



Pagham Beach Coastal Defence Project

Environmental Report

Arun District Council

August 2013
Final Report
9Y1252



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Appendix A Water Framework Directive Compliance Assessment

LIST OF ABBREVIATIONS

Abbreviation	Definition
AA	Appropriate Assessment
AONB	Area of Outstanding Natural Beauty
cBWD	Current Bathing Water Directive
CD	Chart Datum
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CHOPi	Chichester Harbour Oyster Partnership Initiative
CPA	Coast Protection Act
CROW	Countryside and Rights Of Way Act
Defra	Department for Environment, Food and Rural Affairs
DTM	Digital Terrain Model
EC	European Community
EIA	Environmental Impact Assessment
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
ER	Environmental Report
ES	Environmental Statement
EU	European Union
FEPA	Food and Environment Protection Act
GB	Great Britain
GCR	Geological Conservation Review
GEP	Good Ecological Potential
GES	Good Ecological Status
HMWB	Heavily Modified Water Bodies
HRA	Habitats Regulations Assessment
H _s	Significant Wave Height
IBA	Important Bird Area
ICES	International Council for the Exploration of the Seas
IFCA	Inshore Fisheries and Conservation Authority
IPCC	Intergovernmental Panel on Climate Change
ISQGs	Interim Sediment Quality Guidelines
IUCN	International Union for the Conservation of Nature
JNCC	Joint Nature Conservation Committee
LNR	Local Nature Reserve
MCAA	Marine and Coastal Access Act
MCZ	Marine Conservation Zone
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MPA	Marine Protected Area
MPS	Marine Policy Statement
MSC	Marine Stewardship Council
MSFD	Marine Strategy Framework Directive
NCR	National Conservation Review
nm	Nautical Mile
NNR	National Nature Reserve
PAH	Polycyclic Aromatic Hydrocarbon

Abbreviation	Definition
PEL	Probable Effect Level
pMCZ	Proposed Marine Conservation Zone
PNEC	Probable No Effect Concentration
PPG	Pollution Prevention Guidelines
Ppm	Parts Per Million
rBWD	Revised Bathing Water Directive
RLSS	Royal Life Saving Society
rMCZ	Recommended Marine Conservation Zone
rRA	Recommended Reference Area
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SMA	Sensitive Marine Area
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TEL	Threshold Effects Level
TRaC	Transitional and Coastal
UWWT	Urban Waste Water Treatment
WeBS	Wetland Bird Survey
WFD	Water Framework Directive

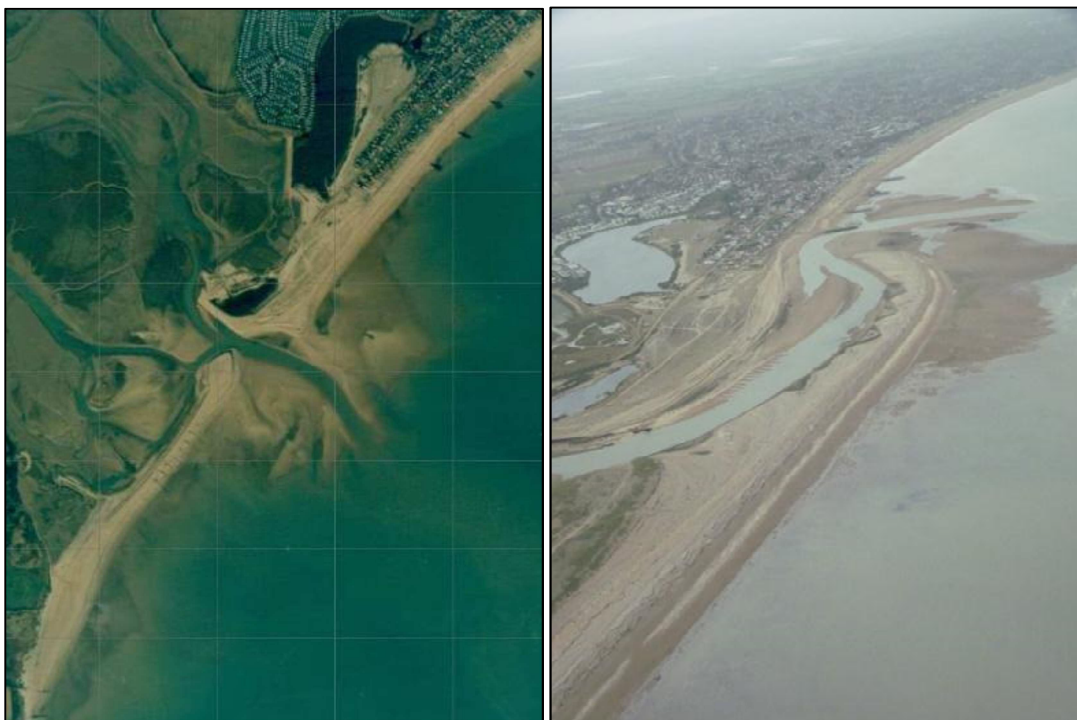
1 INTRODUCTION

1.1 Introduction to the Proposed Scheme

Pagham is located in West Sussex on the south coast of England, approximately four miles west of Bognor Regis and six miles south of Chichester (see **Figure 1.1**). It is situated to the north of the small tidal inlet to Pagham Harbour, the mouth of which lies between the two shingle spits of Church Norton to the south and Pagham to the north.

The frontage at Pagham is dominated by a steep shingle beach and a mixed gravel/sand foreshore. The village of Pagham lies adjacent to the eastern side of the Harbour with a number of residential developments located on the northern spit (Pagham Beach). Over time, the Church Norton Spit has migrated towards Pagham at a rapid rate which has altered the tidal flows around the Harbour entrance (see **Plate 1.1**).

Plate 1.1: Pagham Harbour and the view of Church Norton Spit in 1997 (left) and 2012 (right)



During the winter period of 2012/2013 three separate storm incidences on spring tides, with the same wave direction and wave period, severely eroded the Pagham coastline between the end of the Church Norton Spit and the first of four groynes located north of the Harbour entrance. Before the 2012/2013 winter storms there was approximately 25m of beach front separating the properties from the sea. Each successive storm reduced this width of the beach front, leaving only 16m protecting the properties. Between each storm Arun District Council recycled beach material in the area to try to increase the width of the defence – the recycled material was then removed by the onset of the next storm. The current situation (with approximately 20m of beach front) means that a number of properties on Pagham Beach are at risk of erosion and subsequent flooding (see **Plate 1.2**).

