 (Impact Pathway 9), 8.2.4 (Impact Pathway 12) and 8.2.7 (Impact Pathway 15) of the ES which considered the effects on shingle habitats during the construction and operational phases. In the ES it was advised that measures should be taken to reduce the potential damage to vegetated shingle during construction. In response to a request for additional clarification from ADC and NE, further principles for construction are set out in Section 1.5.2.

In summary, during construction, the plant routes will be clearly defined (with vehicles travelling below the mean high water line as much as possible), and turning of vehicles restricted to clearly defined turning areas. It is proposed that these turning areas are to be agreed in advance with Natural England, see also Section 3.1.3. Also as noted in the ES the details of the temporary access routes and stockpile area would be agreed in advance with Natural England and RSPB to minimise the footprint of impact and any potential damage to vegetated shingle.

With regard to the loss of vegetated shingle at the footprint of the breach and the infill, the shingle here is sparsely vegetated and of a pioneer nature (mainly sea kale species at around 1 % coverage) (see also Sections 8.1.3.6 and 8.2.1 of the ES). Also, no net loss of shingle is anticipated from the development. Natural England has proposed/noted that (letter dated 26 April), mitigation for the loss of pioneer vegetation in the small area under the breach footprint would be provided by the new area

of habitat created at the infill area. To assist with understanding this Natural England asked for extra detail on the scheme design and this is included in Section 1.5.1 (and Figures 1 to 5). Around 1.2 ha of shingle area which lies above the MHW mark in the lee of the shingle spit at the breach and infill would be removed, or covered by shingle. The area of the infill feature which will lay above the MHW mark measures 1.3 ha.

Some of the infill area will be disturbed by walkers. As disturbance is a main inhibiting factor for the establishment of dense vegetated shingle vegetation, it is proposed that the community be further informed about the ecology of vegetated shingle, and that signage be erected to inform visitors and guide them away from sensitive areas. This can be done as part of the community engagement and habitat management actions described above (see also Section 1.5.3).

In this context the changing conditions on site are relevant. The formation of the beach that has occurred due to the spit changes in early 2016, and the disturbance which has arisen due from the revetment placement, is expected to have caused, and continue to cause, damage to vegetated shingle. It is considered that implementing the proposed solution would automatically lead to re-establishment of vegetated shingle along the Pagham Beach frontage, due to the reduced erosion along the whole beach frontage, and particularly fronting Harbour Road, which is anticipated (see also Section 1.4.2 of this Further Information Report).

It is furthermore possible that, alongside with bird wardening volunteer work which is to be initiated to help minimise disturbance to breeding birds on the spit (see Section 1.5.3), the community is also informed about techniques for aiding the establishment of vegetated shingle. The removal of invasive species by volunteers could, for example, be encouraged²⁰. This could further help to mitigate for any damage to vegetated shingle habitat. Prior to commencement of such volunteering actions, the stakeholder group should be consulted.

3.2.4 Further information on mitigating impacts on SSSI geomorphology

In the ADC letter of 7 March 2016, the potential impact of the proposal on the geomorphology of the spit was indicated as an issue requiring further information. This issue was considered under Section 8.2.7 (Impact Pathway 15) of the ES. This concluded that impacts could potentially be minor adverse. Thus, no mitigation was considered to be required in EIA terms. However, Natural England has advised that whilst 'it welcomes that the proposal seeks to work with this dynamic coastline and enable it to evolve after this intervention, the geomorphological interest would nevertheless be altered by the proposal' (26 January).

In their letter dated 26 April 2016, Natural England's advice focuses on 'allowing the geomorphology of the site to evolve as naturally as possible' and it suggests some mitigation measures that could be beneficial and which are based on achieving the greatest level of naturalness. The Natural England advice also states that an impact on geomorphology remains which is the loss of the rapid expansion of the spit. This advice may well pre-date the changes that have taken place which has seen the end of the spit already separated naturally and hence there has been a natural and substantial retreat of the spit in recent months.

²⁰ A SSSI unit stretches along the whole of Pagham Beach frontage, which was assessed as being in unfavourable condition in 2010. This was mainly related to the invasion of Red Valerian *Centranthus ruber*, which 'has established a dense and expanding cover, most likely as a result of garden invasives from the adjacent houses' (Natural England 2010 condition assessment).

The intention of the original proposal had been to deliberately work with natural processes and ensure that the system continues to function and evolve naturally but simply from a revised configuration (i.e. with inlet position returned back to a historical position). Therefore the distinction between natural change and that imposed by the project was intended to be as small as possible with the latter mimicking the former. Since the natural breach has occurred, the distinction between the proposed and the existing configuration is even less evident than it was when the ES was prepared. Based on the current configuration the proposed project will move the main inlet some 350 m to the south and west rather than 950 m. In both cases, natural processes will dominate the site's evolution, driven among other factors by long-shore shingle migration from the south.

For these reasons, it is concluded that the findings of ES that the impact could be minor adverse does not need to be changed²¹. It is recognised however that appropriate measures, as identified by Natural England, could be adopted to enhance the site's naturalness. Many of these do however present clear and significant conflicts with other interests in the designated site as is recognised in the Natural England letter. Following conversations with Natural England they have confirmed that this report should highlight such conflicts and pursue measures which are suitable. Taking the list of measures presented by Natural England the following will be adopted:

- ✧ **Allow the managed breach to evolve naturally and minimise human intervention:** This is a key principle of the proposal and will be done according to the measures set out in Section 1.5.4. Where measures are required to maintain the tidal functioning of the harbour then these will be done as suggested in a way which avoids loss of shingle from the system;
- ✧ **Protect surface geomorphology and shingle re-curves during construction:** As set out in Section 1.5.2 the access routes and plant operation areas are designed to avoid and minimise any such effects; and
- ✧ **Progress regional monitoring to capture post-breach evolution.** The post-breach evolution of the spit will be subject to ongoing monitoring as described in Section 1.5.5.
- ✧ **Foreshore tidying around the area of the New Tern Island.** There will also be opportunities during the construction work to remove loose and accessible debris. In particular the area near the proposed compensation site has an old area of sheet steel piling with loose surface debris that could be removed.

The following suggested/possible measures would not be adopted, and the reasons for this are as follows:

- ✧ **Lower the inner part of the shingle crest.** This is proposed because this is an engineered area that might prevent the natural evolution of the spit. Lowering this area (which extends some 400 m west of the proposed breach and measures around 3 ha), which has not prevented the evolution of the spit feature over the last decade, would cause major damage to an area of heavily vegetated shingle. The importance of this habitat is recognised within the ES, elsewhere in this report, and in the Natural England advice. It is an important area for Chidding Pink plants for example as well as an area that is valuable for breeding birds. The lee of the area is also understood to be a location in which DeFolin's snail could be present (based on past research; Ivan Lang, RSPB, Pers. Comm.). Any changes to this area would be very damaging and therefore this approach will not be adopted.

²¹ It is also of note that the sequence of natural breaches and the subsequent managed breach will, if consented, enhance, rather than detract from, our scientific understanding about the processes that are at work in this system

- **Remove relict hard engineering.** The proposal here is to remove the old easterly (1937) training wall inside the harbour because its presence 'likely to have a detrimental effect on the SSSI geomorphology interest by restricting the natural evolution'. This hard engineering is not thought to be significantly hampering the evolution of the spit and its removal will require the introduction of extra plant and excavation techniques which will greatly increase the costs of the work and its duration as well as increasing the likelihood of the construction work extending further into the overwintering period causing extra levels of potential disturbance to birds. More than that however the training wall is a well-used bird roost site. For example, during the site visit on 20 February 2016 there were dozens of Turnstone, Dunlin and Grey Plover roosting on this sheltered feature. In addition there will be challenges associated with the heritage and cultural value which would need to be considered/assessed and potentially mitigated. Mudflat habitat would also likely be damaged in the process. For these reasons this approach should not be adopted although opportunities for tidying the foreshore should be pursued where possible (as described above).

4 Archaeological Information

This section has been prepared in response to a letter by Historic England dated 25 January 2016. In their advice Historic England asked for further information to understand and assess the impacts to heritage assets. An archaeological assessment was not undertaken for the ES because this topic was scoped out during the planning consultations. However, it has now been requested by Historic England following post-submission consultations undertaken under the MMO marine licensing process. Therefore, this information is provided here subsequent to the original application.

In archaeological terms, and in line with Historic England's advice letter, zones/areas where impacts from the proposed project could occur are:

- At the spit, in the zone where it is proposed to be breached (see Section 3.1 of ES and 1.5 of this Further Information Report);
- In the tidal channel adjacent to the breach, which is proposed to be infilled (and potentially temporarily sheet-piled during construction) (see Sections 3.1 and 3.2 of ES, and 1.5 of this report);
- In the tidally influenced reaches of Pagham Harbour (as tides might change slightly both during construction and operation) (see Sections 6.3 and 8.2 of the ES); and
- At the area where a New Tern Island is to be created (as compensation for potential impacts on Little Tern breeding habitat at the breach) by placing clay/shingle and cutting of a small channel to isolate the island from Little Tern predators (foxes) (see Section 11.2.2 of ES and 1.5 of this report).

A brief archaeological desk based assessment (DBA) has been undertaken. This is appended as Appendix B to this Further Information Report. This section represents a summary of the information contained in the DBA. Relevant sections of the ES are referenced throughout. A summary of the baseline environment is now firstly provided, before the impact assessment is presented.

4.1 Baseline environment

This section constitutes a summary of the baseline description provided in the DBA (Section B3). Please note that relevant legislation and guidance is described in Section B2 of the DBA; this is not summarised here.

4.1.1 Geology

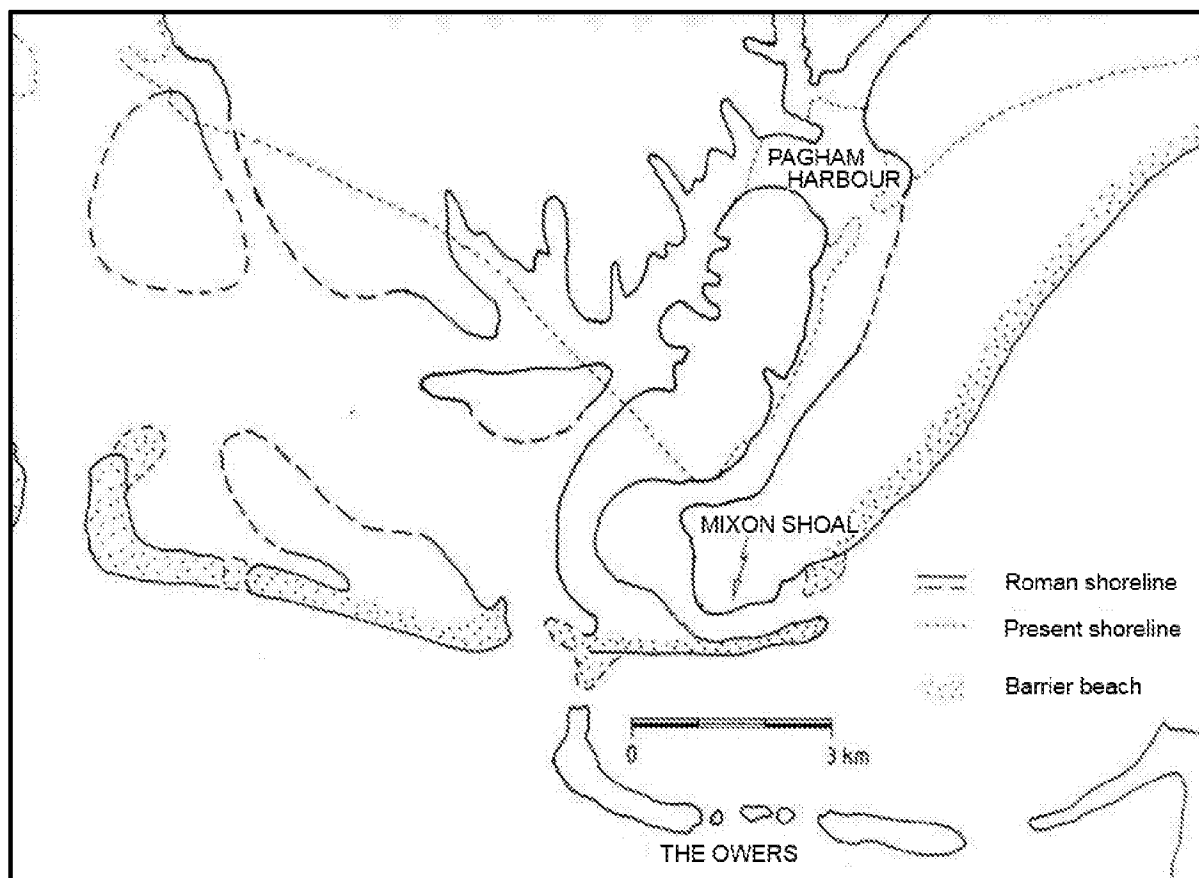
The development area overlies London Clay, which is in turn covered by thick Bracklesham Beds (a dark green medium to fine glauconite sand) and surficial clays, silts, sands and gravel of Pleistocene or recent origin.

4.1.2 Historical geomorphological evolution

The geomorphological development of Pagham Harbour frontage were described in detail in the ES, particularly in Section 6.2.6 (Historical Changes and Recent Developments). The DBA supported a summary of the ES account with further insights on the development of the harbour during the early Holocene.

In summary, the south coast region of England has been a focus for human settlement and subsistence for millennia. For long periods of prehistory, the regional shorelines of southern England would have been several kilometres seawards of their present position (during glacial and post glacial periods). During this time the lower reaches of Sussex Rivers cut deep valleys far below the present day valley floors. Evidence derived from sediment sequences indicates that sea level stood at -5 m at 5,500 BP, at which time, as water levels continued to rise, and low lying valleys were inundated by marine waters (SCOPAC, 2006; quoted by Royal Haskoning, 2009).

Image 14 presents a probable configuration of the Selsey to Pagham coastline approximately 2,000 years BP, delineated using archaeological information and by tracing a submerged wave cut platform (Wallace, 1990, 1996; quoted by Royal Haskoning, 2009).



Source: Royal Haskoning, 2009 - after Wallace, 1996

Image 14. Selsey and Pagham coastline 2000 years BP

Since Roman times, the coastline has progressively retreated, and artificial modifications have had a significant influence on the harbour morphology and adjacent coastline. The current harbour is apparently much smaller than that of the Roman period (ca. 2nd to 5th centuries AD) due to successive phases of land claim, which may have started in Roman times, but certainly intensified during the medieval period. The earliest reliable mapping of the Pagham coastline, drawn in 1587, identifies the presence of two separate shingle spits projecting part way across the mouth of the estuary (see Figure 6.2 of the ES). The harbour itself looked similar to today by around 1778 to 1785 with areas of claimed land behind and defences and sluices built to protect the drained land. However, at this point, the 'Ferry area' was still tidal. By 1825, the Ferry causeway had been constructed to restrict tidal exchange in this area (Environment Agency, ADC, CDC, undated).

In 1876, the inlet was artificially closed and the mudflats within the harbour claimed for pasture land (Robinson and Williams, 1983). In 1910, the shingle ridge was breached by a large storm towards the southern Church Norton side of the harbour (see Figure 6.2 of the ES). In the years since then, the position and size of the inlet continued to change greatly in response to anthropogenic and natural factors (see Figures 6.2 and 6.3 of the ES). In 1937, a new breach entrance in the south, near Church Norton, was created (see Image 15). This was supported by two training walls on either side of the new breach. In the mid-1950s, the spit was breached and the inlet subsequently migrated by 900 m to the north. In 1963, a training wall was introduced at the new location to stabilise the entrance; this situation was largely maintained subsequently (Bray *et al.*, 2004). Over the period from 1969 to 1997 the area generally remained relatively 'stable', aided by regular reshaping by the flood risk authority (up to 2004) (Royal Haskoning, 2009; Dornbusch, 2014; Bray *et al.*, 2004).



Image 15 **The southern entrance in 1945**

Since 2001, Church Norton Spit has grown rapidly in a north-easterly direction, leading to the inlet moving by some 700 m by 2014 (Royal Haskoning, 2014). In 2009, these changes started to cause significant erosion along the beach. This prompted coastal defence works by Arun District Council; first in the form of beach recycling, and in 2013 by installing rock armour.

4.13 Archaeological records

To describe the archaeological record, the Heritage Gateway and the local Heritage Environment Records (HERs) were consulted. Image 16 shows the results for the Heritage Gateway search, excluding those results returned from local records (i.e. West Sussex HER and Chichester Council HER). This revealed no scheduled monuments, listed buildings, registered parks and gardens, historic Battlefields at the breach site, or within the zones potentially impacted by the development.

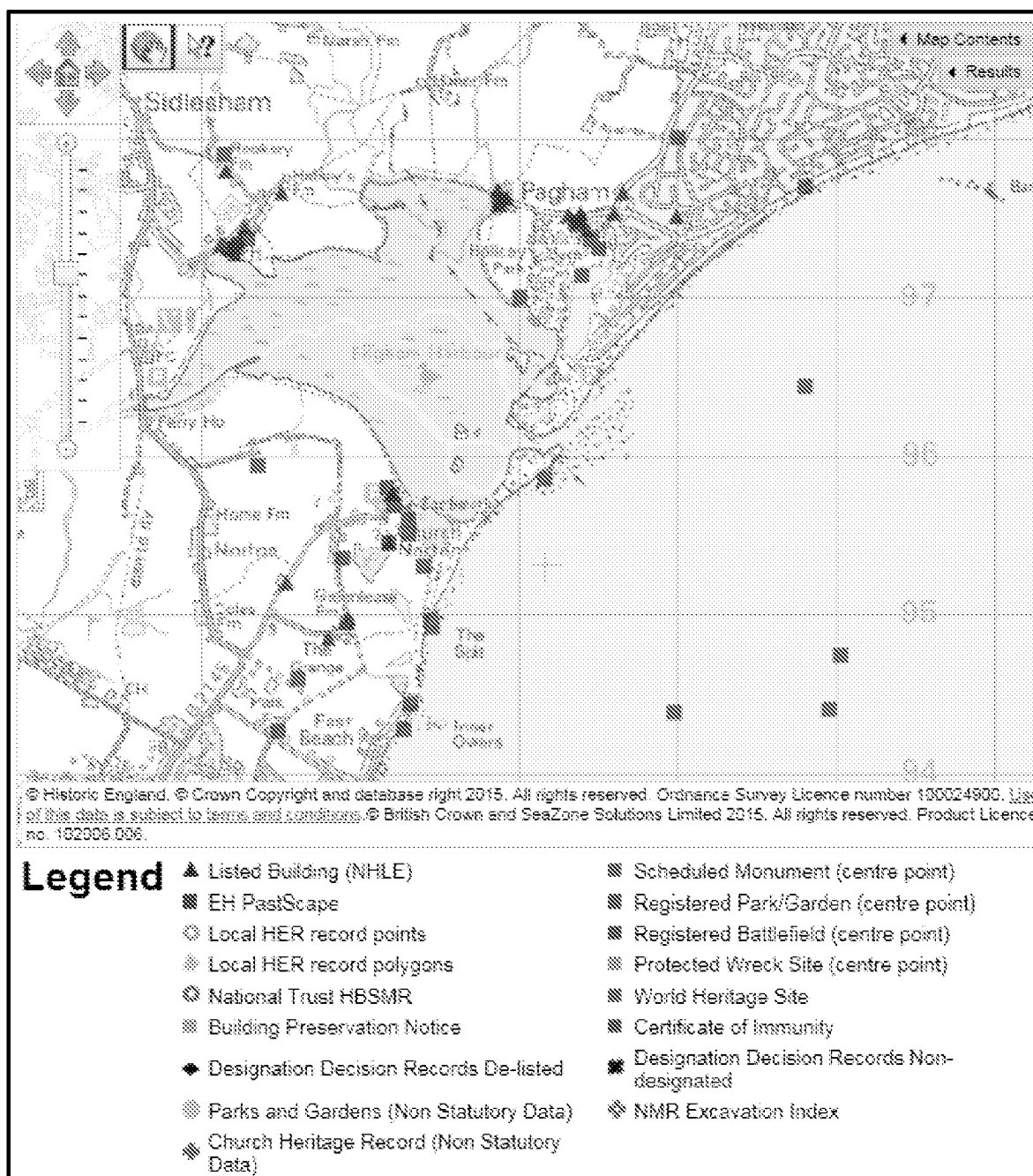


Image 16. Heritage Gateway results within 2 km of the proposed breach

There are no recorded wrecks in the harbour, or the immediate vicinity of the proposed breach. The spit is marked as the indicative location for several wrecks (including one World War II (WWII) aviation wreck) for which the exact position is not known, but whose loss was recorded in the vicinity of Pagham Harbour. These are listed in Table B1 of the DBA in Appendix B below.

Many prehistoric, classical, Saxon and Norman finds have been recorded in the relevant databases in the vicinity of Pagham Harbour; this includes some 28 within 2 km of the proposed breach. The latter are listed in Table B2 of Appendix B. Medieval and post-medieval finds, buildings and monuments are numerous (300+ in the wider study area), and have been consulted to inform the archaeological narrative presented in Section B3.3 of Appendix B (and summarised in the next sub-section).

In a wider study area (5 km), dozens more prehistoric to Norman sites and finds have also been recorded from the beaches and fields extending east and west of Pagham, most notably at Selsey. In addition, during excavations for the nearby Medmerry managed realignment scheme, some 3.5 km to the west of Pagham, several valuable discoveries were made. This is particularly with regard to the Bronze Age; as the finds at Medmerry 'suggest a level of population and structure within the Bronze Age landscape not previously observed in Sussex' (Archaeology South-East, 2014). Medieval fish traps and baskets were also discovered, as was a WWII aircraft wreck.

4.1.4 Archaeological narrative

This section represents a summary of the DBA narrative, with one paragraph per period. Please refer to the DBA for references and record numbers.

During the Palaeolithic (500,000 – 10,000 BC), the first development in human technology is observed with the introduction of stone tools by early hominids which were predominantly scavengers/hunters and gatherers with an advanced knowledge of plants and herbs. Several Palaeolithic finds have been recorded in the wider study area, including flakes, flints and hand axes. No finds have been within the immediate study area, i.e. within 2 km of the proposed breach site.

The Mesolithic (10,000 – 4,000 BC) is characterised by the end of the Ice Age and an ensuing change in climate. This period pre-dates the introduction of agriculture, but witnesses increased seasonal settlement. On the Coastal Plain of West Sussex, the evidence suggests that there were numerous short-stay hunting camps and longer-stay base camps, frequently located alongside or near watercourses. Mesolithic flints were found in a small cliff on the north-eastern side of Pagham Lagoon between 1940 and 1960. Within 5 km of the proposed breach, a low number of other finds have been recorded, including an axe, a flint tool and implements.

The Neolithic Activity (4,000-2,200 BC) is represented by the appearance of pottery and the beginnings of agriculture. Within West Sussex, all related monuments survive on the Downs and none on the Coastal Plain. It has been argued, that this might reflect a true distribution rather than an artefact of preservation. In addition to pottery finds at Medmerry, many implements, flints and axes, as well as some pottery have been recorded in the relevant HERs within 5 km of the proposed breach (over 20 records in total). None of these were found within 2 km of the site.

During the Bronze Age (2,200-700 BC); bronze is first used to produce a range of items including decorative jewellery and axes. Large organised field systems appear during the middle Bronze Age and nucleated and seasonal settlements in the mid to late parts of this period. In addition to the Bronze Age settlement and related finds discovered at Medmerry, other signs of habitation had previously been recorded at two locations in Selsey. Middle Bronze Age pottery and cremation urns were additionally found at the Pagham Church; early Bronze Age flints were also discovered nearby. Furthermore, more than 20 Bronze Age assets finds been identified in the wider 5 km study area, including a Bronze Age founder's hoard, pottery, flints, palstaves / axes and bracelets.

In the Iron Age (800 BC – AD 43), society changes again with the development of organised settlements that are focussed on hillforts for their central administration. There is a change in pottery technology, the development of iron to produce better tools and the introduction of coinage. Manley (2008) notes that 'there is a large and growing body of evidence of Late Bronze Age occupation and high-status metalwork known from the Selsey peninsula', and that 'this together with evidence of land division and cremation suggests an important farming and settlement focus within the region' (p.38). Pottery discovered at Beckett's Barn in Pagham (near the church) is the only find definitely been associated with the Iron Age period within 2 km of the proposed breach. At Church Norton, two scrapers and other worked flints were found in 1911 during excavations on the early Norman

ringworks. In the wider study area, numerous iron age related finds have been recorded both at the beaches around Selsey, and within the settlement itself.

The Roman invasion of AD 43 marks the start of the Roman period (AD 43 – 410) or the Romano-British period. The Romans landed at Richborough in Kent and went onto establish a capital at Colchester. In West Sussex, the Fishbourne Roman Palace is an important site, which was thought to have been constructed in the 1st century AD. The city of Chichester stands on the foundations of the Romano-British city of Noviomagus Reginorum. Away from the main centres of settlement and ritual activity, many finds attest the presence of a dense rural settlement pattern. There are clusters of finds around the tip of the Selsey peninsula, and suggestions of linear distributions along apparent roads or trackways (e.g. south from Chichester towards Sidlesham). Within the immediate study area, several finds at Church Norton, Sidlesham and Church Farm indicate settlements in the area during the Romano British era. During Roman times Pagham Harbour was likely a primary seaport for Southern England.

The Saxon to Medieval period (AD 450 – 1540) first saw the invasion of Britain by the Germanic tribes of Saxons, Angles, Jutes and Frisians at the end of the Roman period of rule. The Saxons are believed to have landed in Sussex in 477 and established the Kingdom of Sussex; the extent of the Kingdom correlates to the former County of Sussex. Several finds of a Saxon nature have been recorded in Selsey and at Pagham. Selsey Abbey is thought to have been located where the old parish church at Church Norton now stands. This abbey was moved to Chichester in 1075. The Normans introduced the first kingdom wide census since the Romans, known as Domesday in 1086. This survey records the parishes of Selsey and Sidlesham and a church at Pagham. The only Norman record in the wider study area is the Norman ringwork at Church Norton. However, at Pagham, it is thought that at least one earlier church was on the site of the present parish church of St. Thomas a'Becket, which was built about 1206. There is documented evidence for medieval activity in the wider study area. Pagham Parish contains a number of buildings dating back to the medieval period, including Old Cottage, Becket's Barn, Barton Manor and the Lion Inn. It is reported that until the 14th century, Pagham continued as one of the foremost English ports, trading wool to Europe. However, following a large storm and gradual siltation, Pagham's wealth gradually diminished. Black Death in the 14th century decimated large numbers of the population in the region and led to villages being deserted. It was not until the end of the medieval period that population numbers began to increase.

The post-medieval period (1540 – 1901) had a significant impact on the English landscape, including through the enclosure of open fields and common land mainly between 1700 and 1850, the introduction of industry from the end of the 18th century, the growth of towns and railways from 1840 onwards, and the Agricultural Depression between 1870 and 1914. A great number of post-medieval sites, buildings and finds have been recorded in the wider study area; including at Sidlesham, Church Farm (Pagham) and around Church Norton. For example, the CDC HER lists some 250 such records within the wider study area. During this period, significant land claim took place around the harbour. By 1825, the Ferry causeway between the mainland and Selsey had been constructed, and in 1876, all of the harbour was claimed. However, in 1910, the shingle ridge was breached by a large storm, and the harbour thus re-established.

Post 1901, key events in the 20th century comprise the First and Second World Wars and non-war development of the rapidly expanding urban landscape. During the Second World War, strategic lines of defence were constructed in 1940-41, primarily for anti-tank operations (Wills, 1985). The defences around Pagham Harbour formed part of the Sussex coast defences; which ran from north of Pagham harbour to West Wittering. For a brief period in 1944/45 the harbour was used as an aerial gunnery practice range and Mulberry Harbours were stored offshore of Selsey. One Mulberry Harbour caisson can still be seen from Pagham Beach at low tide (some 1.9 km from the proposed breach point).

4.2 Impact assessment

The following proposed actions/pathways in relation to the proposed development have the potential to impact archaeological resources.

- Breaching at the spit;
- Infilling of the channel adjacent to the breach (including potential temporary sheet-piling);
- Indirect changes due to tidal characteristics both during construction and operation; and
- Creation of the new tern island in the west of the harbour, which is to include covering a concrete feature with clay and gravel, and cutting a channel.

These four impact pathways were highlighted by Historic England as those which should be assessed with regard to their impact on the archaeological resource at, and around, the harbour. Their assessment is undertaken in the next four sub-sections. As outlined above, no known sites or finds have been located within the impact zones themselves. However, the theoretical potential exists for as yet unknown undesignated heritage assets to be encountered/exposed during excavation works and due to scouring, and secondary context finds could be located in the shingle ridge.

The impact assessment methodology was summarised in the DBA (see Section B4.1), based on the ES methodology, which is set out in full in Section 5.6 of the ES.

4.2.1 Managed breaching of the spit

Context

As outlined in Section 3.1 of the ES, it is proposed to breach the spit in the location indicated in Figure 2 of this Further Information Report. Based on the baseline presented above, particularly the historical geomorphological summary, it is clear that, whilst there is significant potential for archaeological materials to be encountered around the harbour, such potential should be viewed as very low in the location of the breach itself where the works will be undertaken. This is because the breach is proposed in a location where the harbour inlet would have been located many times over the past centuries, and certainly where it was found several times since the inlet position was fixed in the 1960s (see Image 17, which was Image 6.12 in the ES).

The low value of the site will apply not just for the areas that will be deliberately excavated but also the areas that will be influenced by natural channel scouring to, and beyond, the depth of excavation. For example, the natural channel which led to the inlet as per its location in 2013, went to a depth of up to -2.1 m ODN. Thus, it is anticipated that the breach will be cut entirely into sediment deposited over the past 50 to 60 years, and that no *in situ* resource or undiscovered wrecks will be encountered. The discovery of reworked finds such as flints and pottery in the beach deposits can however not be discounted.

Impact Assessment

For reasons outlined above, the probability of encountering all but reworked archaeological finds is considered to be negligible, leading to an exposure assessment of 'low'. Whilst the sensitivity and importance of *in situ* and wreck receptors would potentially be high, the impact is assessed as **not significant** due to the 'negligible' probability of occurrence. This assessment is supported by Historic England's opinion that 'breaching of the spit is unlikely to affect archaeological deposits'. Should reworked archaeological finds be encountered during the shifting of shingle, the relevant council officer should be informed.

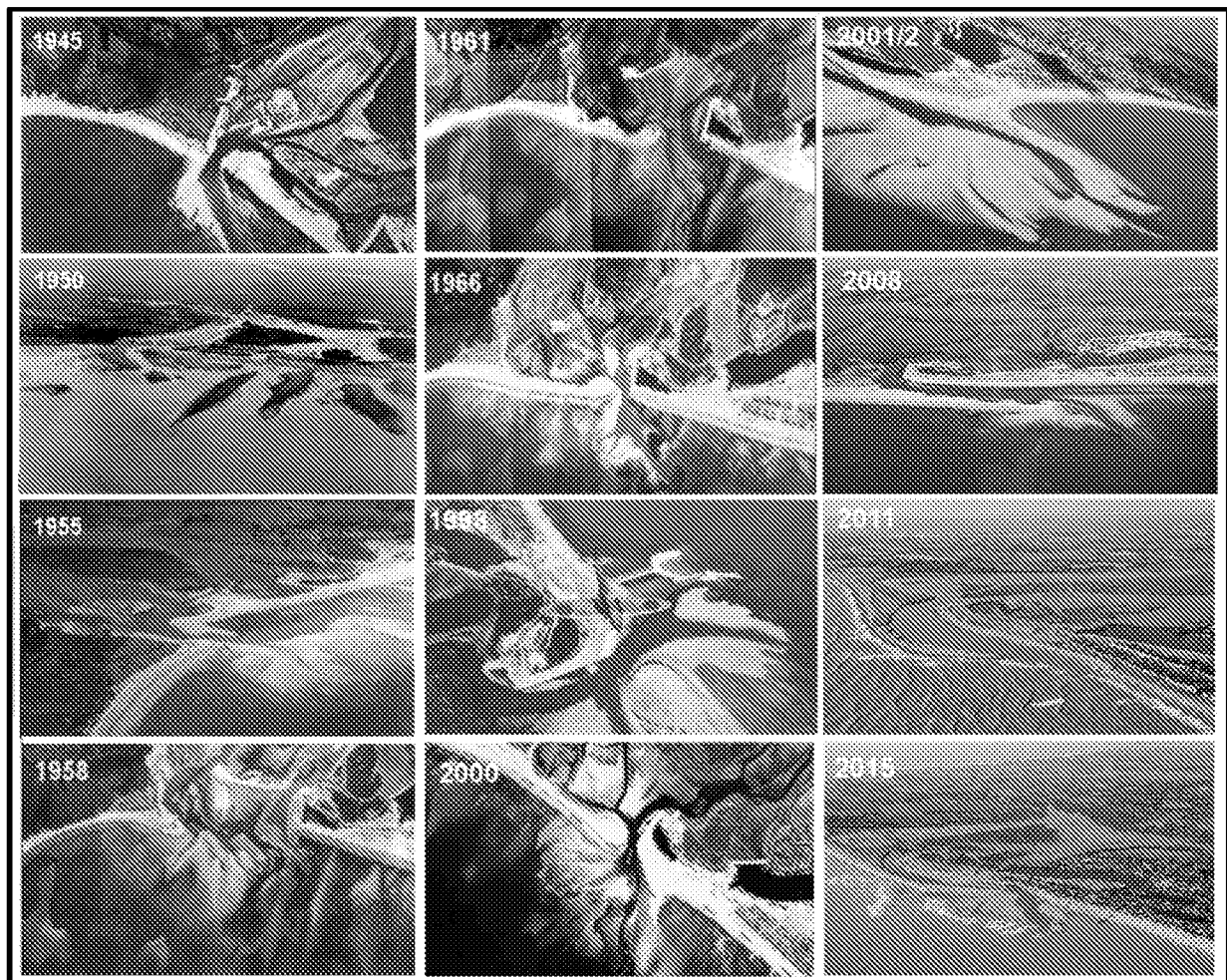


Image 17. Changing configurations of the spit, inlet and delta complex

4.2.2 Infilling the channel

Context

As outlined in Section 3.2.1 of the ES, and Section 1.5 of this Further Information Report, in order to ensure that the existing inlet is blocked, the channel immediately adjacent to the new proposed inlet is to be infilled. In order to create this infill, and also provide access to the breach location for construction vehicles, a temporary access 'causeway' may well need to be created. This aspect is under review as it appears from the recent natural breach witnessed on site (see Section 1.3.3), that it may well be possible to undertake the construction work without the need for sheet-steel piling.