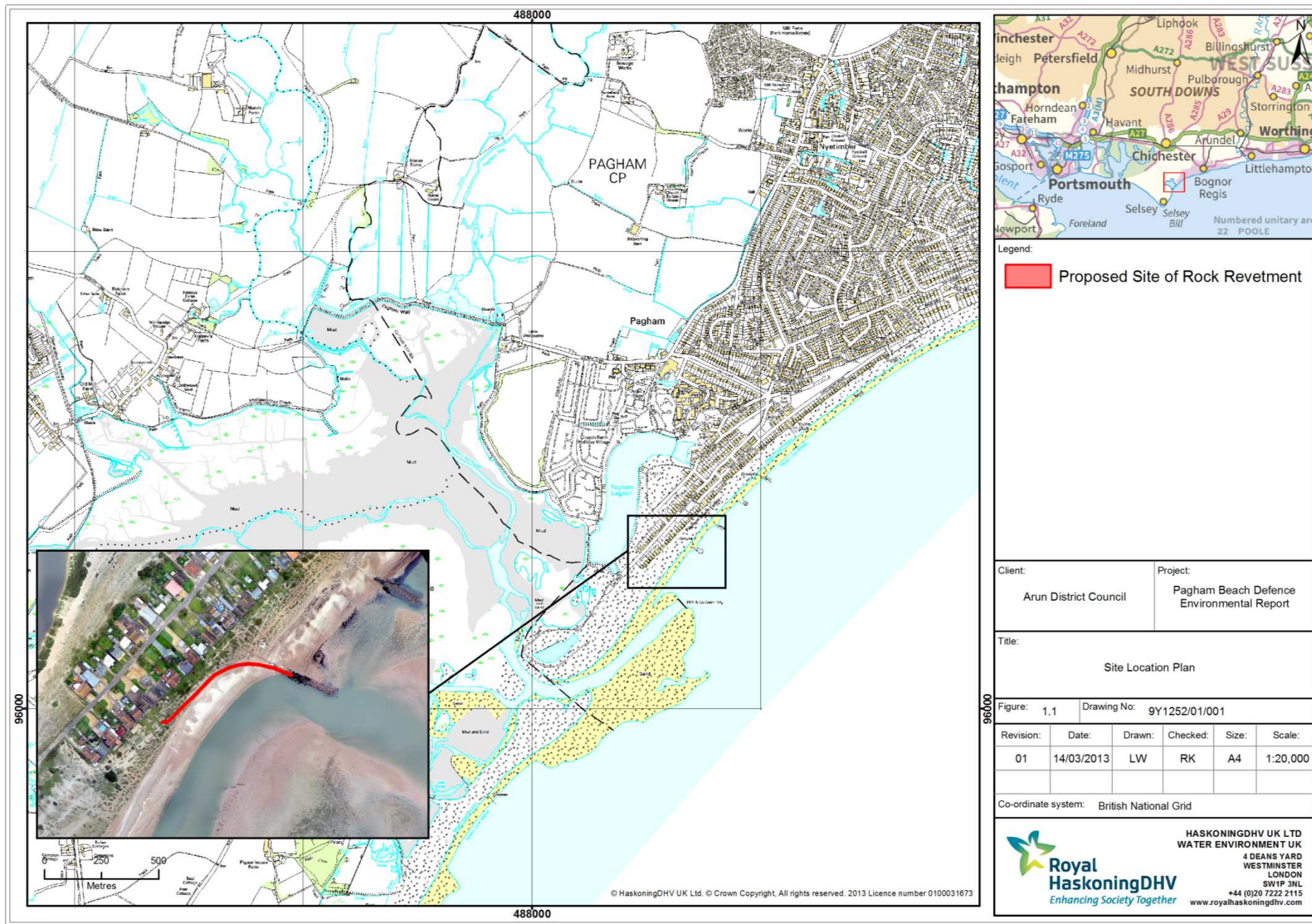


Plate 1.2: Pagham Beach frontage in 2013 following the winter storms in 2012/2013



The storm events that occurred through the winter of 2012/2013 are highly likely to be repeated in the winter of 2013/2014 and the ability of Arun District Council's beach recycling efforts to cope with the storm erosion cannot be guaranteed. Arun District Council, therefore, needs to find a more sustainable and longer term solution to the problem in order to ensure that the properties in the area are not lost to the sea or flooded.

1.2 Need for the Coastal Defence

The proposed Pagham Beach coastal defence scheme – a rock revetment – is needed in order to ensure that the properties behind Pagham Beach are protected from future localised scour and coastal erosion caused by storm waves focussing on the beach, due to the migration of the Church Norton Spit. The spit itself has been rapidly extending for the last 10 years or so, but the current coastal erosion problem has only occurred in the last few years, culminating in the response of the beach to the storm events last winter.

The works are proposed to take place on the shoreline at Pagham which consists of a shingle beach with no seawalls or revetments. There is an ageing steel sheet pile training wall along the north side of the Harbour entrance (which is some 900m to the west of the revetment site). South-west of the Harbour entrance there are timber groynes near Church Norton and also further towards East Beach at Selsey; the latter were refurbished in 2008.

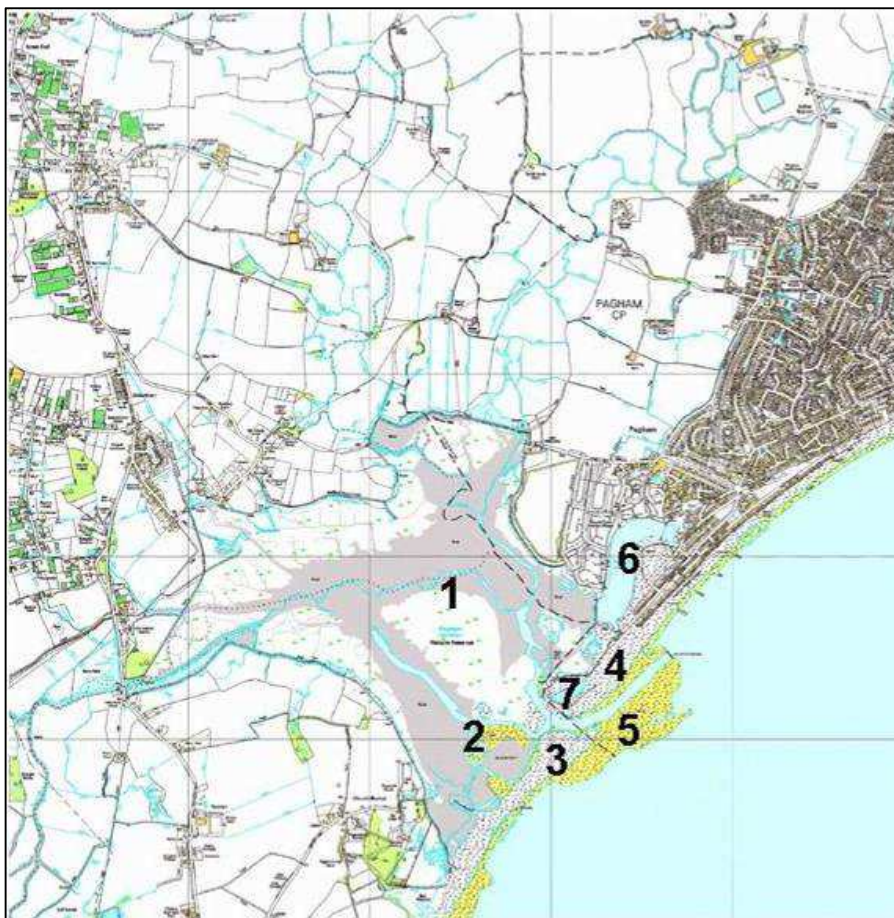
North-east of the Harbour entrance, four rock groynes that were constructed in the 1960s, re-profiled in 1985/1986 and extended in 1991/1992 by Arun District Council were designed to manage the coastal processes at the time, but are not currently of an appropriate design to manage the evolving coastal processes.

At present approximately 20m of beach frontage stands between the beach crest and the gardens of approximately 15 affected residential properties on Pagham Beach (those adjacent to the most westerly rock groyne closest to Pagham Harbour). The proposed works are required to protect these properties and the residents as the current strategy of recycling beach material is not considered to be a sustainable and sufficiently robust solution.

1.3 Pagham Harbour

Pagham Harbour is a complex and diverse area of natural habitats and features. Whilst the proposed rock revetment is not located directly within the Harbour, it is necessary to consider the potential impacts of the scheme on the Harbour. The main features of geomorphological and ecological interest in the Harbour which are discussed within this Environmental Report (ER) are presented in **Figure 1.2**.

Figure 1.2: Location of features within the local study area



Key

1 - Pagham Harbour; 2 - Little Tern Island; 3 - Church Norton Spit; 4 - Pagham Beach/spit; 5 – Original ebb tidal delta that has evolved into Church Norton Spit as the spit has extended; 6 - Pagham Lagoon; 7 - Pagham Little Lagoon

1.4 Purpose of this Document

The works proposed need to be licensed under the Marine and Coastal Access Act 2009 prior to work commencing (refer to **Section 3**). Arun District Council has commissioned Royal HaskoningDHV to prepare an ER in support of a Marine Licence application to the Marine Management Organisation (MMO) for a rock revetment to be placed in front of the affected properties on Pagham Beach prior to winter 2013/2014. The Marine Licence application will also include the sourcing of beach material for backfilling behind the proposed rock revetment. In addition, a planning application has been submitted to Arun District Council for these works.

Due to the urgency of the works, construction is proposed to occur in September/October 2013 and, therefore, a combined screening and scoping request, along with an accompanying Environmental Scoping Report, was submitted. The Environmental Scoping Report was prepared in March and April 2013 (Royal HaskoningDHV, 2013) and the screening and scoping request was submitted on the 4th of April 2013 to the MMO to establish whether an

Environment Impact Assessment (EIA) would be required for the proposed scheme. On the 19th July 2013 the MMO provided a Screening and Scoping Opinion to confirm that no EIA would be required for the project, but that Natural England had requested an ER be written to outline the potential impacts associated with the marine elements of the project in more detail.

Arun District Council also submitted a screening and scoping request to the Planning Services Department for a screening/scoping opinion, along with the Environmental Scoping Report. It was determined that an EIA would not be required for the project, however, a full Planning Application would need to be submitted. Arun District Council submitted the full Planning Application to the Planning Services in July 2013 and it is anticipated that planning permission will be granted in the next few weeks.

Section 3 provides further details of the environmental assessment process and consents required for this scheme. This ER has been written based on the Screening and Scoping Opinion received from the MMO.

1.5 Structure of this Report

This ER comprises a number of sections which lead the reader through the environmental assessment of the marine elements of the proposed scheme by introducing the project, relevant legislation and consultation strategy, identifying and describing the existing baseline environment, and identifying potential impacts both during the construction and operational phases of the project.

This section, **Section 1**, introduces the project and the ER. **Section 2** provides a full description of the works proposed. **Section 3** describes the legislative requirements, and **Section 4** outlines the consultation process undertaken to date and details the formal consultation that has taken place. **Section 5** provides the scope of the report, outlining which aspects have been included within the report and why.

Section 6 provides details of the relevant nature conservation designations, and then for each relevant environmental parameter **Sections 7 to 13** provide a description of the baseline conditions, identify the potential impacts of the scheme during the construction and operational phases, and outline proposed mitigation measures to minimise, reduce or to avoid any impacts identified.

A summary is provided in **Section 14** and references are set out in **Section 15**.

2 DESCRIPTION OF THE PROPOSED SCHEME

2.1 Introduction

Pagham Beach has been changing through the past decade under the influence of coastal processes and hydrodynamic changes in the area. A Coastal Defence Study carried out by Royal HaskoningDHV (2009a) indicated that erosion rates over a 10 year period (1997-2007) led to a net shortage of shingle of 20,000m³ to 30,000m³ in the area immediately landward of the existing rock and timber groynes on the Pagham Beach frontage.

The Church Norton Spit has also migrated towards Pagham at a rapid rate which has altered the tidal flows around the Harbour entrance. The width of the beach front has reduced significantly in the past three years – down to approximately 16m of beach front – due to successive storm events that occurred through the winter of 2012/2013; this has been recovered to the current position of 20m by recycling. The current situation means that a number of properties on Pagham Beach (15) are at risk of erosion.

In the past five years Arun District Council has undertaken a number of works in order to consolidate the beach frontage and protect the coastline at Pagham against physical pressures from the sea, including:

- recycling of material – 3 separate operations (each 2,000m³ – 5,000m³) in 2012/13; and
- recycling / renourishment (10,000m³ recycled for the ebb delta and 20,000m³ brought in from licenced dredging areas) in 2009/10.

Furthermore, with increasing physical pressures from predicted sea level rise, increases in the number and frequency of storms and continuing growth of the Church Norton Spit, a sustainable solution is required to accommodate the Pagham coastal frontage over the next 10 to 20 years.

To this end Arun District Council proposes to construct a rock revetment where coastal erosion recurred in 2012/2013 in order to avoid any further coastal retreat. The construction of the proposed revetment would include a number of aspects:

- importing of the rock via barge deliveries;
- transporting of the rock along the beach in dumper trucks;
- excavation of the foundations for the revetment footprint;
- placement of a rock revetment; and
- excavation of material to provide backfill material for the revetment.

Details of each of the above are provided in the following sub-sections.

Due to the current vulnerability of the houses along the Pagham frontage, it is proposed that the construction phase would commence in September/October 2013 and should be completed within six weeks. Full details of the proposed working hours are provided in **Section 2.2.7**.

2.2 Construction Phase

2.2.1 Rock revetment design

The proposed coastal defence works at Pagham Beach would involve the placement of a rock revetment along the frontage to protect the residential properties from coastal erosion, and in particular from any future winter storms (similar to those seen in the winter of 2012/2013), which have the potential to remove large volumes of the beach material.