Whilst a final construction methodology is currently being developed, the need for some temporary sheet piling cannot be discounted at present. It is currently envisaged that this could involve driving sheet piles using a vibratory hammer across the channel at the north eastern extent of the proposed infilled channel or 'dam' to a top level of 0 mODN. The depth of the sheet-piles is likely to be around -3 mODN, and their width just over 100 m. Ultimately, towards the end of the construction period, the sheet-piles would be removed and the infill created on top of the causeway, to a level of around 4.5 mODN. Profiles for this infill can be seen in Figure 4 (see Profiles B and C).

Profile B of Plan 4 is drawn in the approximate location of the temporary sheet piling, should it be employed. It can be seen that at this location, the channel depth is approximately -1.8 mODN, and the width just over 100 m. The sheet piling could conceivably affect previously undisturbed deposits,

though this is considered highly unlikely given that no archaeology has obviously been exposed along the edges of the channel, and given that this location is where channels would have meandered many times over the past decades and centuries. For example, a wider, slightly more landward channel is indicated in a 1961 aerial image (see Image 15). However, encountering riverside maritime finds including moorings, fish traps or wrecks which might have been buried at depth in these previous channels cannot be discounted, also given the number of recorded wreck losses listed for the vicinity of the breach location in Table B1 of Appendix B.

Impact assessment

This pathway considers the potential for unrecorded riverside or maritime finds, which could conceivably be buried at depth, to be impacted by the temporary sheet-piling. It is not considered that the creation of the infill *per se* could damage archaeological resources. Given that no indications have been found of related finds along the eroded channel, and given that large proportions of the affected deposits are exposed, a low probability is assessed.

Combined with a small magnitude due to the temporary, and vertical, nature of the sheet-piling, a negligible exposure to change is assessed. Whilst the sensitivity of a wreck feature to sheet-piling would be assessed as moderate, the vulnerability is considered to be low. The importance of a wreck, should it be one of those listed in Table B1 in Appendix B, could potentially be high, and the impact may thus be '**minor adverse**'.

4.2.3 Indirect changes due to tide (including scour)

Context

As outlined in Sections 6.3 and 8.2 of the ES, tidal behaviour in the harbour, and flows into and out of the harbour, might change during both construction and operation. During the construction phase, due to the construction of the temporary causeway (if used) to approximately 0 mODN, less water will essentially enter the harbour and through the inlet channel (see Section 8.2.5 of the ES). As outlined in Section 6.3.2 of the ES, post construction, within the harbour, flows are unlikely to change significantly, and there are predicted to be slight reductions on both the flood and ebb tide, with these changes decreasing away from the harbour entrance.

As outlined in Section 6.3.2.4 of the ES, post breach, there is the potential for some scour to occur at the breach and into the fronting intertidal, as the breach adjusts to a new equilibrium. 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. The site will of course continue to change into the future as it has continually in the past. It will just do so from a new, and less damaging, morphology.

Impact assessment

This pathway assesses potential indirect impacts from construction and operation in relation to water level and flow changes associated with the proposed development.

It is not thought that a temporary reduction in water levels or flow energies would impact any hitherto undiscovered archaeological sites within the harbour, and construction impacts are thus assessed as **not significant**.

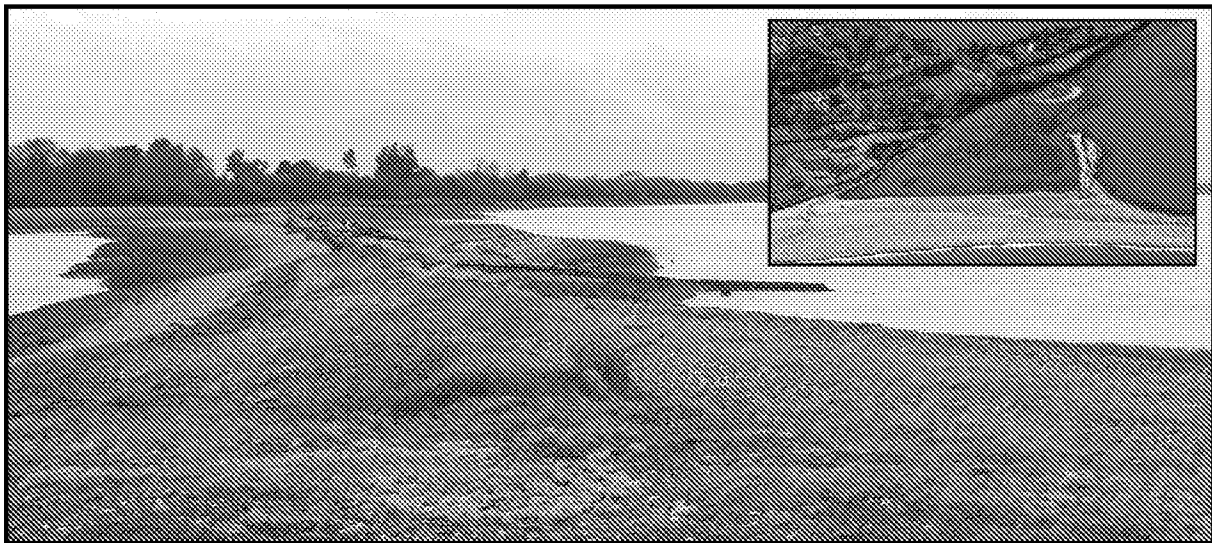
It is considered unlikely that slight reductions in flow speeds within the harbour post breach will affect previously undisturbed archaeological deposits/resources. Thus, the impact is assessed as **not significant**.

With regard to scour at, and around the breach, no significant increase in scour is predicted in the longer term. Given the short duration of the scour which is predicted, the exposure to change is assessed as negligible to low. The sensitivity of the deposits around the breach is considered to be low given the likely recently deposited nature thereof. Thus, a vulnerability of none to low is assessed. It is considered unlikely that any deposits which might be affected by scour are of more than low archaeological value; thus the impact from short term scouring is assessed as **not significant**

4.2.4 Creation of New Tern Island in harbour

Context

In order to provide compensation for the potential reduction in Little Tern breeding habitat, the creation of an additional breeding island in the harbour is proposed. The design for this island is described in additional detail in Section 1.5.6. This is to involve covering the remnants of the westerly 1937 training wall shown in Image 18 with gravel (approximately 1 m on average, and up to 1.5 m), and cutting a 20 m-wide channel between this island and the Church Norton Spit to a depth of -0.5 mODN. This would involve excavations of around 3.5 m in depth, as can be seen in the profiles provided in Figure 5 of this further information document. The top layer measuring some 1.7 m in thickness would consist of shingle thought to have largely been deposited around the time of the training wall construction, and below this would be estuarine mud.



Source: ABPmer 20 February 2016; inset/aerial John Akerman 7 February 2007

Image 18. View from the south east (seaward) end of the proposed New Tern Island

This location would have formed part of the harbour for many centuries, and would have been sheep pasture for the 37 years the harbour was claimed from the sea between 1876 and 1910. It appears that the proposed cut channel will be in the location of that of a field drain from the claimed period (called the 'Beach Channel'), as indicated by old OS mapping, and also Image 15 (where remnants of this drain can still be observed in the 1945 aerial imagery). Thus, encountering any pre-land claim and post training wall construction archaeology (i.e. post 1937) is considered unlikely.

Impact assessment

This pathway assesses impacts resulting from covering a concrete structure (see Image 18) with shingle and cutting a channel to isolate the new island.

The old westerly training wall which was constructed of concrete in 1937 is to be covered in shingle, but not otherwise affected. The wall itself is considered to be of low archaeological value. Covering it is not thought to impact the feature itself, and the impact is thus assessed as **not significant**.

The cutting of the channel at the end of the proposed new island to a depth of -0.5 mODN would affect estuarine mud and shingle mostly accreted and deposited between 1910 and 1937, as described above. Thus excavating the channel would not be expected to yield any significant archaeology or affect the concrete structures. The exposure to change is thus considered negligible, and the impact assessed as **not significant**.

4.2.5 Conclusions

In conclusion, no impacts on archaeological receptors are anticipated which would require mitigation. Should sheetpiling be employed to infill the channel, a limited low tide investigation of the exposed sections of the channel where the sheet-piles are to be located, prior to works commencing, might be prudent in order to look for signs / finds related to possible wrecks.

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6 Abbreviations/Acronyms

AA	Appropriate Assessment
ABPmer	ABP Marine Environmental Research
AD	Anno Domini
ADC	Arun District Council
AEOI	Adverse Effect on the Integrity
ATV	All-Terrain Vehicle
AWC	Adur and Worthing Councils
BC	Before Christ
BMP	Beach Management Plan
BP	Before Present
CCO	Channel Coastal Observatory
CDAS	Chichester and District Archaeology Society
CDC	Chichester District Council
CIfA	Chartered Institute for Archaeologists
DAS	Design and Access Statement
DBA	Desk Based Assessment
Defra	Department for Environment, Food and Rural Affairs
EH	English Heritage
EIA	Environmental Impact Assessment
ES	Environmental Statement
FDGiA	Flood Defence Grant in Aid
HAT	Highest Astronomical Tide
HBSMR	Historic Buildings, Sites and Monuments Record (National Trust)
HER	Heritage Environment Records
HLMO	High Level Marine Objectives
HRA	Habitats Regulations Appraisal
IPENS	Improvement Programme for England's Natura 2000 Sites
IROPI	Imperative Reasons of Overriding Public Interest
JNCC	Joint Nature Conservation Committee
LIA	Late Iron Age
LiDAR	Light Detection and Ranging
LSE	Likely Significant Effect
MCZ	Marine Conservation Zone
MHW	Mean High Water
MLW	Mean Low Water
MMO	Marine Management Organisation
MPS	Marine Policy Statement
MSL	Mean Sea Level
NE	Natural England
NHLE	National Heritage List for England (re. listed buildings)
NMR	National Monuments Record
NPPF	National Planning Policy Framework
NRA	National Rivers Authority
OD	Ordnance Datum
ODN	Ordnance Datum Newlyn
OS	Ordnance Survey
PPC	Pagham Parish Council

Ramsar	Wetlands of international importance, designated under the The Convention on Wetlands (Ramsar, Iran, 1971
RSPB	Royal Society for the Protection of Birds
SCOPAC	Standing Conference on Problems Associated with the Coastline
SPA	Special Protection Area
SRCMP	Strategic Regional Coastal Monitoring Programme
SSSI	Site of Special Scientific Interest
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
WeBS	Wetland Bird Survey
WWII	World War II

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Figures





- Application Site
- Extent of Church Norton Spit in January 2015
- Arun District
- Chichester District

Access tracks for plant machinery will use existing paths

Date	By	Size	Version
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QA		DLW	
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Produced by ABPmer			

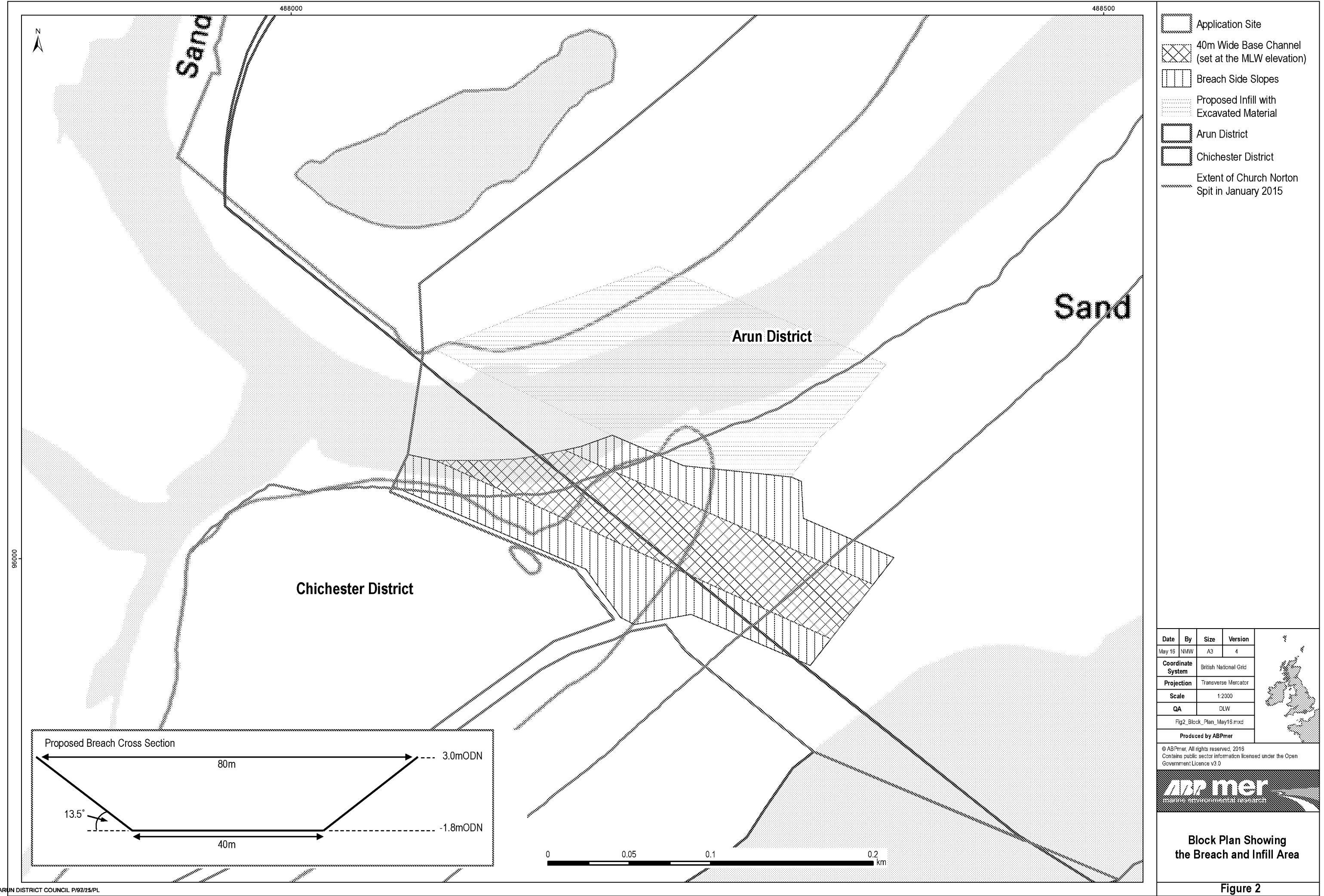


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Location Plan Showing the Application Area (Red Line Boundary)

Figure 1





- Application Site
- Proposed Location of a New Tern Island
- Excavation to Create Isolated Island
- Profile D
- Profile E

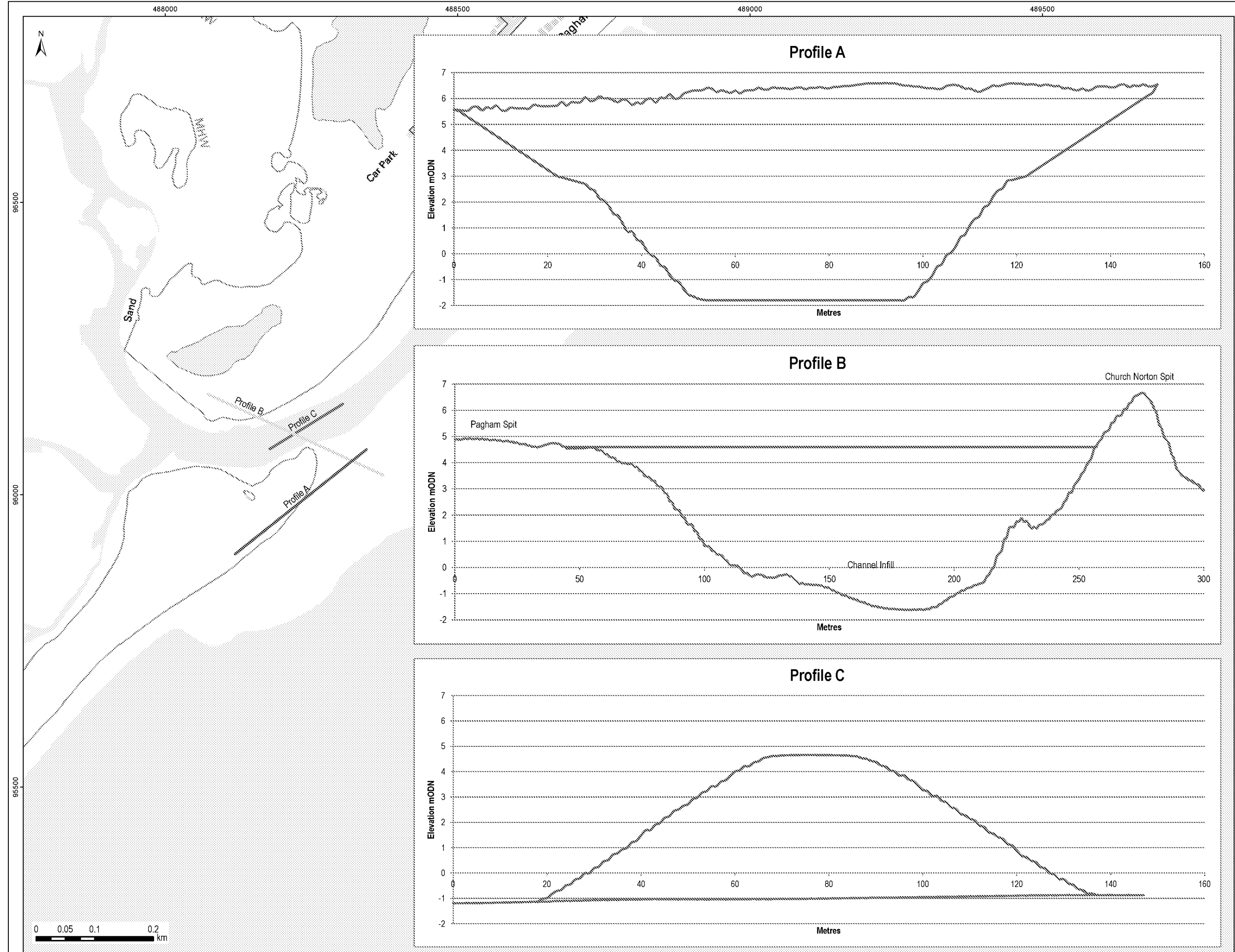
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QA		DLW		
Fig3_Block_Plan_May2016.mxd				
Produced by ABPmer				