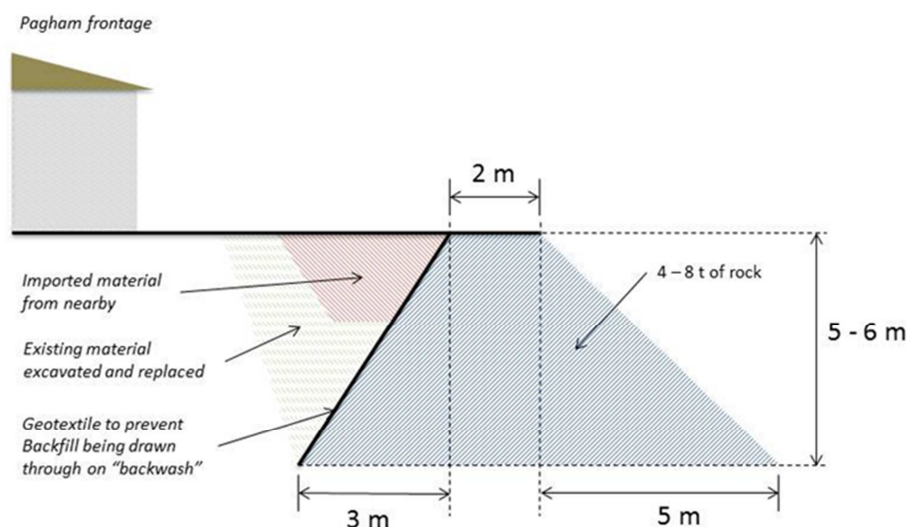
The rock revetment would be placed adjacent to the most westerly of the four existing rock groynes along Pagham Beach, in the area of erosion caused by the winter storms of 2012/2013. It has been designed to join the western edge of the groyne. The location of the rock revetment is indicated in **Figure 2.1**. It would be located approximately 22 to 25m away from the properties behind it.

The rock revetment is planned to consist of approximately 6,500 tonnes of rock in four to eight tonne pieces and it would be approximately 170m long. It would be 5 to 6m in height with a 2m wide crest. The structure crest elevation would be at existing crest elevation to avoid visual impact; wave run-up would be limited during storms by the increased surface roughness of the revetment (over a shingle beach) thus reducing the risk of further erosion.

The base of the revetment would be 10m wide, and the amount of seaward face exposure would vary from zero at the west end to approximately 2.5m at the eastern end. The front of the revetment would have a 1 in 1 slope and the back would be as steep as possible, with seaward protrusions at the toe to avoid tidal currents creating a deep channel and scouring material in front of the revetment.

The design of the rock revetment is provided in **Figure 2.2** and a typical cross section of the rock revetment is shown in **Figure 2.3**.

Figure 2.3: Cross section of the rock revetment proposed for Pagham frontage (not to scale)



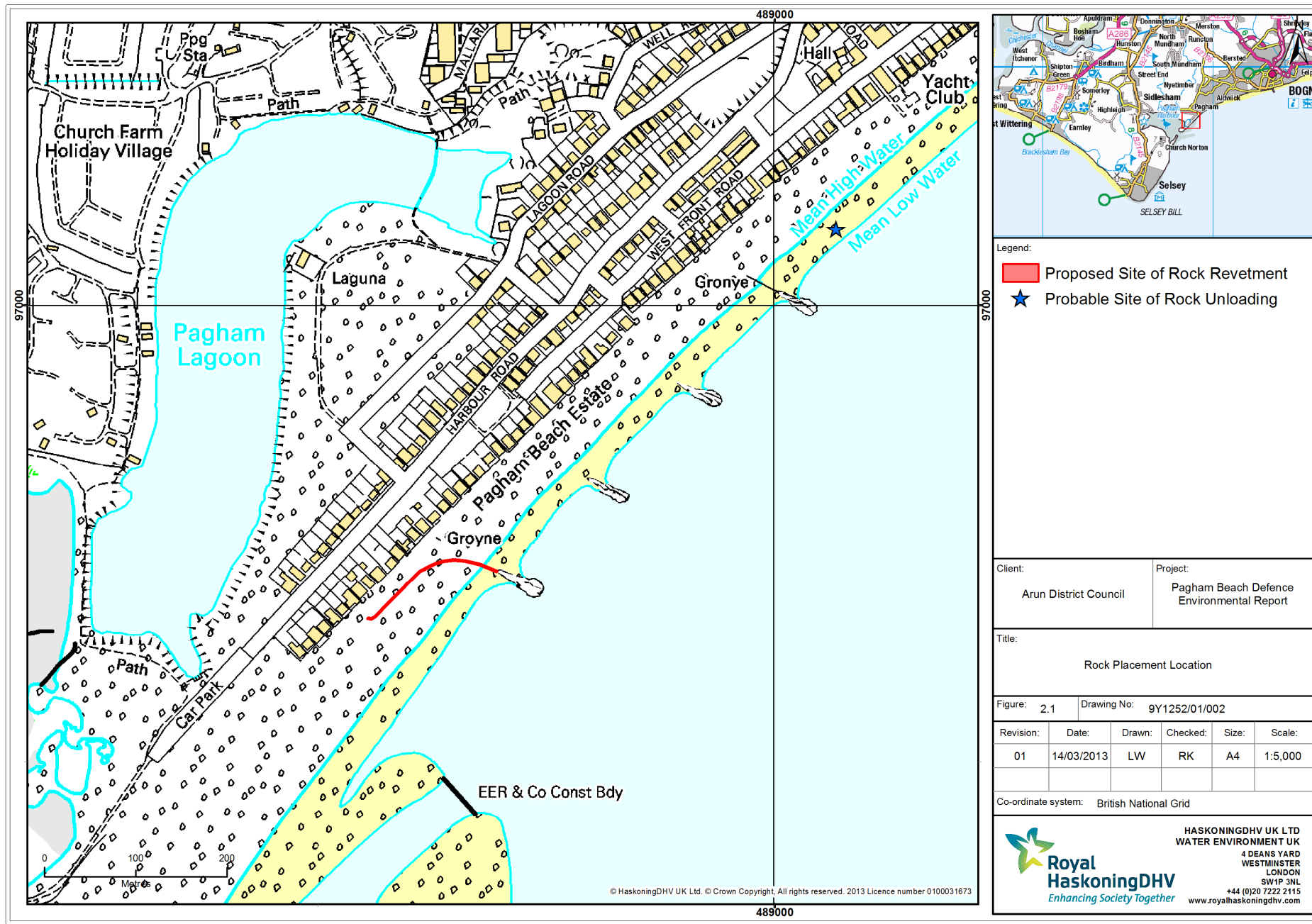
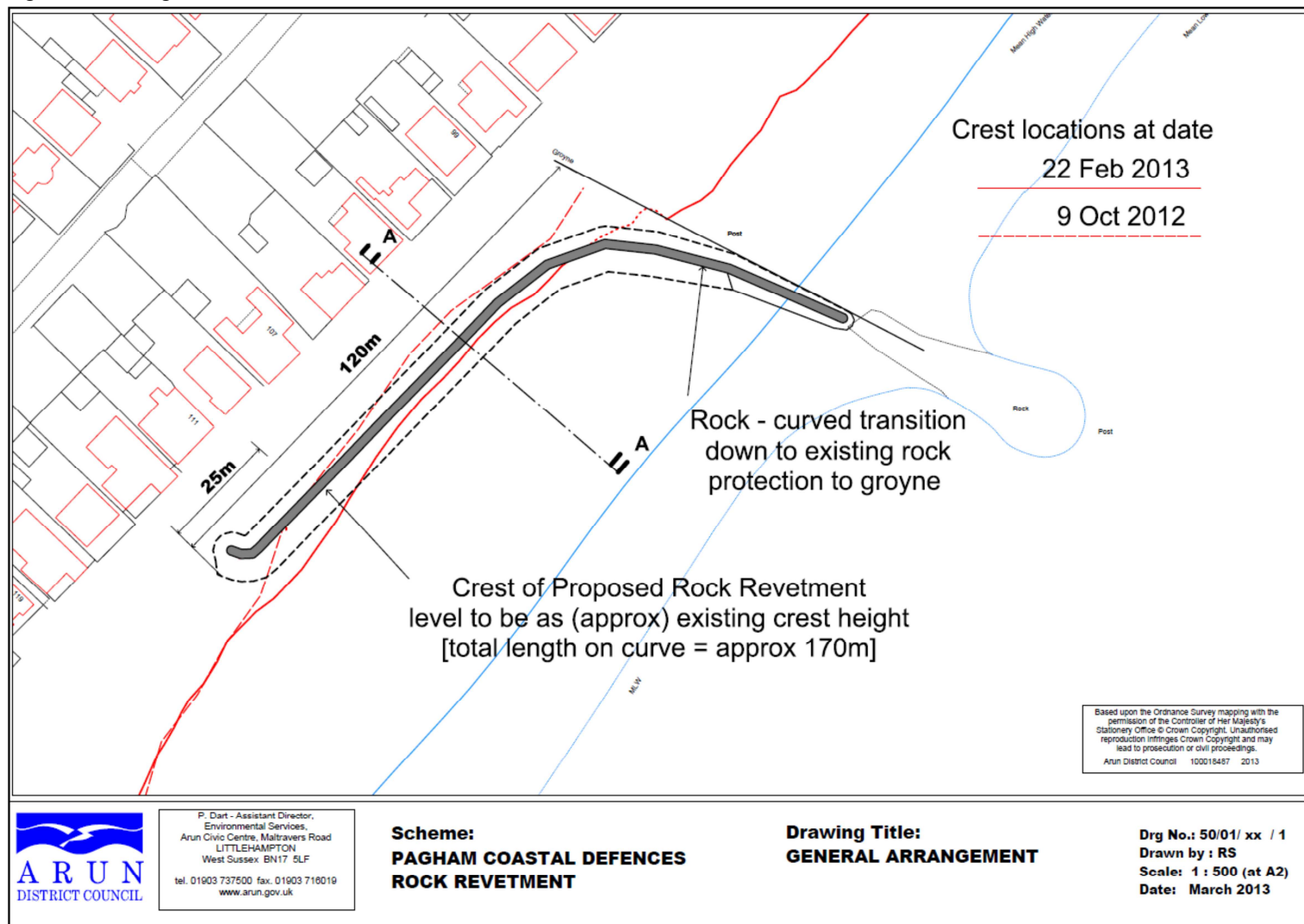


Figure 2.2: Design of rock revetment



Upon completion it is planned that the structure would be largely buried under normal circumstances and the crest would be at or around beach height directly in front of the properties. Beach material would be used to infill behind the completed structure and it is estimated that no more than 1,000m³ of extra infill material would be required. The backfill would be made up of the excavated material (as described below) supplemented by material taken from areas of accretion around the Harbour entrance (refer to **Section 2.2.2**).

A small amount of excavation would be required to prepare the ground prior to laying the rock revetment. The volume of this excavated material would be dependent on the weather conditions leading up to the works and, therefore, the current conditions on the beach at the time (i.e. if the beach was in a depleted state or recharged state). It is proposed that the material would be stockpiled on the beach avoiding vegetated areas, and then used as backfill once the rock revetment had been completed.

The rock revetment would initially be constructed at low tide, commencing with the proposed excavation and then the rock placement itself. As the works proceed, the rock revetment would increase in height which would make it possible to work for longer periods either side of low water.

Once delivered to site, the rocks shall be worked into the required position with a combination of excavator(s) and dumper trucks.

2.2.2 Backfill material

The amount of extra backfill material required to infill behind the completed rock revetment is estimated to be approximately 1,000m³; however, less material may be required and this would be determined once the rocks are in place.

If only a small amount of material is required for the backfill, this would be made up initially of the stock-piled material which would be excavated prior to the placement of the rocks.

If further material is required, the material would be sourced from an area along the coastline previously used for recent recycling events. **Figure 2.3** below indicates the proposed area where the supplementary backfill material would be taken from. It would only be possible to collect this material at low tide due to its position on the intertidal. .

Once placed, the backfill material would be worked into the required position with an excavator.



2.2.3 Barge deliveries

The rock would be delivered to Pagham Beach by sea on a barge and unloaded onto the beach at high tide at a point as near to the construction site as prevailing bathymetry allows. The rock would then be collected from the intertidal once exposed by the falling tide and trucked along the beach to the proposed rock revetment site in dumper trucks. The rock would be loaded onto the dumper trucks using an excavator.

It would not be possible to transport the rock directly to the site in the barge due to the shallow bathymetry and the strong currents within the Harbour channel. It is proposed that a site approximately 400 to 500m north-east from the rock revetment site (near to Pagham Yacht Club and the site) would be suitable for the unloading from the barge (refer to **Figure 2.1**). This would be confirmed through review of the bathymetry by the Contractor prior to any work being undertaken to ensure the safety of the vessel(s).

It is anticipated that only a small number of barge loads would be required to deliver all of the rock to the beach i.e. 6,500 tonnes of rock in four to eight tonne pieces. If the rock is to be source from France, it is likely that three or four barge loads would be required. Another possibility is that the rock would come from Norway, in which case a larger barge would be used and only one trip would be required.

The barges would not be able to travel all the way up the beach, even at high tide, and so it is anticipated that the rock would be unloaded relatively low down the beach.

This approach to delivery of rock by barge has been successfully used at Pagham in the past during the construction of the rock groynes.