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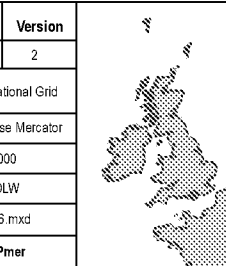
Block Plan Showing the Proposed Compensation Area ('New Tern Island')

Figure 3



Current Elevation
Proposed Elevation

Date	By	Size	Version
May 16	NMW	A3	2
Coordinate System	British National Grid		
Projection	Transverse Mercator		
Scale	1:6000		
QA	DLW		
Fig4_Profiles_May16.mxd			
Produced by ABPmer			

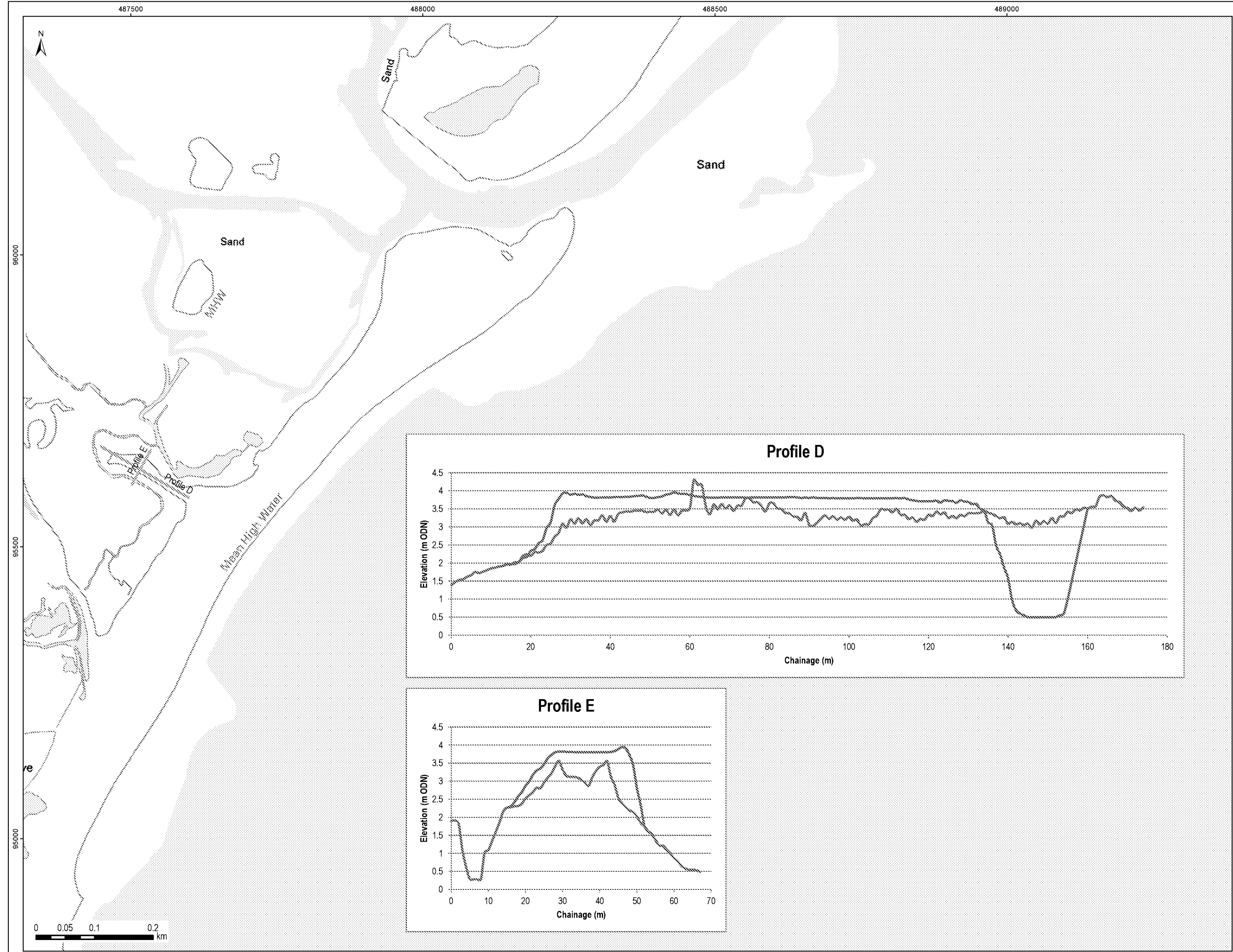


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Cross-section Profiles of the Breach and Infill Barrier

Figure 4



Current Elevation
Proposed Elevation

Breach side slopes to be determined based on safe plant machinery removal

Date	By	Size	Version	
May 16	NMW	A3	2	
Coordinate System		British National Grid		
Projection		Transverse Mercator		
Scale		1:6000		
QA		DLW		
Fig5_Tern_Profile_May16.mxd				
Produced by ABPmer				

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Cross-section Profiles of the New Tern Island

Figure 5

Appendices



A ADC Planning Application Letter (7/3/16)

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Arun Civic Centre
Maltravers Road
Littlehampton
West Sussex, BN17 5LF

Tel: 01903 737500
Fax: 01903 730442
DX: 57406 Littlehampton
Minicom: 01903 732765
e-mail: simon.davis@arun.gov.uk



Mr C Scott,
ABP Mer,
Quayside Suite,
Medina Chambers,
Town Quay,
Southampton,
SO14 2AQ

07 March 2016

Your Ref: R/4282/4

Please ask for:
Simon Davis
Planning Department

ADC Ref: P/97/15/PL
MMO Ref: MLA/2015/00390
CDC Ref: SY/15/03053/FUL

Direct Dial: 01903 737874

Dear Mr Scott,

Re: Planning Application and application for Marine Licence by Pagham Parish Council for managed breach of shingle spit, blocking of adjacent tidal inlet channel with shingle barrier and formation of Shingle Island within Pagham Harbour following excavation of adjacent area of spit

This response represents the joint response from Arun District Council (ADC), Chichester District Council (CDC) and the Marine Management Organisation (MMO) who are working in conjunction under the Coastal Concordat. Following our meeting on the 11th February 2016, I write to you as promised to outline the further information that is required in order to progress both the marine licence and planning permission applications. Furthermore this document details the additional information required for CDC to conduct an Appropriate Assessment under the Habitat Regulations Assessment Regs.

Firstly, as stated during our meeting, I would like to confirm that the competent authorities have completed screening for likely significant effects and all agree that an Appropriate Assessment (AA) is required to address the impacts of the proposal on the Pagham Harbour SPA/Ramsar site. Furthermore, I would also confirm that ADC will act as the lead for the planning application, CDC will lead on the AA and the MMO will carry out the Stage 1 Assessment for the Marine Conservation Zone (MCZ). ADC will also remain the point of contact for submitting information.

I now set out the information required in respect of (a) the Appropriate Assessment (in terms of the impacts on the SPA/Ramsar site), (b) in respect of potential derogation tests and (c) the Environmental Statement & MCZ1 Assessment (in terms of the impacts on the SSSI/MCZ).

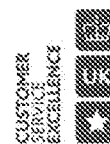
Please note that I have used the following abbreviations for the relevant contributors to this letter.

NE – Natural England;
RSPB – The Royal Society for the Protection of Birds;
HE – Historic England;
EA – Environment Agency;

Nigel Lynn Chief Executive
Nigel Croad Resources Director and Deputy Chief Executive

1

Environmental Health
Littlehampton and Bognor Regis
Customer Services Help Points



MMO – Marine Management Organisation (who are leading on the MCZ1);
CDC EC – Chichester District Council's Environmental Coordinator (who will be leading on the AA);
CDC CE – Chichester District Council's Coastal Engineer; and
ADC PP – Arun District Council Planning Policy

Information Required for the Appropriate Assessment (AA)

The overall purpose of the AA is to enable the competent authority to ascertain that a plan or project will not adversely affect the integrity of a European site. This assessment needs to be undertaken in respect of the site's conservation objectives. Please also note that although the application can be assessed as submitted, where there is a lack of information or where there is "reasonable scientific doubt" as to the absence of effects then the precautionary principle applies.

It is considered that the main issues that need to be considered are:

- (1) Impacts to the Little Tern population - through loss of breeding habitat and the potential increased risk of disturbance and predation due to the altered accessibility of their nesting habitats;
- (2) Impacts to SPA/Ramsar bird populations due to changes in supportive habitat within the harbour through the risk of any subsequent harbour closure following the initial re-opening of the breach. This should include analyses of the probability of such an occurrence as well as its severity. The emphasis is on the applicant to identify the mitigation measures which might be applied and how these will be maintained after the initial 8 year period;
- (3) The impacts of construction on bird SPA/Ramsar bird population – via disturbance from personnel working on site and changes to supportive habitat.

NE/CDC/RSPB advises that further information is needed to clarify these impacts and to set out in detail how these will be addressed by any proposed mitigation measures. It was suggested in respect of the closure of the harbour that a "What-If Matrix" should be provided.

In respect of the construction information needed, please note the following:

- Cold weather restrictions are needed to ensure bird fitness - there should be an avoidance of working in cold weather to prevent disturbance to birds when they are resting/keeping warm;
- There needs to be a watching brief undertaken during the Tern nesting period;
- More detail is required as to the construction method to include details/numbers of machinery & people and to give different buffer zones for machinery and for people;
- The construction period should take place between the departure of breeding birds and the arrival of over-wintering birds;
- The duration of the construction period needs to be agreed with the applicant to agree the least sensitive time;
- A Construction Schedule and/or Construction Management Plan would be a good way to address these issues; and
- As discussed at the meeting, the EA has refined their comments in respect of the avoidance of working during the bathing season. They now consider that there is scope to allow certain works to take place before October.

Information required in preparation for potential future Derogation tests

You may wish to consider the following requirements now or defer any expenditure until this stage is reached.

- (1) Consideration of Alternatives – please see the section below regarding the Environmental Statement but note that the level of information required for the Habitats Regulations Alternatives test is higher/greater than that which would be required under the EIA regulations;
- (2) Project Objectives – please see the section below regarding the Environmental Statement but note that the level of information required for the Habitats Regulations Alternatives test is higher/greater than that which would be required under the EIA regulations;
- (3) Tern Island – further work needs to be carried out to develop the proposal for the new Little Tern habitat. This should include details of its design/appearance, vegetation control measures, anti-predator fencing, appropriate wardening/management and clarification of who will be legally responsible for the compensatory measures.

Information required for the ES and MCZ1

Further information is required in respect of the impacts on the SSSI and MCZ and this needs to consider the impacts on the SSSI/MCZ1 features and mitigation proposed to minimise these impacts. The identified impacts are as follows:

- On Vegetated Shingle;
- On SSSI overwintering & breeding birds (including populations of Pintail, Ringed Plover, Grey Plover, Oystercatcher & Black Tailed Godwit). This should include the impacts of stopping water flow during construction of the bund;
- On MCZ1 features including the Defolin's Lagoon Snail, it is recommended that a buffer zone of between 5 and 10m be implemented around the Little Lagoon but it is agreed that there is no need for any further surveys to determine the presence of the snail as such surveys could disturb this species; and
- On the geomorphology of the spit which is a unique feature.

Further information is also required (as a duplication to the information required for the AA) to address the impacts that may arise to the natural environment if the breach closes up a second time (noting that the proposal allows for one subsequent closure & re-breach). NE suggested that a "What-If Matrix" should be provided.

I have also had comments from CEFAS (Centre for Environment, Fisheries and Aquaculture Science) by way of the MMO to say that a breach monitoring plan should be developed and agreed with the regulator. The plan should also include plans for post-breach maintenance as specified within section 3.2.7 (page 55) of the ES. They comment on section 11.3 (page 250) of the ES which defines a requirement for ongoing (post-breach) monitoring and management which may require technical oversight (possibly by a panel of stakeholders). They ask how this panel will be formed & managed and who will chair the panel. They state that the panel's monitoring and management plan should be developed and agreed with the regulator.

Please also note that the RSPB, CDC EC and ADC PP have indicated that the Environmental Statement is deficient in certain respects. It is considered that the following amendments are required:

- In respect of Project Need & Alternatives –
 - Section 2.1.3 (Proposed Community Project and its Objectives) – distinguish clearly between those objectives that are genuine public interest objectives (and therefore relevant to the alternative solutions and IROPI tests) and those that are project-level objectives only. RSPB consider that public interest objectives could include those relating to public safety (e.g. achievement of larger and longer-term coastal defence benefits) and the need to avoid the risk of further and uncontrolled damage to the SPA/Ramsar site through unmanaged breaches;

- Section 2.2 (Alternatives) – include a section that specifically addresses the alternative solutions test (as opposed to alternatives in their ES sense). This section should compare the possible alternative solutions to meet the stated public interest objectives and set out how the proposed solution will be the least damaging (or at worst cause equivalent damage) to the SPA/Ramsar features of the various alternative solutions identified that could meet the public interest objectives. At present, the information does not yet provide a clear description that would enable the Councils to conclude that there is no alternative solution to the proposal.
 - Alternatives (general comment) – it is considered that the starting point is the underlying project objective and that this should be: “how can homes in Pagham be protected from damage?” Therefore, objectives set around concerns about the appearance and amenity value of alternative measures would not be appropriate for a habitats regulations test that is concerned primarily with minimising the impacts on wildlife. Furthermore, that there are alternatives that would defend the homes and be less damaging to the designated species of the SPA, particularly given the loss of little tern habitat and the increased access afforded to much of the remaining habitat on the former spit from the settlement of Pagham. These alternatives need to be considered;
 - Include a new sub-section that summarises the justification for imperative reasons of overriding public interest in light of the amended sections; and
 - Correct the ES (page 16 of the Non-Technical Summary) to confirm that the Tern Island is compensation not mitigation.
- To address uncertainty – for example at paragraph 8.2.8.2. The low confidence expressed raises concerns about whether the information provided for the purposes of EIA meets the criteria of providing “complete, precise and definitive findings and conclusions capable of removing all reasonable scientific doubts as to the effects of the works proposed on the protected site”;

I also include separately the requirements as expressed by Historic England. Although these also relate to a deficiency with the ES, we consider best to keep these separate to the wildlife issues:

HE considers that the scheme has the potential to cause harm to undesignated heritage assets whether known or unknown. They recommend that a desk based assessment of the significance of the historic environment and potential impacts upon it should be undertaken. This should examine the available archaeological, geo-archaeological and marine geophysics data. HE considers it likely that follow up investigation work will be required and a program will need to be drawn up in consultation with Historic England and Chichester’s Archaeological Officer. It is stated that this can be subject to a condition but in view of the need to get on site promptly, you may prefer to provide a report prior to determination?

HE considers that the scheme has the potential to impact on the following:

- Boats, moorings, quays, platforms, fish traps and other riverside structures in the area, from prehistoric time onwards;
- Landscape features or deposits associated with the Norman castle at Church Norton and the Roman tide mill at Sidlesham;
- A potential shipwreck site in the general vicinity of the Spit;
- The existing concrete structure which will form the basis of the Tern Island (HE comment that this structure could have originated as some form of military defence feature); and
- Harbour deposits of as yet uncertain archaeological potential.

HE also considers that it would be beneficial for a small number of geo-archaeological boreholes to be drilled on the drier ground within the harbour area, to assess the nature of the harbour deposits and their likely archaeological potential. Furthermore, that the channel area where the sheet pile wall will be situated may require exploratory fieldwork or survey to establish the presence or absence of marine heritage assets. In addition, the area designated for the Tern Island will need to be investigated to see if the concrete structure is of heritage significance and whether there are any deposits in the proposed channel area adjacent to the island.

It should be also be noted that CDC CE have stated that they consider that there is too much uncertainty as to whether the re-opening of the harbour entrance in the former location of 2000-2003 will be stable and not result in any damage to the listed habitat or result in increased risk of erosion to Pagham beach.

ADC Engineers have also indicated that they have previously verbally asked you for detailed 'cut and fill' calculations (and the topography of the spit at the relevant locations), together with allowances for construction losses, in order that the viability of the proposed operation can be assessed. It is understood that we have so far only had very outline figures and we need the detail to be able to properly assess the proposal.

Finally, I believe that my Team Leader, Daniel Vick spoke to you after the meeting regarding providing drawings that are truly representative of the proposals. It is noted that the submitted plans show an apparent discrepancy in that Figure 2 shows a consistent 40m wide base channel with 20m on each side of the breach for side slopes (a total width of 80m). However Figure 4, Profile A appears to show a total width of 150m which is some 70m more than would be anticipated from an examination of Figure 2. Are you able to provide an explanation for this? If the plans need amending then please provide these within 21 days of this letter.

Next Steps

I would recommend that the additional information be set out in the form of additional addendum reports which can then be disseminated to the relevant consultees.

I would also stress that the information outlined above is required to enable the relevant authorities to properly determine the application. Whilst not wishing to pre-determine the application, we are all keen to work with you in order to reach a satisfactory conclusion.

Finally, please note that NE is working on a package of helpful advice to inform both the AA and the consideration of the SSSI/MCZ impacts and they are aiming to provide this as soon as possible.

Yours sincerely,



Simon J Davis RTP1
Principal Planning Officer

cc MMO
 Natural England
 RSPB
 Chichester District Council (Environmental Coordinator & Engineers)
 Historic England
 Environment Agency
 Arun District Council (Engineers & Policy)

B Archaeological Desk Based Assessment

B.1 Introduction and Context

This appendix contains a brief archaeological Desk-Based Assessment (DBA) undertaken for the Pagham Managed Breach project. This project seeks to undertake a:

*Managed breach of shingle spit and blocking of adjacent tidal inlet channel with shingle barrier.
Formation of shingle island within Harbour following excavation of adjacent area of spit.*

The location of the proposed breach point is shown in Image B1 below.

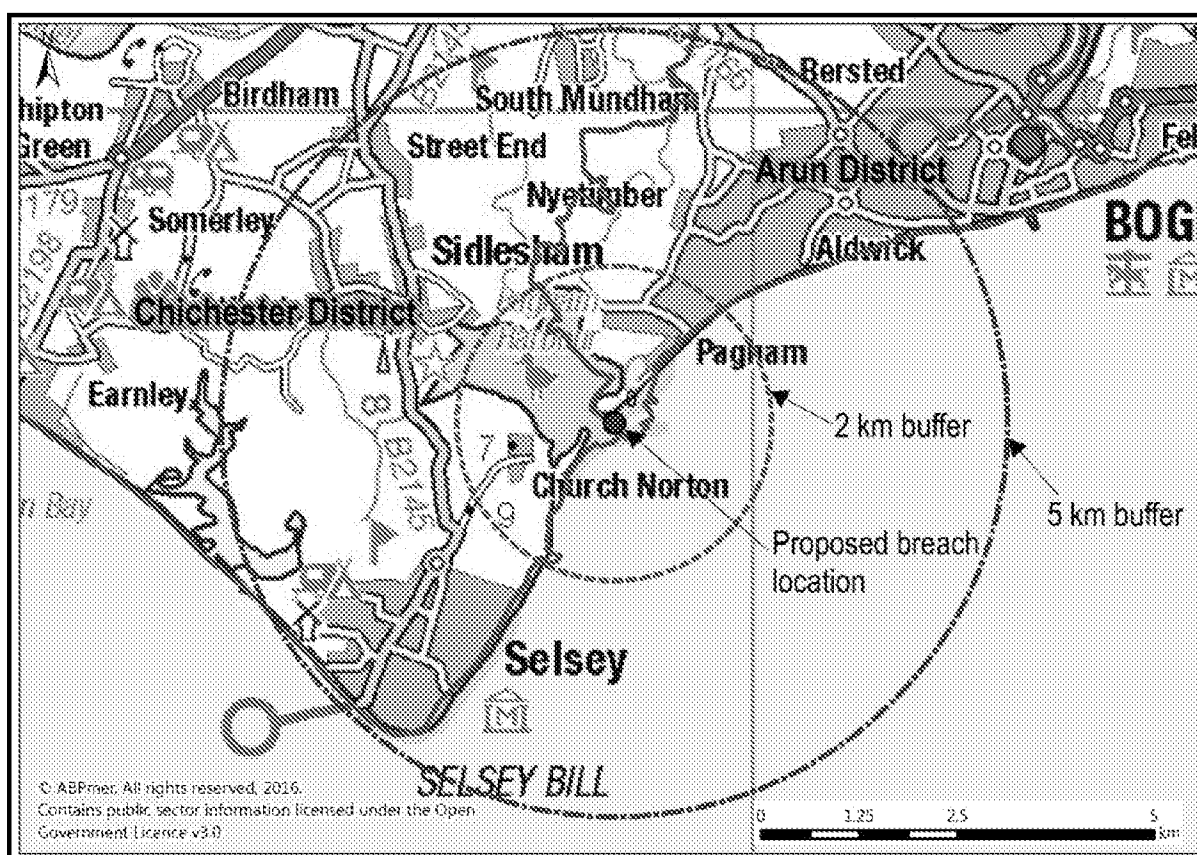


Image B1. Location of proposed breach and study buffer areas (immediate buffer within 2 km, wider buffer within 5 km)

The planning application for this proposal was submitted by Pagham Parish Council jointly to Arun District Council (ADC) and Chichester District Council (CDC) on 9 September 2015 and the application for a marine licence was submitted to the Marine Management Organisation (MMO) on 10 September 2015. An archaeological DBA was not undertaken for these original submissions because this topic was scoped out during the planning consultations. However, it was subsequently requested by Historic England following post-submission consultations undertaken under the MMO marine licensing process.

Under the National Heritage Act 2002 English Heritage (statutory responsibilities now with 'Historic England') gained responsibility for maritime archaeology in the English area of the UK territorial sea. As such Historic England is the primary advisor to the MMO for the marine historic environment.

This DBA assesses the potential impacts of the proposed development on archaeological resources. A full description of this development was provided in Section 3.1 of the Environmental Statement (ES) (ABPmer, 2015), which was submitted with the planning application in 2015. In archaeological terms, zones/areas where impacts from the proposed project could occur are:

- ✱ At the spit, in the zone where it is proposed to be breached (see Section 3.1 of ES and 1.5 of this Further Information Report);
- ✱ In the tidal channel adjacent to the breach, which is proposed to be infilled (and potentially temporarily sheet-piled during construction) (see Sections 3.1 and 3.2 of ES, and 1.5 of this report);
- ✱ In the tidally influenced reaches of Pagham Harbour (as tides might change slightly both during construction and operation) (see Sections 6.3 and 8.2 of the ES); and
- ✱ At the area where a New Tern Island is to be created (as compensation for potential impacts on Little Tern breeding habitat at the breach) by placing clay/shingle and cutting of a small channel to isolate the island from Little Tern predators (foxes) (see Section 11.2.2 of ES and 1.5 of this report).

This DBA has been undertaken with reference to the Chartered Institute for Archaeologists' (CIfA) Standard and Guidance for Historic Environment Desk-based Assessment (CIfA, 2014). It forms part of a 'Further Information Report' which has been prepared in order to address further comments received from regulators and statutory advisors since the submission of the planning application documents in 2015 (see Section 1 of the main report).

Key legislation is now briefly discussed before the baseline is presented in Section D.3, and the impacts assessed in Section D.4.

B.2 Legislation and Guidance

The UK Marine Policy Statement (MPS) and UK High Level Marine Objectives (HLMO) set out the importance of cultural heritage as a component of delivering sustainable development in the UK through the use of a system of Marine Planning. The documents clearly identify cultural heritage as an important component of decision making and state that non-designated heritage sites should be considered subject to the same policy principles as applied to designated heritage assets. This approach accords with the relevant detail of the 2012 National Planning Policy Framework (NPPF) which clearly states that non-designated sites of demonstrable equivalent significance should be subject to the same policies as for designated heritage assets.

According to the MPS and NPPF, the interest and significance of all heritage assets that may be affected by a proposed development should be identified and properly assessed to minimise conflict. Similarly, these policies state that identified heritage assets are to be conserved in a manner proportionate to their significance. The key legislation which relates specifically to the maritime historic environment in UK territorial waters is the Protection of Wrecks Act 1973. This enables the Secretary of State to protect specific wreck sites within UK territorial waters from unauthorised interference if they have been designated on the basis of their historic, archaeological or artistic importance.

The Merchant Shipping Act 1995 states that any wreck material which comes from UK territorial waters (up to the high water mark) must, by law, be declared to the Receiver of Wreck (Section 236 of

the Merchant Shipping Act 1995). 'Wreck' is defined as "flotsam, jetsam, derelict and lagan found in or on the shores of the sea or any tidal water". It includes ships, aircraft and hovercraft, parts of these, their cargoes and equipment.

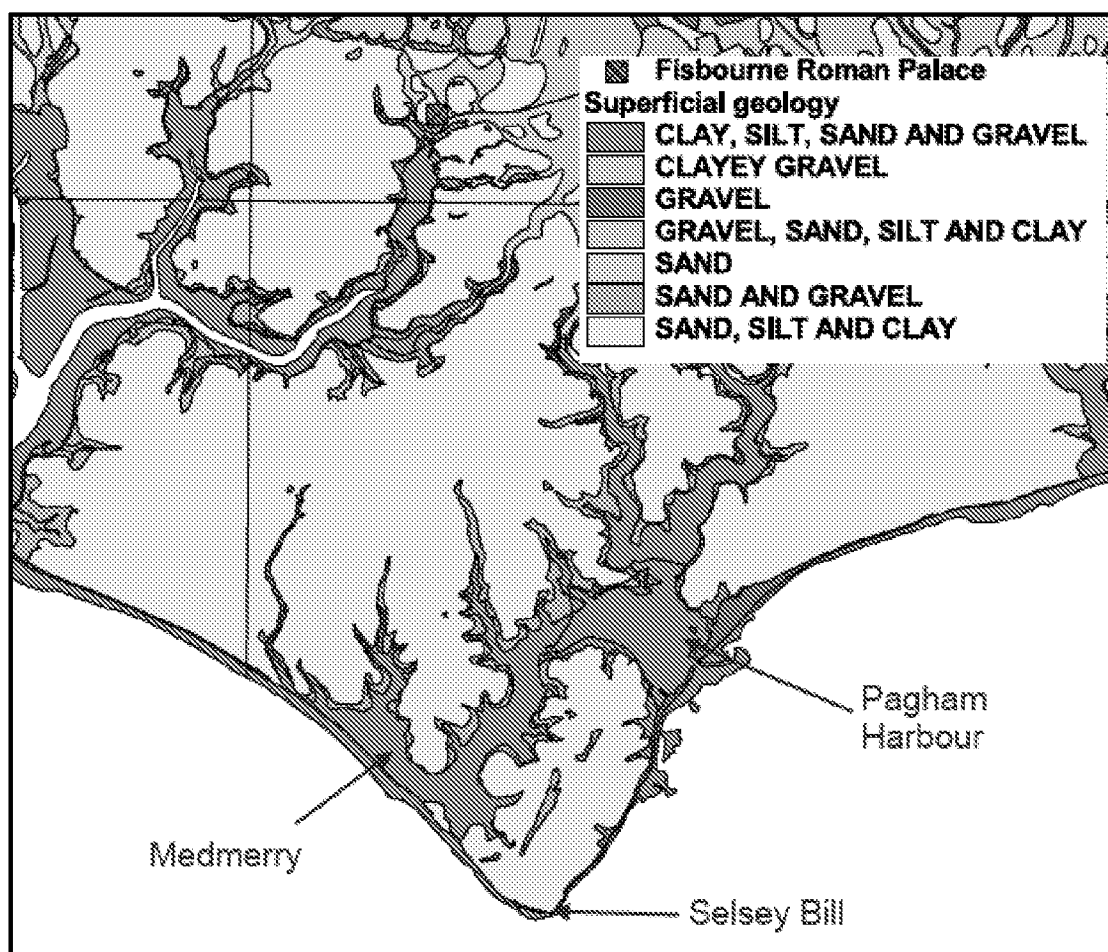
The Protection of Military Remains Act 1986 makes it an offence to interfere with the wreckage of any crashed, sunken or stranded military aircraft or designated vessel without a valid License, irrespective of loss of life or whether the loss occurred during war or peacetime. All aircraft lost in military service are automatically designated as Protected Places under this legislation.

B.3 Baseline information

B.3.1 Geology and Historical geomorphological changes

Geology

The superficial geology of Pagham Harbour and surroundings is shown in Image B2. Royal Haskoning (2009) reports that most of the surficial geology within the study area is of Pleistocene or recent origin with only a few occurrences of older Eocene strata. At the base of the geological sequence lies the London Clay above which lie the Bracklesham Beds, a dark green medium to fine glauconite sand, which dip gently to the south and are up to 100 m in thickness. These Eocene formations are in turn unconformably overlain by Pleistocene deposits.



Source: Manley, 2008; place annotations by ABPmer

Image B2. Superficial geology of Pagham Harbour and its surroundings

Many of the surface features observed at present within the study area are remnant of the last period of glacial activity. A band of 'erratics' marks the earliest Pleistocene deposits in the area (Reid, 1892; quoted by Royal Haskoning, 2009). Above the erratics lie a series of marine and estuarine mud indicative of a regressive phase of sea-level change (Palmer and Cooke, 1923; quoted by Royal Haskoning, 2009).

A series of littoral sands and gravels overlie these regressive deposits, indicating a change to a transgressive sea-level regime, which are in turn overlain by raised beach deposits. The deposit is composed predominantly of compact coarse flint and gravel (125 mm in diameter) with a matrix of finer material of sand. The raised beach deposits and the underlying marine deposits form the source of much of the local beach material in the area. The recent geological evolution of Pagham Harbour and beach are the result of rising sea-levels the reworking of the Pleistocene deposits under spatial and temporally variable hydrodynamic conditions.

Historical geomorphological changes

The geomorphological development of Pagham Harbour, and the various breaches were described in detail in the ES, particularly in Section 6.2.6 (Historical Changes and Recent Developments). A summary of the account presented in the ES is provided here, supported by further insights on the development of the harbour during the early Holocene.

During the last glacial cold stage (Devensian), sea levels fell to at least -50 to -60 m OD around the coast of Britain, with regional shorelines of southern England some 5-7 km seawards of their present position. During this time the lower reaches of Sussex Rivers cut deep valleys far below the present day valley floors. Sea levels consequently rose again during the post glacial period; evidence derived from sediment sequences indicates that sea level stood at -27 m at 9,000 Before Present (BP); -15 m at 7,500 BP and -5 m at 5,500 BP, at which time, as water levels continued to rise, low lying valleys were inundated by marine waters (SCOPAC, 2006; quoted by Royal Haskoning, 2009).

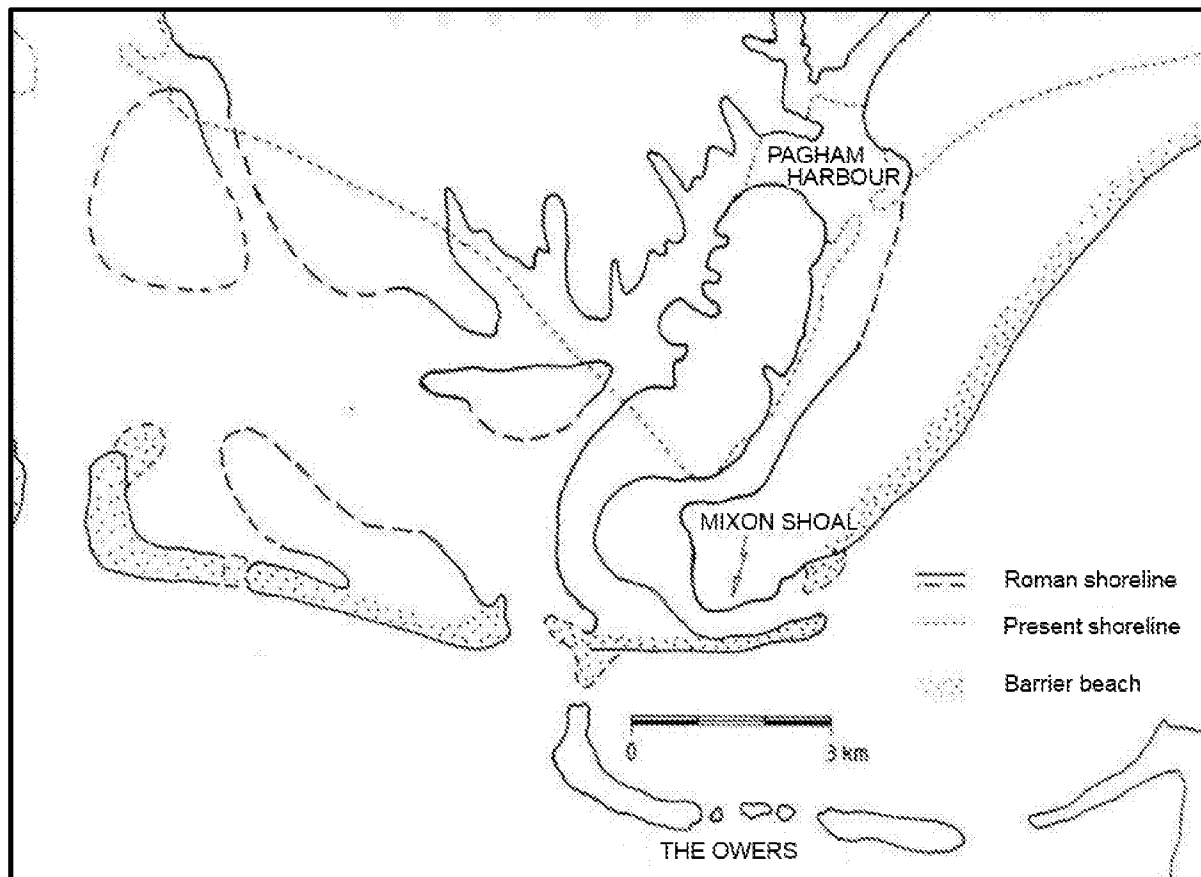
It has previously been described that the following five stages of Holocene evolution can be applied to both the Pagham coastline and harbour (Jennings and Smyth, 2001; ; quoted by Royal Haskoning, 2009):

- ✧ **Phase 1:** 11,000 to 10,000 BP: Reworking of sediments with rising sea levels.
- ✧ **Phase 2:** 10,000 to 5,000 BP: Transport of sediment landward.
- ✧ **Phase 3:** 5,000 to 300 BP: Sediments transported onshore following the stabilisation of sea levels allowing development of accretionary landforms.
- ✧ **Phase 4:** 300 BP to present: Most available sediments transported onshore resulting in a switch from offshore/onshore sediment supply to longshore drift.
- ✧ **Phase 5:** Present-future: Gravel is redistributed into sediment sources and sinks along the coast.