2.2.4 Dumper trucks

The rock would be transported along the beach in a Moxy type truck as indicated in **Plate 2.1** below. It is anticipated that two or three trucks would be used for the works, depending on the Contractor's methodology. These trucks would be able to hold approximately 25 tonnes of rock in each load. This would amount to at least 260 truckloads along the beach, 520 lorry movements in total. There is also a possibility that 40 tonne dumpers could be used which would reduce the truckloads to 163, or 325 two way movements. For the purpose of this ER and in order to maintain a conservative approach to the assessment, it has been assumed that 25 tonne dumper would be used. A temporary "haul-route" along the intertidal would be created for the trucks to drive along. This would not be a formal road, but a bulldozer may be used to ensure that the intertidal is negotiable by the trucks.

The dumper trucks would be required to collect the rocks from relatively low down the beach where they would be unloaded from the barges and, therefore, the rocks would only be recovered on lower stages of the tide.

With respect to the four groynes along the beach between the proposed unloading site and the rock revetment site, it is anticipated that the trucks would be able to drive over the two middle groynes (as there is beach on either side and with minimal work the road could be built up and over the groynes). The easterly groyne could be ramped over if required, although this groyne may be outside of the construction footprint. The land behind the westerly groyne, which is adjacent to the proposed rock revetment area, has

been disturbed due to previous recycling events so could be driven over, with the plan to reinstate it once the construction works are complete.

Plate 2.1: Proposed trucks to be used to transport the rock along the beach



2.2.5 Excavators

Excavators (with suitable grapples) would be required to load the rocks, which have been delivered by the barges, onto the dumper trucks. They would also be used once the rock has been tipped from the dumper trucks, to construct the revetment and to place backfill material into the required position behind the completed rock revetment.

The number of excavators required would be determined by the Contractor, however, it is likely that at least two excavators would be required; one to load the rocks into the dumper trucks at the eastern end of the working area, and one to build the revetment once the rocks have been tipped out of the dumper truck at the western end. The excavators would be equipped with some form of rock grapple.

2.2.6 Access to the beach and safety

During the construction works, access to the beach frontage would be restricted but not prohibited. Pedestrians would be directed away from the direct footprint of the works to avoid interference with the dumpers, bulldozers and excavators. The area of works would be well signed posted to warn the public of hazards and discourage access.

2.2.7 Working hours

It is proposed that the working hours for the barge deliveries would be 24 hours a day, seven days a week. The barge deliveries are anticipated to be completed within a few days.

The movement of the rock along the beach from the offloading site to the rock revetment placement area would occur between Monday and Saturday, from 7am to 7pm. It is not proposed that any work would occur on Sundays. It is anticipated that these works

would last for approximately four to six weeks and would occur in September to October 2013.

It is anticipated that at night the trucks would be parked either on the top of the beach where they have been working or in the Yacht Club car park. There would also be a site office cabin and mess facilities in the Yacht Club car park for the duration of the works.

Overall, it is anticipated that no more than 10 workers would be required to work on the site.

Following completion of the construction of the rock revetment, the plant and equipment would be removed from the beach. The temporary road which the trucks would have used to transport the rock along the beach and the area behind the beach would both be reinstated. Given the level of the recycling works that have occurred in the area in the past, the beach has been extensively disturbed and, hence, the reinstatement would improve existing conditions.

2.3 Operational Phase

It is not proposed that any works would be undertaken during the operational phase, and no maintenance activities are planned.

It is also not currently proposed that the rocks would be removed during the operational life of the defence, although the future management of the site would be dependent on the natural movements of the spit. At some point in the future the rock revetment may no longer be necessary if, for instance, the spit continues to grow and the current pattern of wave focussing during specific storm conditions changes, and therefore the need for protection from erosion diminishes with the passage of time.

Should inspections of the development of the spit over time begin to indicate a change in a positive direction then, at that time, the MMO, Natural England, the Environment Agency and other key regulators would be consulted and discussions initiated with regard to the best way to decommission the rock revetment.

At this time as it cannot be predicted when or if this might occur, as the future baseline conditions at the site cannot be anticipated. It is not, therefore, possible to suggest a decommissioning and reinstatement plan at this time; rather it is proposed that regulatory advice is sought and consultation occurs as required.

3 LEGISLATIVE REQUIREMENT

3.1 Current Legislation

This section outlines the legislative requirements that the project is subject to, including the requirement for a Marine Licence.

3.1.1 Marine and Coastal Access Act 2009

Part 4 of The Marine and Coastal Access Act (MCAA) 2009 provides a framework for the marine licensing system for works below the level of MHWS tides. The current marine licensing system has been in force since 6 April 2011 and consolidates and replaces previous statutory controls, including:

- licences under Part 2 of the Food and Environment Protection Act (FEPA) 1985;
- consents under Section 34 of the Coast Protection Act 1949 (CPA);
- consents under Paragraph 11 of Schedule 2 to the Telecommunications Act 1984; and
- licences under the Environmental Impact Assessment and Natural Habitats (Extraction of Minerals by Marine Dredging) Regulations 2007.

The MMO is the regulatory authority for marine licensing in English inshore and offshore waters. As stated above, the placement of a rock revetment on the foreshore at Pagham requires a Marine Licence from the MMO.

3.1.2 Town and Country Planning (EIA) (England and Wales) Regulations 1999

The proposed works down to Mean Low Water Spring (MLWS) would require planning permission under the Town and Country Planning Act 1990, however, a full EIA is not required.

A full Planning Application was submitted to Arun District Council in July 2013 and it is anticipated that planning permission will be granted in the next few weeks.

3.1.3 The Conservation of Species and Habitats Regulations 2010

Pagham Beach is protected by a number of national and international nature conservation designations, including a Special Protection Area (SPA), a Ramsar site and two Sites of Special Scientific Interest (SSSIs). Consequently, the proposed coastal defence works are subject to the provisions of EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive), implemented in the UK through The Conservation of Species and Habitats Regulations 2010 (the Habitats Regulations). The potential impacts to protected species or habitats are assessed within this report (see **Section 10**).

3.1.4 Water Framework Directive 2000

The Water Framework Directive (WFD) (2000/60/EC) establishes a legal framework to protect and restore clean water across Europe to ensure its long-term, sustainable use. It applies to waters out to one nautical mile from the baseline from which territorial

waters are drawn. One of the aims of the WFD is to ensure that all European water bodies are of Good Ecological Status (GES) or Potential (GEP) by 2015 by the setting of Environmental Quality Objectives (EQOs) for water chemistry, ecological and hydromorphological quality parameters.

The works associated with the project are located to the east of Pagham Harbour and lie within the WFD coastal water body 'Sussex'. A WFD compliance assessment for this project has been progressed through Stage 1 (screening) and Stage 2 (scoping). The assessment was included within the Environmental Scoping Report issued in April 2013 and is presented separately in **Appendix A** of this ER. The WFD compliance assessment concluded that the relevant Environmental Objectives would be met by the scheme and there would be no deterioration of the status of any associated water bodies.