Image B3 presents a probable configuration of the Selsey to Pagham coastline approximately 2,000 years BP delineated using archaeological information and by tracing a submerged wave cut platform. It has been suggested that barrier breaching and shoreline recession associated with rising sea-levels and storm events caused The Mixon barrier to become an offshore bank, or shoal, at approximately 950-1,050 AD (Wallace, 1990, 1996; quoted by Royal Haskoning, 2009).

The recent historic development of the coastline at Pagham can be characterised by Phases 4 and 5 in the bullets above. During these phases artificial modifications have also have had a significant influence on the harbour morphology and adjacent coastline. The current harbour is apparently much

smaller than that of the Roman period (ca. 2nd to 5th centuries AD) due to successive phases of land claim, which may have started in Roman times, but certainly intensified during the medieval period.



Source: Royal Haskoning, 2009 - after Wallace, 1996

Image B3. Selsey and Pagham coastline 2000 years BP

The earliest reliable mapping of the Pagham coastline, drawn in 1587, identifies the presence of two separate shingle spits projecting part way across the mouth of the estuary. The harbour itself looked similar to today by around 1778 to 1785 with areas of claimed land behind and defences and sluices built to protect the drained land. However, at this point, the 'Ferry area' was still tidal. By 1825, the Ferry causeway had been constructed to restrict tidal exchange in this area (Environment Agency, ADC, CDC, undated).

In 1876, the inlet was artificially closed and the mudflats within the harbour claimed for pasture land (Robinson and Williams, 1983). Over the next 34 years (1876 to 1910) the beach at Pagham extended seawards as the ebb delta deposits were eroded and moved onshore leading to a build-up of the foreshore (Royal Haskoning, 2009). In 1910, the shingle ridge was breached by a large storm towards the southern Church Norton side of the harbour (see Figure 6.2 of the ES). This allowed the sea to flow again across the low-lying land into Pagham Harbour. In the years since then, the position and size of the inlet continued to change greatly in response to anthropogenic and natural factors (see Figures 6.2 and 6.3 of the ES).

In 1937, a new breach entrance in the south, near Church Norton, was created (see Image B4). This was supported by two training walls on either side of the new breach. In the mid-1950s, the spit was breached and the inlet subsequently migrated by 900 m to the north. In 1963, a training wall was introduced at the new location to stabilise the entrance; this situation was largely maintained subsequently – amongst others by reconstructing the training wall in the mid to late 1980s following

its major collapse (Bray *et al.*, 2004). Over the period from 1969 to 1997 the area generally remained relatively 'stable' when compared to past conditions (Royal Haskoning, 2009; Dornbusch, 2014). Through the 1990s and up to 2004, the Church Norton Spit and ebb delta were subject to regular annual intervention by the National Rivers Authority (NRA) until 1996 and then the Environment Agency. This involved taking approximately 15,000 m³/year sediment on average from the harbour mouth nearshore banks and ebb delta and then using it to rebuild and reshape the beach fronting the Church Norton spit following winter storms (Bray *et al.*, 2004).



Image B4 The southern entrance in 1945

Since 2001, Church Norton Spit has grown rapidly in a north-easterly direction, leading to the inlet moving by some 700 m by 2014 (Royal Haskoning, 2014). In 2009, these changes started to significantly affect the beach frontage at Pagham, as the direction of the distal end of the spit extension turned towards the southern section of Pagham Beach in the form of a re-curve – leading to significant erosion along the beach. This prompted coastal defence works by Arun District Council; first in the form of beach recycling, and in 2013 by installing a rock armour revetment (which required remedial works in subsequent years).

B.3.2 Archaeological records

To describe the archaeological record, the Heritage Gateway and the local Heritage Environment Records (HERs) were consulted. Image B5 shows the results for the Heritage Gateway search, excluding those results returned from local records (i.e. West Sussex HER and Chichester Council HER). This revealed no scheduled monuments, listed buildings, registered parks and gardens, historic Battlefields at the breach site, or within the zones potentially impacted by the development.

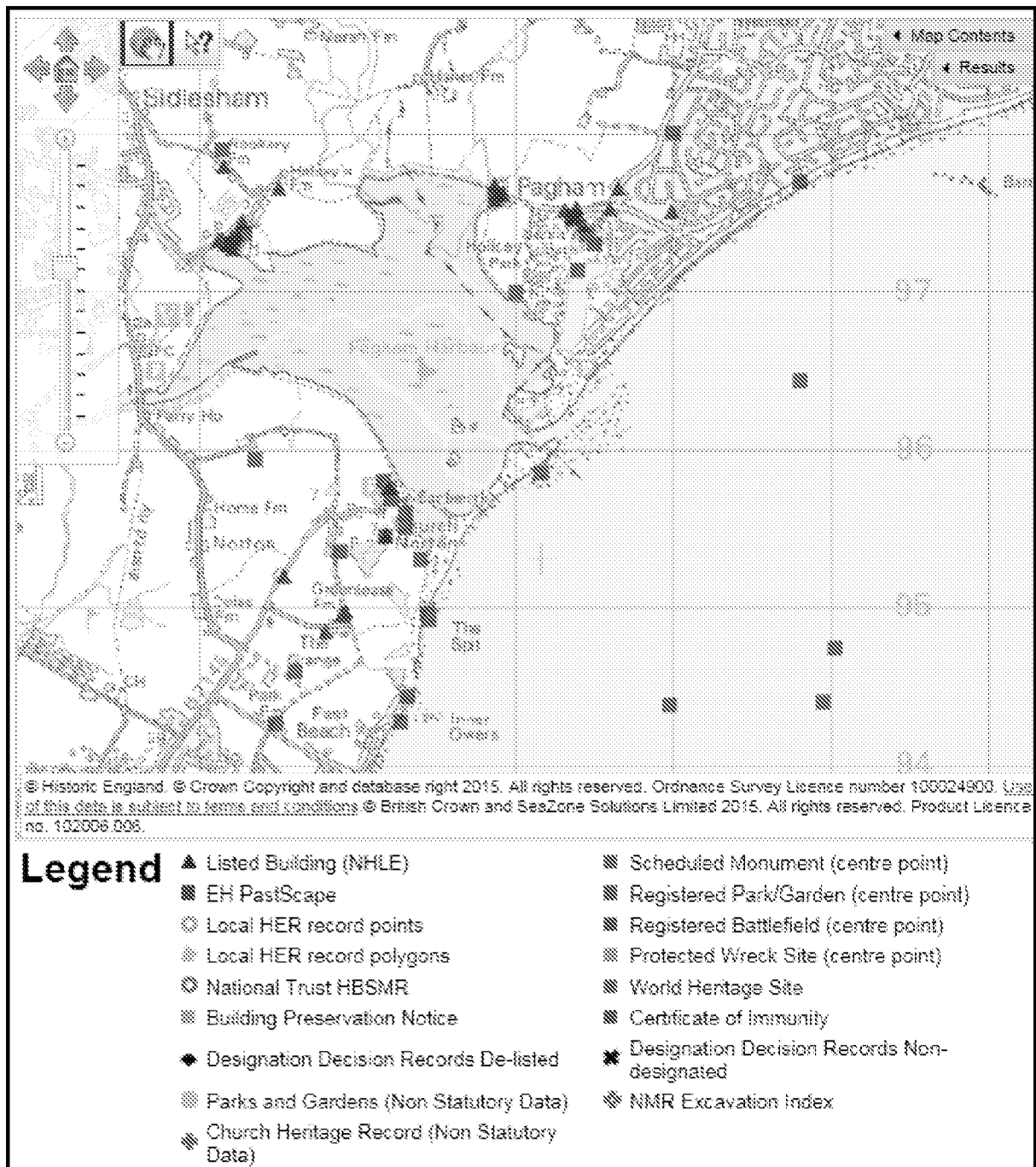


Image B5. Heritage Gateway results within 2 km of the proposed breach

Maritime and aviation archaeological receptors

There are no recorded wrecks in the harbour, or the immediate vicinity of the proposed breach. The spit is marked as the indicative location for several wrecks (including one aviation wreck) for which the exact position is not known, but whose loss was recorded in the vicinity of Pagham Harbour. These are listed in Table B1 below.

Table B1. Recorded losses at Pagham

Name / Description	Grid Reference	Record Number	Description
English barge, 1916	SZ 8816 9585	West Sussex HER: MWS10010; Monument no: 903589, NMR no: SZ 89 NE 56	Lloyd's list (1969): 'This barge was seen outside Bognor Rocks, attempting to weather Selsey Bill, but the wind and tide prevented her [doing so] and she developed a leak. Her crew anchored in partially sheltered water at the edge of the bay by Pagham harbour, going ashore in their boat and landing at Aldwick. The leak was obviously much worse than was thought and before the crew returned, she sank at anchor with her cargo, becoming a total wreck' (Pastscape).
Brig, 1753	SZ 8816 9585	Monument no: 902577, NMR no: SZ 89 NE 54	Lloyd's list (1969): 'A brig, Jones master, from Chester for London, with lead, wire etc. is stranded on Pagham Beach, the cargo is saved, and 'tis thought the vessel will be got off' (Pastscape).
William Pitt (British craft, 1861)	SZ 8816 9585	Monument no: 1176893, NMR no: SZ 89 NE 60	Bognor 26 November: A large packet of papers, apparently from the WILLIAM PITT...the body of a man, quite recently drowned, and a ship's boat, without name, have come ashore. It is supposed that the above vessel, and perhaps another, went down last night about three miles west of this place.' (Pastscape)
Spring (British cargo vessel, 1827)	SZ 8816 9585	Monument no: 1176571, NMR no: SZ 89 NE 62	Lloyd's list (1969): Chichester, 6 December. The SPRING, Hayne, from Bombay to London, struck on the Owers yesterday afternoon, and had 9 feet water in her hold, but came off at flood tide, and was run on shore to the eastward of Pagham harbour, in order to save the crew and cargo.' (Pastscape).
Possible 1361 wreck	SZ 8816 9585	Monument no: 1448427, NMR no: SZ 89 NE 70	'1361. Nov. 3. Westminster. [...] on complaint by Simon, archbishop of Canterbury, that whereas he has, and his predecessors time out of mind have had, wreck of sea in the port of Wydering, co. Sussex, Henry Gargate, Laurence, vicar of the church of Sydlesham, Robert, bishop of Chichester, Adam "the bisshopesboteler of Chichestre", John Athelard and others, carried away 4 tuns, 1 pipe, of wine, worth 45 marks, at Wederyng within the said port, pertaining to him as wreck.' [Wydering" identified as Pagham] (Pastscape).
Junkers Ju88A (333) 4D+AD	SZ 8816 9585	Monument no: 1400949, NMR no: SZ 89 NE 64	A German Junkers Ju88 that was part of Stab III/KG30. It was on a mission to attack London and was engaged by Spitfires. Both engines were disabled and it ditched off Pagham at 5.50 p.m. (09/09/1940). (Pastscape).

Finds and monuments from the prehistoric to the Norman periods

Many prehistoric, classical, Saxon and Norman finds have been recorded in the relevant databases in the vicinity of Pagham Harbour; those within 2 km of the proposed breach are listed in Table B2 below. Medieval and post-medieval finds, buildings and monuments are numerous (300+ in the wider study area), and have been described in Section D3.3.

Table B2. Prehistoric, classical, Saxon and Norman finds / monuments around Pagham Harbour

Name / Description	Grid Reference	Record Number	Description
Mesolithic Flints	SZ 8839 9714	West Sussex HER: MWS 1602; Monument no: 462250, NMR no: SZ 89 NE 10	Mesolithic flints (10,000 to 4,001 BC) found in a small cliff on NE side of Pagham Lagoon between 1940 and 1960 (HER).
Leaf Shaped Arrowhead and Flint Scatter, West of Church Farm	SZ 8793 9719	West Sussex HER: MWS5748	Worked flints in the form of large flakes, single and multi-faced cores, scrapers and one broken leaf-shaped arrowhead. Weapons, Early Bronze Age - 2350 BC to 1501 BC. (HER)
Bronze Age Cremations, Pagham Church	SZ 8831 9744	West Sussex HER: MWS5745	Three middle Bronze Age cremations (<i>in situ</i>) were found, and copious quantities of prehistoric pottery were scattered over most of the site. (West Sussex HER)
Beaker Pottery	SZ 8839 9714	West Sussex HER: MWS1603	A beaker sherd found on the NE side of Pagham Lagoon in a small cliff. Bronze age ceramic, 2,350 BC to 702 BC) (HER).
Bronze Age palstave - Pagham Harbour	SZ89NE	CDC HER: 791	The upper part of a Bronze Age palstave was found at Pagham harbour (HER).
Bronze Age Founder's hoard - N. of Rookery Lane	SZ89NE	CDC HER: 806	A Bronze Age founder's hoard from Sidlesham. Fields around the site were fieldwalked by D. Dunkin in 2007(?) (HER).
Bronze Age or RB objects - Sidlesham	SZ89NE	CDC HER: 798	Findspot of 'Roman spearheads and implements' found on a shore near the Crab and Lobster' noted by OS (HER).
Iron Age Pottery, Beckett's Barn	SZ 8848 9745	West Sussex HER: MWS4194	Middle/late Iron Age pottery (HER)
Flint finds - Church Norton	SZ89NE	CDC HER: 795	Two scrapers and other worked flints were found in 1911 during excavations on the early Norman ringwork (HER).
Fieldwalk, Church Lane, Pagham (100 BC to 1065 AD)	SZ 8793 9718	West Sussex HER: MWS7026	A concentration of burned and worked flint was found in this area. A few finds of LIA, Roman and Saxon pottery were also made. (HER)
RB pottery - Charity Farm	SZ89NE	CDC HER: 787	Roman pottery was found at Charity Farm, Sidlesham in about 1860 (HER).
Roman coins - Crab and Lobster	SZ89NE	CDC HER: 824	2 Roman coins found in this area - south of the Crab and Lobster (HER).
Roman gold ring - East Beach - Selsey	SZ89SE	CDC HER: 939	Roman gold ring - 3rd or 4th century, found on the beach at Selsey (HER).
Roman coins - East Beach - Selsey	SZ89SE	CDC HER: 940	Bronze coins of Diocletian (284-305) and Constantine (HER).
Roman jug - Church Norton Priory	SZ89SE	CDC HER: 966	A Roman pewter jug, probably 4th century, 'found inverted in clay near priory at Church Norton.' (HER)
Roman finds - St. Wilfred's Chapel - Church Norton	SZ89NE	CDC HER: 990	Roman tiles and bricks in walls of rectory; Roman potsherds found near churchyard and rectory. (HER)

Name / Description	Grid Reference	Record Number	Description
Roman occupation debris - Church Farm, Sidlesham	-	CDC HER: 6277	Roman occupation debris including pottery and tile was recovered during fieldwalking by CDAS in 2008 on fields to the south of Mill Lane, Sidlesham. (HER)
RB material - Church Norton	SZ89NE	CDC HER: 799	A quantity of Roman tiles and pottery, was found in 1911 during excavations on the early Norman ringwork. (HER)
RB pottery - Pagham bird reserve	SZ89SE	CDC HER: 883	Romano-British pottery found in 1930. (HER)
Romano British Pottery, The Lido, Pagham	SZ 890 980	West Sussex HER: MWS1612	Roman sherds were found when digging trenches for a new house near the Lido, Pagham (HER).
Romano British Occupation, Becket's Barn	SZ 8842 9741	West Sussex HER: MWS5705	RB drainage ditch, running N-S (recut three times); another ditch, running E-W. Pottery finds dated to 100 AD to 199 AD. (HER)
Romano British Pottery, West of Church Farm	SZ 8793 9719	West Sussex HER: MWS3611	Romano-British pottery recovered in a field to the west of Church Farm (HER).
Romano British Pottery South East of Pagham Church	SZ 8845 9736	West Sussex HER: MWS1609	The discovery of a Roman pot is indicated on the OS 6 ins. map of 1875 (HER).
Saxon find - Church Norton	SZ89NE	CDC HER: 800	An Anglo-Saxon bronze belt tab was found in 1911 during excavations on the early Norman ringwork. (HER)
Saxon Material, Pagham Church	SZ 8831 9744	West Sussex HER: MWS5743	Saxon pottery from grave fill, and a ditch containing Saxon pottery aligned E- W and parallel with the existing church. (HER).
Saxon Cremation, Pagham Churchyard	SZ 8829 9745	West Sussex HER: MWS1605	Fragments of an ornamented Saxon cinerary urn and fragments of two plain pots were found. (HER).
Saxon Occupation, Becket's Barn	SZ 8842 9741	West Sussex HER: MWS5706	Saxon Features consisted of a cobbled path overlain by a midden cut by three ditches. Pottery from the midden was dated 650-950 and a radiocarbon date of 820 (variation 60) was also obtained. (HER)
Norman ringwork - Church Norton, Selsey	SZ89NE	CDC HER: 794	A Norman ringwork motte, partially levelled on the north side, which formerly supported a freestanding stone tower or keep. (HER).