3.1.5 Wildlife and Countryside Act 1981 (as amended)

Under the terms of Section 28(4)b of the Wildlife and Countryside Act 1981 as amended by Schedule 9 to the Countryside and Rights Of Way Act (CROW) 2000, any operations within, or adjacent to, a SSSI require consent from Natural England.

3.1.6 Land Drainage Act 1991 and Water Resources Act 1991 and associated byelaws

The Water Resources Act established the National Rivers Authority (now replaced by the Environment Agency) and regulates water pollution. The Act defines the Environment Agency's role in water pollution, water resource management, flood defence, fisheries and navigation. It covers discharges to surface and ground waters, estuaries and coastal waters, and controls the abstraction and impounding of water.

Under the terms of the Land Drainage Act 1991, Water Resources Act 1991 and associated byelaws, prior written consent from the Environment Agency is required for any works on or near a main river or within 8m of a flood defence.

3.1.7 Coastal Protection Act 1949

Whilst the Marine and Coastal Access Act 2009 (refer to **Section 3.1.1**) replaces existing controls under Part II of the Coast Protection Act (CPA) 1949, some aspects of the CPA remain. For the proposed Pagham Beach coastal defence scheme it was necessary to go through the CPA Section 5 Notice Procedure, whereby objections to and approvals of the proposals to carry out coastal protection work are noted. In this instance, no objections were raised to the proposed works.

3.1.8 Crown Estate Consent

The Crown Estate owns the majority of the foreshore and subtidal seabed around the UK. It is, therefore, always necessary to determine the ownership of the foreshore, and gain the consent of the Crown Estate where applicable, prior to the commencement of any works.

In the case of Pagham Beach, Arun District Council has a regulating lease from The Crown Estate for the eastern side of the Pagham Harbour entrance channel.

3.2 The Marine Licence Application Process

This section provides further details of the Marine Licence application process followed for the proposed scheme.

3.2.1 Legislative requirement

Arun District Council intends to apply for a Marine Licence from the MMO under the MCAA (2009) for construction of the rock revetment and associated works on the foreshore at Pagham (see **Section 3.1.1**).

As outlined in **Section 1.4**, a formal combined Screening and Scoping Opinion was requested from the MMO on 4th April 2013 with respect to the proposed scheme. An Environmental Scoping Report (Royal HaskoningDHV, 2013) was included with the screening and scoping request in order to provide information on the project. This conjoined approach was adopted in order to fast track the process in the hope of issuing the Marine Licence before the autumn of 2013.

The MMO confirmed in their Screening and Scoping Opinion dated 19th July 2013 that an EIA was not required; however, they advised that an ER should be developed to support the Marine Licence application.

This ER has, therefore, concentrated on the project elements identified by the regulators through consultation (refer to **Section 4**), as well as providing further information where relevant on other marine aspects.

3.2.2 Approach to identification and evaluation of impacts

The potential environmental impacts associated with both the construction and operational phases of the proposed coastal defence works are identified in this ER.

An impact is determined based on the characteristics of the existing baseline environment and the potential for the works to alter any physical, chemical, biological or perceived characteristics of that environment.

For each environmental parameter considered to be potentially at risk due to the construction and operational phases of the proposed scheme, a list of potential impacts was identified (informed by the scoping phase) and an assessment of the predicted significance of each impact was undertaken.

While the proposed scheme has the potential to alter hydrodynamic and sedimentary processes, the significance of such change or effects have not been defined in the coastal processes and hydrodynamics section as impacts. This is because coastal processes themselves are not considered to be receptors sensitive to change. Hence, while a change to a process can be predicted and described with respect to the known baseline in terms of its magnitude, it is not appropriate to predict the significance of an impact on the process. The significance of this change is nevertheless assessed with respect to those environmental receptors that could be influenced, such as water quality, marine ecological interests and waterbird populations, within the other relevant sections of this ER.

Where adverse impacts have been identified, potential mitigation measures are recommended where they are available. These are methods or actions which aim to reduce or alleviate the impact, as far as possible, to environmentally acceptable levels. Following the inclusion of mitigation, the impact is reassessed to determine the scale and magnitude of the impact and recorded as the 'residual impact'. Where mitigation measures are described, their implementation is the responsibility of the developer.

4 CONSULTATION

A number of recycling and renourishment schemes have been undertaken on Pagham Beach over a number of years, which have been approved and supported by the relevant regulators.

The most recent major renourishment event occurred in 2009/2010, when consent was provided for Arun District Council to place 30,000m³ of shingle along the beach frontage at Pagham in order to raise the standard of coastal defence. 10,000m³ of the shingle was sourced from Church Norton Spit where it had been accreting and 20,000m³ was sourced from licensed offshore dredging areas. The regulators were supportive of the scheme but noted the sensitivity of the area and an EIA was required.

In January 2013 a meeting was held between Arun District Council, Natural England, the Environment Agency and West Sussex County Council to explore all options for further coastal defence provision at Pagham and to draw up a short-list of options based on a range of criteria, including:

- speed of implementation (approval process, contract lead-in and installation time [onset of benefit]);
- longevity;
- level of EIA risk (effect on environmental designations);
- outline likely Cost;
- likelihood of success;
- effect on adjacent beaches (including effect on sediment transport regime);
- damage to nearby property; and
- residual benefit.

In February 2013 a further meeting was held between Arun District Council, Natural England, the Environment Agency and Royal HaskoningDHV to discuss the short-listed options. Natural England and the Environment Agency are keen to allow the spit to develop naturally but recognise the need to protect the residential properties on Pagham Beach, and were supportive of the Council's proposals.

Further email correspondence has been undertaken with Natural England and the Royal Society for the Protection of Birds (RSPB) to obtain current information on the bird breeding areas on Church Norton Spit and water vole records for Pagham Lagoon. It was agreed with Natural England and the RSPB that there would not be any impact on the water voles as a result of the proposed works.

Arun District Council has also held meetings with individual residents, the Pagham Harbour and Coastal Issues Group, Pagham Parish Council and the Pagham Beach Residents' Association to discuss the proposed scheme.

Since submission of the screening and scoping request in April 2013, further consultation has been undertaken with Natural England regarding the likely impacts of the proposed works. Whilst Natural England confirmed that there would be no

requirement for an EIA, there were concerns raised regarding the proposed works and sensitivities in the area; hence the need for this report.

The formal Scoping Opinion was received from the MMO on 19th July 2013 and **Table 4.1** outlines the key points raised by the various regulators and stakeholders within the Scoping Opinion.