In a wider study area (5 km), dozens more prehistoric to Norman sites and finds have also been recorded from the beaches and fields extending east and west of Pagham, most notably at Selsey. In addition, during excavations for the nearby Medmerry managed realignment scheme, some 3.5 km to the west of Pagham, several valuable discoveries were made; these have been described as follows:

- ✧ Neolithic (c. 4,000 – 2,500 BC): Several small assemblages of Early Neolithic pottery were recovered from archaeological features. These finds doubled the number of known features of this date from non-monumental sites on the Coastal Plain (Peninsula Partnership, 2016).
- ✧ Bronze Age (2,500-750 BC): Numerous features from this period were uncovered at Medmerry along the north-east edges of the site, including: three large and two small circular houses/structures, enclosures and field systems, water management features, 'burnt' mounds, a cremation cemetery. It would appear that a large area of Bronze Age landscape was preserved at Medmerry under alluvial and storm beach deposits and the site also preserved wooden structures, such as a section of wattle work recorded at the base of a Bronze Age well, which has been C14 dated to around 1,100 BC. Other features were dated by finds of Bronze Age pottery, some of which was decorated (Peninsula Partnership, 2016). These finds suggest a level of population and structure within the Bronze Age landscape not previously observed in Sussex (Archaeology South-East, 2014).
- ✧ Iron Age (750 BC TO AD 43) and Roman (43 - 410 AD): Iron Age and early Roman remains were notable by their absence, with only one ditch containing a single sherd of Iron Age pottery. This may suggest that the lower lying areas of the site were regularly flooded during

this period making them unsuitable for settlement and other uses which would leave an archaeological signature. The area could still have been used as pasture and settlement in these periods, most likely lying to the north on higher ground. A large amount of mid Roman high status pottery, a cremation with ancillary vessels and a large mill stone recovered during the excavation of the V-ditch, suggest that there may have been a high status settlement near to the site during the later Roman period (Peninsula Partnership, 2016).

- ✧ Medieval (AD 1066-1485): Several features including substantial ditches and wells suggest a differing pattern of settlement during the medieval period around Easton and Ham farms. One of the wells was chalk lined and a timber ring template in very good condition was recovered from the base. The quality of construction suggests that the well was for domestic use but historic maps dating back to the mid-18th century do not show settlement in this area (Peninsula Partnership, 2016). A c. 200 m long medieval timber structure constructed of wattle 'sails' was also uncovered, preserved in silts at the base of a wide channel. The structure was provisionally interpreted as a fish weir; the first discovered in Sussex (Archaeology South-East, 2014).

Post breach, coastal erosion at the Medmerry frontage has exposed further finds:

- ✧ 'Burnt flint mounds', which are likely to be of Bronze Age date;
- ✧ Wattle fencing, related to static fish traps or channel revetments, and two fish baskets, likely to be medieval (one basket was subsequently dated by radiocarbon to 1449-1635 AD); and
- ✧ An early Iron Age skeleton of a middle aged man (dated by radiocarbon to 760-410 BC).

B.3.3 Archaeological Narrative

Palaeolithic Activity (500,000 – 10,000 BC)

This period is the first development in human technology and sees the introduction of stone tools by early hominids like *Homo Heidlebergensis*, (500,000 BC) found at Boxgrove in Sussex. The early hominids in this period were predominantly scavengers/hunters and gatherers with an advanced knowledge of plants and herbs. The technology of this time starts with crude flakes and develops into the production of hand axes (Environment Agency, 2010).

Several Palaeolithic finds have been recorded in the wider study area, including flakes, flints and hand axes (within 5 km of the site, mostly on Selsey Beach). Finds at Selsey include a range of finds from those found rolled on the modern foreshore to apparently *in situ* material from Pleistocene deposits overlying the Coastal Plain (West and Sparks, 1960). Of note are the Middle Palaeolithic flakes from a Pleistocene channel exposed on the Selsey foreshore (Woodcock, 1981). None of these were found within the immediate study area, i.e. within 2 km of the proposed breach site.

Mesolithic (10,000 – 4,000 BC)

The Mesolithic is characterised by the end of the Ice Age and an ensuing change in climate. The Mesolithic denotes the period that is at the end of the Ice Age and pre-dates the introduction of agriculture. During the earlier Mesolithic period the settlement pattern was of a traditional nomadic way of life, with the seasonal exploitation of resources taking place over a large area from a sequence of temporary residence locations occupied on more than one occasion. In the later Mesolithic period a new pattern of settlement and resource exploitation appeared with short-stay temporary hunting camps, and inland task-specific, seasonally occupied sites suggesting that a sedentary pattern of settlement could not be ruled out. It is also likely that there was extensive exploitation of coastal resources, however the effect of coastal erosion and sea-level change means that this information has been largely lost. On the Coastal Plain of West Sussex, the evidence suggests that there were

numerous short-stay hunting camps and longer-stay base camps, frequently located alongside or near watercourses (Manley, 2008).

Mesolithic flints were found in a small cliff on the north-eastern side of Pagham Lagoon between 1940 and 1960, as listed in Table B2 NMR no: SZ 89 NE 10). Within 5 km of the proposed breach, four other finds have been recorded at Selsey (and axe, an axe head, a flint tool and 'implements, mostly found on the beach).

Neolithic Activity (4,000-2,200 BC)

The Neolithic period is represented by the appearance of pottery and the beginnings of agriculture. It is in this period that the domestication of cereal and livestock begins, along with a focus on community and the very beginnings of settlements. The dead were buried in communal tombs known as long barrows or chambered cairns. Stonehenge was begun in around 3,000 BC and Avebury stone circle in 2,700 BC (Environment Agency, 2010). Within West Sussex, all monuments survive on the Downs and none on the Coastal Plain. It has been argued, that this might reflect a true distribution rather than an artefact of preservation (Manley, 2008).

In addition to the pottery finds at Medmerry, many implements, flints and axes, as well as some pottery have been recorded in the relevant HERs within 5 km of the proposed breach (over 20 records in total); these were again mostly found on the beach of Selsey, though also in gravel pits and in private gardens in Selsey. None of these were found within 2 km of the proposed breach site.

Bronze Age (2,200-700 BC)

The Bronze Age is represented by the first use of bronze to produce a range of items including decorative jewellery and axes. Large organised field systems appear during the middle Bronze Age and nucleated and seasonal settlements in the mid to late parts of this period. There is a notable movement away from the communal burial structures in the earlier periods to the appearance of individual burials in barrows. Studies of the late Neolithic and Bronze Age in Sussex have identified that the 90% of recorded barrow sites (the most common form of funerary monument) are located on the chalk downs (Garwood, 2003). Woodcock speculates that, during the later prehistoric and Roman periods, the Selsey Peninsula 'extended considerably seaward of the present coast; [possibly ...] as far south as the Mixon Reef, some 2 kilometres off shore' (Woodcock 2003, p.4) (supported by the account provided in Section D3.1).

In addition to the Bronze Age settlement and related finds discovered at Medmerry, other signs of habitation had previously been recorded at two locations in Selsey (Manley, 2008). Middle Bronze Age pottery and cremation urns were additionally found at the Pagham Church (MWS5745); early Bronze Age flints were also discovered nearby (MWS5748). Furthermore, more than 20 Bronze Age assets finds been identified in the wider 5 km study area, five of which were in close proximity of the modern day shore of Pagham Harbour, although one of these might be Roman (see Table B2, HER no. 798). One of these includes 'a Bronze Age founder's hoard' discovered in 2007 in a field near Sidlesham (some 2.8 km from the proposed breach). Other finds at include pottery, flints, palstaves / axes and bracelets.

Iron Age (800 BC – AD 43)

In the Iron Age society changes again with the development of organised settlements that are focussed on hillforts for their central administration. There is a change in pottery technology, the development of iron to produce better tools and the introduction of coinage. Connections with Europe are of greater significance as larger trade links are established. Cross channel trade between

the Roman Empire and the Sussex coast developed in the 100 years before the Roman conquest (Environment Agency, 2010). Manley (2008) notes that 'there is a large and growing body of evidence of Late Bronze Age occupation and high-status metalwork known from the Selsey peninsula', and that 'this together with evidence of land division and cremation suggests an important farming and settlement focus within the region' (p.38).

Pottery discovered at Beckett's Barn in Pagham (near the church) is the only find definitely been associated with the Iron Age period within 2 km of the proposed breach (MWS4194). At Church Norton, two scrapers and other worked flints were found in 1911 during excavations on the early Norman ringwork, at the in the same location and at the same time as Roman tiles and pottery (see HER records 795 and 798 in Table B2 above). In the wider study area, excavations during the Medmerry realignment did not yield any significant Iron Age finds, however, numerous iron age related finds have been recorded both at the beaches around Selsey, and within the settlement itself. These include human remains (cremated bones) in Selsey, and the above mentioned skeleton found at Medmerry beach in 2014. Other assets include three hoards (one of which possible), six individual coin finds of coins, mostly found on the beaches, as well as pottery and occupational debris.

Manley (2008, p.33) comments that: *'the collection of findspots and features at the tip of Selsey Bill is still problematic to interpret. Older theories saw the concentration as marking the location of an entrepot, associated with the supposed oppidum, the entrepot perhaps being almost surrounded by water, but whether there is anything to be gained by a further evaluation of the finds is doubtful (Bedwin 1983). Bedwin concluded that the only objects of definite Late Iron Age date were the gold coins, and these could have come from a single hoard. The apparent wealth of Late Iron Age material is therefore considerably less impressive than at first sight.'*

Roman/Romano-British (AD 43 – 410)

The Roman invasion of AD 43 marks the start of the Roman period or the Romano-British period. The Romans landed at Richborough in Kent and went onto establish a capital at Colchester. As London expanded it replaced Colchester as the capital in the 2nd century AD. Hillforts were replaced with new villas and towns were established. By the end of the third century Britain was descending into civil disorder and by the fourth century it was under increasing attack from the Saxons and Irish. The Roman army eventually withdrew from England in the mid fifth century (Environment Agency, 2010).

In West Sussex, the Fishbourne Roman Palace is an important site, which was thought to have been in the 1st century AD. The city of Chichester stands on the foundations of the Romano-British city of *Noviomagus Reginorum*, in its later stages a walled Roman town. Away from the main centres of settlement and ritual activity, many finds attest the presence of a dense rural settlement pattern. There are clusters of finds around the tip of the Selsey peninsula, and suggestions of linear distributions along apparent roads or trackways (e.g. south from Chichester towards Sidlesham) (Manley, 2008). During Roman times Pagham Harbour was likely a primary seaport for Southern England (Pagham Parish Council, 2011).

Within the immediate study area, several finds at Church Norton, Sidlesham and Church Farm indicate settlements in the area during the Romano British era (see Table B2). In the wider study area, at Medmerry, a large amount of mid Roman high status pottery, a cremation and a large mill stone were also recovered during excavations. Furthermore, numerous finds, some burials and several occupation sites have been recorded at Selsey. As outlined in Section D3.1, during this period, Pagham Harbour is thought to have been located at the upper reaches of an estuary, and land claim around the harbour may have first been practiced in this period.

Saxon, Norman and Medieval (AD 450 – 1540)

The Germanic tribes of Saxons, Angles, Jutes and Frisians all invaded Britain at the end of the Roman period of rule. The Saxons are believed to have landed in Sussex in 477 and established the Kingdom of Sussex; the extent of the Kingdom correlates to the former County of Sussex before it was divided into east and west. The Normans introduced the first kingdom wide census since the Romans, known as Domesday in 1086. Black Death in the 14th century decimated large numbers of the population and led to villages being deserted. It was not until the end of the medieval period that population numbers began to increase (Environment Agency, 2010).

Several finds of a Saxon nature have been recorded in Selsey, and at Pagham, Saxon features indicative of occupation were located at Becket's Barn (HER no. MWS 5706), with two other Saxon findspots in close proximity (see MWS 1605 and 5743, Table B2). Selsey Abbey is thought to have been located where the old parish church at Church Norton (on the western shore of Pagham Harbour) now stands. The abbey was founded by St Wilfrid in AD 681 and became the seat of the Sussex bishopric, until it was moved, after a synod in 1075, to Chichester.

The only Norman record in the wider study area is the Norman ringwork at Church Norton, which is a 'Norman ringwork motte, partially levelled on the north side, which formerly supported a freestanding stone tower or keep' (see Table B2, HER record 794).

There is documented evidence for medieval activity in the wider study area. In a Saxon Charter Caedwalla, King (of the west Saxons) granted fifty five hides (tributarii) in and around Selsey and 32 hides elsewhere in West Sussex to Bishop Wilfred in AD 673 (Kelly 1998). The Domesday survey records the parishes of Selsey and Sidlesham and a church at Pagham. The latter, as well as probably at least one earlier church were on the site of the present parish church of St. Thomas a'Becket, which was built about 1206. Pagham Parish contains a number of buildings dating back to this period. Opposite the Church is the Old Cottage, built at the same time as the current Church in 1206. Becket's Barn in the Church Farm Holiday Centre is the restored tithe barn of a large rectory first mentioned in 1299. In parts 1200 years old, Barton Manor is reputedly the oldest continuously occupied manor house in England. The Lion Inn dates from the 15th century and the Inglenook Hotel from the 16th century. It is reported that until the 14th century, Pagham continued as one of the foremost English ports, trading wool to Europe. However, following a large storm and gradual siltation, so Pagham's wealth gradually diminished after the 14th century (Pagham Parish Council, 2011). As mentioned in Section D3.1 above, this period also saw significant land claim around Pagham Harbour.

Post medieval (1540 – 1901)

The post-medieval period covers the period from the dissolution of the monasteries by Henry VIII to the beginning of the 20th century. Key points that had a significant impact on the English landscape in this period include the enclosure of open fields and common land mainly between 1700 and 1850, the introduction of industry from the end of the 18th century, the growth of towns and railways from 1840 onwards, and the Agricultural Depression between 1870 and 1914 (Environment Agency, 2010).

A great number of post-medieval sites, buildings and finds have been recorded in the wider study area; including at Sidlesham, Church Farm (Pagham) and around Church Norton (see Image B5). For example, the CDC HER lists some 250 such records within the wider study area (i.e. 5 km of the site). During this period, significant land claim took place around the harbour; as outlined in Section D3.1 above. By 1825, the Ferry causeway between the mainland and Selsey had been constructed, and in 1876, all of the harbour was claimed. However, in 1910, the shingle ridge was breached by a large storm, and the harbour thus re-established.

Modern 1901 – Present

Key events in the 20th century comprise the First and Second World Wars and post-war development of the rapidly expanding urban landscape. During the Second World War, strategic lines of defence, known as Stop Lines, were constructed in 1940-41. These defensive lines were constructed primarily for anti-tank operations and consisted of pillboxes, anti-tank blocks, trenches, weapons pits, barbed wire and minefields (Wills, 1985).

The defences around the harbour formed part of the Sussex coast defences; which ran from north of Pagham harbour to West Wittering. For a brief period in 1944/45 the harbour was used as an aerial gunnery practice range for Spitfire and Hurricane fighter planes (Sidlesham Parish Council, 2007). Remnants of Mulberry Harbours can be found in the subtidal fronting Pagham harbour. These were temporary portable harbours developed by the British during World War II to facilitate the rapid offloading of cargo. One Mulberry Harbour caisson (originally stored offshore prior to D-Day) can still be seen from Pagham Beach at low tide; this is located some 1.9 km from the proposed breach point. With regard to further defence records, the 'Defence of Britain' project's database (2002/06), which holds records of the 20th century militarised landscape of the United Kingdom, shows five such assets around the harbour itself, including two pill boxes, an anti-tank wall, an airfield and a 'flame fougasse' (see Image B6).

As outlined in Table B1, a German Junkers Ju88 was shot down near Pagham in 1940. During excavations at the Medmerry realignment, at least one plane crash site related to World War Two was also located (Archaeology South-East, 2014).



Image B6. Defence of Britain records within 5 km of the proposed breach

This period also saw the main settlements around the harbour expanding considerably, including the Church Farm holiday village at Pagham, adjoining Pagham Harbour. Dating from before the First World War, the Beach Estate in Pagham, whose houses are closest to Pagham Harbour (and along the beach), originally consisted of holiday homes largely created from redundant railway carriages. These gradually became permanent homes and were extended by various additions. During the immediate post-war years the village of Pagham began a period of rapid expansion, this has continued to the present day (Pagham Parish Council, 2011).

B.4 Impact Assessment

As outlined in the introduction of this DBA, the following proposed actions/pathways in relation to the proposed development have the potential to impact archaeological resources.

- ✧ Breaching at the spit;
- ✧ Infilling of the channel adjacent to the breach (including potential temporary sheet-piling); Indirect changes due to tidal characteristics both during construction and operation; and
- ✧ Creation of the new tern island in the west of the harbour, which is to include covering a concrete feature with clay and gravel, and cutting a channel.

These four impact pathways were highlighted by Historic England as those which should be assessed with regard to their impact on the archaeological resource at, and around, the harbour. In summary, no known sites or finds have been located within the impact zones themselves. However, the theoretical potential exists for as yet unknown undesignated heritage assets to be encountered/exposed during excavation works and due to scouring, and secondary context finds could be located in the shingle ridge.

The impact assessment methodology is now briefly summarised in Section D.4.1 before the impact assessment itself is undertaken in Section D.4.2.

B.4.1 Methodology

The impact pathways will now be assessed using the impact assessment methodology set out in Section 5.6 of the ES. For a full description of the methodology, please refer to the ES (ABPmer, 2015). In summary, the key significance levels for either beneficial or adverse impacts are described as follows:

- ✧ **Insignificant:** Neutral change not having a discernible effect;
- ✧ **Minor:** Effects that are discernible but tolerable;
- ✧ **Moderate:** Effects that are of a local to regional nature, of medium to long term duration and/or where effects are anticipated to potentially be above accepted guidelines/standards. Where these changes are adverse they may require mitigation; or
- ✧ **Major:** Acute effect on a national or international scale, of long term or permanent duration, and clearly above accepted guidelines or standards. Where these changes are adverse they will require mitigation.

The following three iterative tables are used to arrive at the final decision of impact significance. Again, Section 5.6 of the ES provides a full description and examples of how these are applied.

Table B3. Exposure to change, combining magnitude and probability of occurrence

Probability of Occurrence	Magnitude of Change			
	Large	Medium	Small	Negligible
High	High	Medium	Low	Negligible
Medium	Medium	Medium/Low	Low /Negligible	Negligible
Low	Low	Low /Negligible	Negligible	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

Table B4. Estimation of vulnerability based on sensitivity and exposure to change

Sensitivity of Receptor	Exposure to Change			
	High	Medium	Low	Negligible
High	High	High	Moderate	None
Moderate	High	Moderate	Low	None
Low	Moderate	Low	Low	None
None	None	None	None	None

Table B5. Estimation of significance based on vulnerability and importance

Importance of Receptor	Vulnerability of Receptor to Impact			
	High	Moderate	Low	None
High	Major	Moderate	Minor	Insignificant
Moderate	Moderate	Moderate/Minor	Minor/Insignificant	Insignificant
Low	Minor	Minor/Insignificant	Insignificant	Insignificant
None	Insignificant	Insignificant	Insignificant	Insignificant

B.4.2 Assessment

B.4.2.1 Managed breaching of the spit

Context

As outlined in Section 3.1 of the ES, it is proposed to breach the spit in the location indicated in Figure D1 above, and precisely detailed in Figure 2 of this Further Information Report. This 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 54,545 m³ (see Section 1.5.1 of the Further Information Report) of which the majority will be used for the channel infill while around 2,000 m³ will be used at the compensation site.

Based on the baseline presented above, particularly the historical geomorphological summary, it is clear that, whilst there is significant potential for archaeological materials to be encountered around the harbour, such potential should be viewed as very low in the location of the breach itself where the

works will be undertaken. This is because the breach is proposed in a location where the harbour inlet would have been located many times over the past centuries, and certainly where it was found several times since the inlet position was fixed in the 1960s (see Image B7, which was Image 6.12 in the ES).

The low value of the site will apply not just for the areas that will be deliberately excavated but also the areas that will be influenced by natural channel scouring to, and beyond, the depth of excavation. For example, the natural channel which led to the inlet as per its location in 2013, went to a depth of up to -2.1 m ODN. Thus, it is anticipated that the breach will be cut entirely into sediment deposited over the past 50 to 60 years, and that no *in situ* resource or undiscovered wrecks will be encountered. The discovery of reworked finds such as flints and pottery in the beach deposits can however not be discounted.

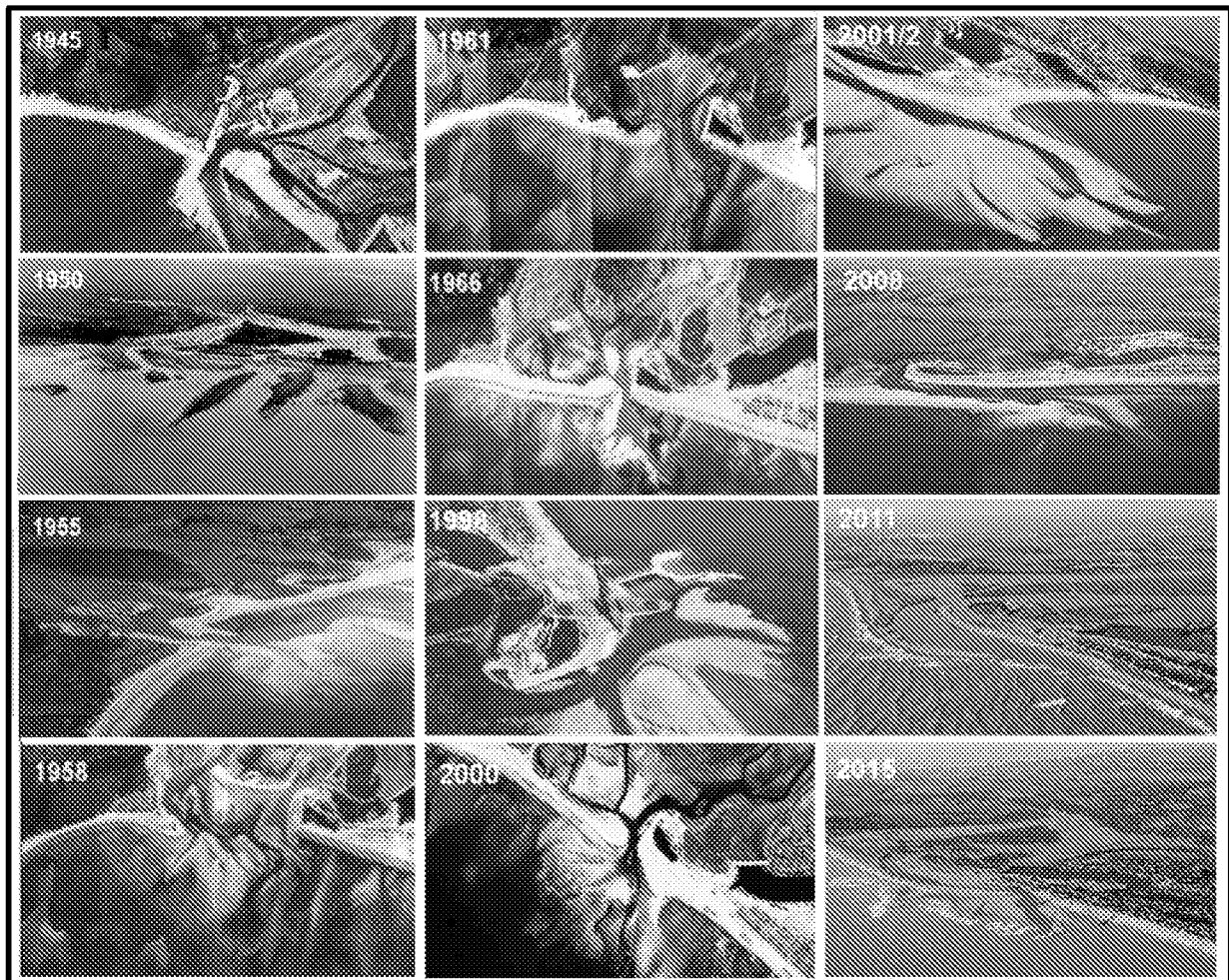


Image B7. Changing configurations of the spit, inlet and delta complex

Impact assessment

This pathway considers the potential for archaeological resources to be impacted by the excavation of the breach. For reasons outlined above, the probability of encountering all but reworked archaeological finds is considered to be negligible, leading to an exposure assessment of 'low'. Whilst the sensitivity and importance of *in situ* and wreck receptors would potentially be high, the impact is assessed as **not significant** due to the 'negligible' probability of occurrence.

This assessment is supported by Historic England's opinion that 'breaching of the spit is unlikely to affect archaeological deposits'. Should reworked archaeological finds be encountered during the shifting of shingle, the relevant council officer should be informed.

B.4.2.2 Infilling the channel

Context

As outlined in Section 3.2.1 of the ES, and Section 1.5 of this Further Information Report, in order to ensure that the existing inlet is blocked, the channel immediately adjacent to the new proposed inlet is to be infilled. In order to create this, and also provide access to the breach location for construction vehicles, a temporary access 'causeway' may well need to be created. This aspect is under review as it appears from the recent natural breach witness on site (see Section 1.3.3 of the Further Information Report), that it may well be possible to undertake the construction work without the need for sheet-steel piling.

Whilst a final construction methodology is currently being developed, the need for some temporary sheet piling cannot be discounted at present. It is currently envisaged that this could involve driving sheet piles using a vibratory hammer across the channel at the north eastern extent of the proposed infilled channel or 'dam' to a top level of 0 mODN. The depth of the sheet-piles is likely to be around -3 mODN, and their width just over 100 m. Ultimately, towards the end of the construction period, the sheet-piles would be removed and the infill created on top of the causeway, to a level of around 4.5 mODN. Profiles for this infill can be seen in Figure 4 of this Further Information Report (see Profiles B and C).

Profile B of Plan 4 is drawn in the approximate location of the temporary sheet piling, should it be employed. It can be seen that at this location, the channel depth is approximately -1.8 mODN, and the width just over 100 m. The sheet piling could conceivably affect previously undisturbed deposits, though this is considered highly unlikely given that no archaeology has obviously been exposed along the edges of the channel, and given that this location is where channels would have meandered many times over the past decades and centuries. For example, a wider, slightly more landward channel is indicated in a 1961 aerial image (see Image B7). However, encountering riverside maritime finds including moorings, fish traps or wrecks which might have been buried at depth in these previous channels cannot be discounted, also given the number of recorded wreck losses listed for the vicinity of the breach location in Table B1.

Impact assessment

This pathway considers the potential for unrecorded riverside or maritime finds, which could conceivably be buried at depth, to be impacted by the temporary sheet-piling. It is not considered that the creation of the infill *per se* could damage archaeological resources. Given that no indications have been found of related finds along the eroded channel, and given that large proportions of the affected deposits are exposed, a low probability is assessed.

Combined with a small magnitude due to the temporary, and vertical, nature of the sheet-piling, a negligible exposure to change is assessed. Whilst the sensitivity of a wreck feature to sheet-piling would be assessed as moderate, the vulnerability is considered to be low. The importance of a wreck, should it be one of those listed in Table B1, could potentially be high, and the impact may thus be '**minor adverse**'.

A limited low tide investigation of the exposed sections of the channel where the sheet-piles are to be located (if they are to be used), prior to works commencing, might be prudent in order to look for signs / finds related to possible wrecks.

B.4.2.3 Indirect changes due to tide (including scour)

Context

As outlined in Sections 6.3 and 8.2 of the ES, tidal behaviour in the harbour, and flows into and out of the harbour, might change during both construction and operation. During the construction phase, due to the construction of the temporary causeway (if used) to approximately 0 mODN, less water will essentially enter the harbour and through the inlet channel (see Section 8.2.5 of the ES). As outlined in Section 6.3.2 of the ES, post construction, within the harbour, flows are unlikely to change significantly, and there are predicted to be slight reductions on both the flood and ebb tide, with these changes decreasing away from the harbour entrance.

As outlined in Section 6.3.2.4 of the ES, post breach, there is the potential for some scour to occur at the breach and into the fronting intertidal, as the breach adjusts to a new equilibrium. 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. The site will of course continue to change into the future as it has continually in the past. It will just do so from a new, and less damaging, morphology.

Impact assessment

This pathway assesses potential indirect impacts from construction and operation in relation to water level and flow changes associated with the proposed development.

It is not thought that a temporary reduction in water levels or flow energies would impact any hitherto undiscovered archaeological sites within the harbour, and construction impacts are thus assessed as **not significant**.

It is considered unlikely that slight reductions in flow speeds within the harbour post breach will affect previously undisturbed archaeological deposits/resources. Thus, the impact is assessed as **not significant**.

With regard to scour at, and around the breach, no significant increase in scour is predicted in the longer term. Given the short duration of the scour which is predicted, the exposure to change is assessed as negligible to low. The sensitivity of the deposits around the breach is considered to be low given the likely recently deposited nature thereof. Thus, a vulnerability of none to low is assessed. It is considered unlikely that any deposits which might be affected by scour are of more than low archaeological value; thus the impact from short term scouring is assessed as **not significant**.

B.4.2.4 Creation of New Tern Island in harbour

Context

In order to provide compensation for the potential reduction in Little Tern breeding habitat, the creation of an additional breeding island in the harbour is proposed. The design for this island is described in additional detail in this Further Information Report, see Section 1.5.6. This is to involve covering the remnants of the westerly 1937 training wall shown in Image B4 with gravel (approximately 1 m on average, and up to 1.5 m), and cutting a 20 m-wide channel between this

island and the Church Norton Spit to a depth of -0.5 mODN. This would involve excavations of around 3.5 m in depth, as can be seen in the profiles provided in Figure 5 of this further information document. The top layer measuring some 1.7 m in thickness would consist of shingle thought to have largely been deposited around the time of the training wall construction, and below this would be estuarine mud.

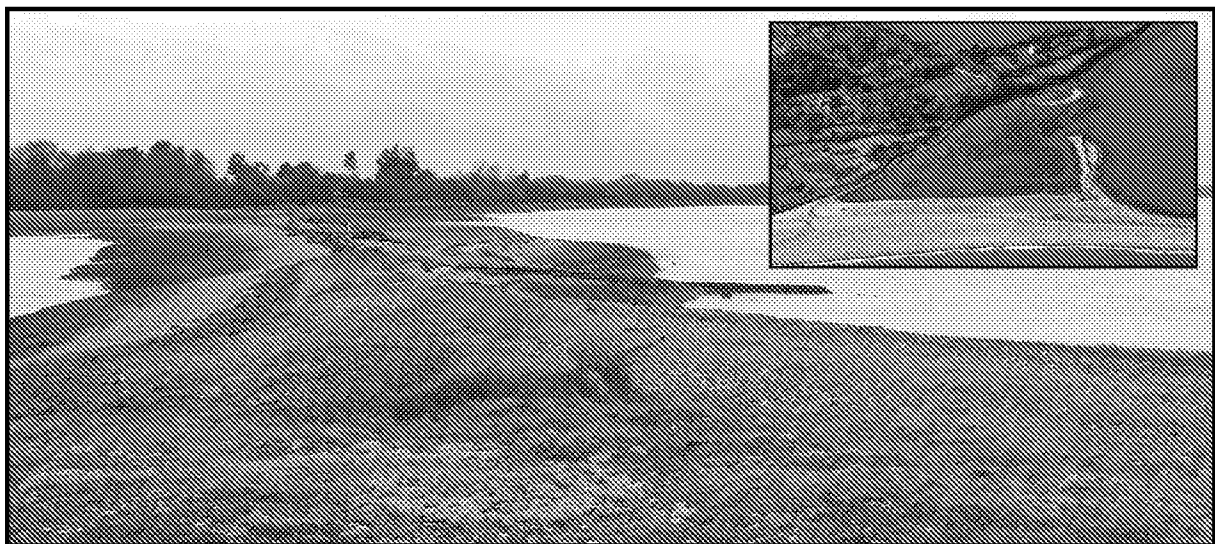
This location would have formed part of the harbour for many centuries, and would have been sheep pasture for the 37 years the harbour was claimed from the sea between 1876 and 1910. It appears that the proposed cut channel will be in the location of that of a field drain from the claimed period (called the 'Beach Channel'), as indicated by old OS mapping, and also Image B4 (where remnants of this drain can still be observed in the 1945 aerial imagery). Thus, encountering any pre-land claim and post training wall construction archaeology (i.e. post 1937) is considered unlikely.

Impact assessment

This pathway assesses impacts resulting from covering a concrete structure (see Image B8), with shingle and cutting a channel to isolate the new island.

The old westerly training wall which was constructed of concrete in 1937 is to be covered in shingle, but not otherwise affected. The wall itself is considered to be of low archaeological value. Covering it is not thought to impact the feature itself, and the impact is thus assessed as **not significant**.

The cutting of the channel at the end of the proposed new island to a depth of -0.5 mODN would affect estuarine mud and shingle mostly accreted and deposited between 1910 and 1937, as described above. Thus excavating the channel would not be expected to yield any significant archaeology or the concrete structures. The exposure to change is thus considered negligible, and the impact assessed as **not significant**.



Source: ABPmer 20 February 2016; inset/aerial John Akerman 7 February 2007

Image B8. View from the south east (seaward) end of the proposed New Tern Island

B.5 References

References for this DBA appendix have been included in the main reference section for this Further Information Report.



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