Table 4.1: Key issues raised within the MMO Scoping Opinion

Consultee	Summary of Comments
Cefas	• The impacts identified in the scoping report are likely to be temporary and localised in nature as stated, therefore, it is unlikely that they will cause a significant adverse impact to the marine environment. • I agree with the identified potential effects of this proposed project upon coastal processes and hydrodynamics receptors. There is the potential for wave energy to be refracted along the revetment and for this to lead to erosion in other locations along the Pagham frontage, therefore I would recommend that the potential impact of this effect is considered and assessed in the application. • The proposed works are within a broad area used for nursery grounds by plaice, sole, thornback ray, undulate ray and lemon sole. The proposed works are within a broad area used as spawning grounds by cod, plaice, sand eel, sole lemon sole and sprat. The proposed works, through the excavation and construction works on the beach, have the potential to increase levels of suspended sediment that can have an adverse effect on fish resources. However, due to the nature (temporary and carried out at low tide) and scale (approximately 150 m long and 10 m wide) of the proposed works, it is unlikely that there will be a significant adverse impact upon local fish resources. • The proposal is within the Pagham Harbour SPA and Ramsar site, of which the designated features are breeding and over-wintering bird assemblages and regularly supporting at least 20,000 waterfowl. The proposal is also within Pagham Harbour SSSI, of which the designated features are littoral sediment, supralittoral sediment and standing open water and canals. The pre-application states that the applicant has consulted Natural England and the Environment Agency with regards to this proposal. I would recommend further liaison in order to establish the potential impacts upon the features of these designated sites. • It is my opinion that the proposed works do not fall within the specifications of the Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended). Due to the nature and scale of the proposed works, it is unlikely that there will be a significant adverse impact on the marine ecological receptors identified above. I defer comment to Natural England regarding the requirement for an Appropriate Assessment (AA). • The potential impact associated with wave energy refraction along the revetment and for this to lead to erosion in other locations along the Pagham frontage, requires consideration and assessment within the application.
Environment Agency	• In our opinion the project is unlikely to have a significant effect on marine water quality or water framework directive objectives due to the scale, timing and duration of construction and long term impacts. • The applicant identified a possible increase in suspended solids during the construction phase of this scheme, which they envisage to begin in September/October. We would like to advise the applicant that the Bathing Water season runs through to the end of September. Increased suspended solids and the

Consultee	Summary of Comments
	associated re-suspension of sediment-bound bacteria can impact on water quality at the nearby designated Bathing Water. • Further information is required on the degree of interruption to the physical coastal processes. The site is close to two important spits, and already vulnerable beaches to erosion, as well as within the vicinity of areas designated for the geological conservation. There could be impacts to the ebb tidal delta entrance and to the spits and adjacent beaches because of change to hydrodynamics (waves, tides, currents). The rock revetment will hold the meander in place in the estuary, and is likely to alter the physical conditions and processes within this channel, also. • We would recommend further studies (predominately desk studies). At this point, we do not know how the hydrodynamics are going to behave in detail. It is likely any change is small scale but there is a risk to the integrity of other sites hence the need for further assessment.
Natural England	• Having considered the information provided in the screening document and scoping report, Natural England believes that there are a number of environmental issues that would need to be addressed in relation to this proposal. However, following detailed discussions with Arun District Council and their consultant we are optimistic that there is scope for these impacts to be avoided or mitigated. We will however, require reassurance within the proposal through its design and an accompanying environmental report, how this will be successfully achieved. This does not necessarily need to be through the EIA process. • Natural England advises that the application needs to consider the following issues: timing of works, geomorphology, shingle sourcing and beach restoration. • Below are further details that we consider should be within an environmental report. Some of these issues have been or are outlined to be addressed in the submitted scoping report: • Information to inform the need or otherwise for a Habitats Regulation Assessment - this information has been outlined in the accompanying scoping report and demonstrates how impacts on the SPA (particularly nesting terns and waders on areas of shingle) can be avoided through the timing of works outside of the sensitive bird breeding and overwintering period. Work should therefore not occur within the period April – end July when little terns especially may be breeding on Church Norton Spit directly opposite the proposed application site. If work is required to start in mid-July, a walk over by the RSPB warden should be requested to check and confirm that all the little terns have finished nesting before work can begin. Although, the work is proposed to take place in September to October over 6-8 weeks, we suggest that there is a need to consider a contingency should this timetable over run. An assessment and reassurance on the potential impact to overwintering birds also needs to be considered. The majority of overwintering birds use the inner harbour, however some wading & gull species will feed out in the intertidal zone, early on in the season and this might present a local temporary risk of disturbance outside of prime feeding and roosting habitat. • The interest features of national designations (SSSI and proposed Marine Conservation Zones (pMCZs)): • The geomorphology (SSSI) interest feature of Church Norton Spit should not be impacted, this will need to be confirmed. • The need to consider the pMCZ interest features in the assessment and how potential impacts will be avoided. • Impacts on the vegetative shingle (SSSI) should be avoided where possible

Consultee	Summary of Comments
	during construction and the proposal should explain how this will be restored as well as any potential biodiversity gains in relation to this work. • Shingle source – Natural England is confident that the sourcing of the proposed small amount of shingle for backfilling the revetment, from within the inner channel from the location outlined in the scoping report is not likely to impact the geomorphology of the site. An assent provided by Natural England earlier in the year allowed shingle to be taken from this location. The proposal and accompanying information should confirm that sourcing further shingle from this location will not affect the geomorphology of the spit and that shingle will continue to accrete in this area. • Future works - Within the proposals, consideration should be given to the circumstances under which the defences, should they no longer be needed (for example as a result of changes to the spit which alter the channel location) would be removed and potentially repositioned? The proposal should detail the circumstances that this would occur, how it would deal with shingle beach and vegetation restoration. This is a large structure which is proposed within a SSSI and it is important to consider its removal if it is no longer needed.

5 SCOPE OF THE REPORT

This ER has been developed based on the findings of the Environmental Scoping Report issued in April 2013 (Royal HaskoningDHV, 2013) and the Scoping Opinion received from the MMO which contained the comments from the statutory consultees detailed in **Table 4.1**.

The following receptors/environmental parameters were highlighted in the Environmental Scoping Report and through consultation as requiring further consideration to fully outline any potential environmental impacts:

- coastal processes and hydrodynamics;
- water and sediment quality;
- marine ecology;
- fish and shellfish;
- marine mammals;
- ornithology; and
- navigation.

These receptors/environmental parameters are all relevant to the Marine Licence application.

As outlined in the Environmental Scoping Report, a number of parameters were “scoped out” from further assessment. These parameters have not been included within this report as it is not considered that they are relevant to the Marine Licence application.

6 NATURE CONSERVATION DESIGNATIONS

6.1 Introduction

The Pagham coastline is an area of high biological and nature conservation significance. This is reflected by the designation of a number of sites through national and international legislation for the species and habitats that they support.

6.2 Internationally Protected Sites

The Pagham coastline is protected by two international designations, Pagham Harbour SPA and Pagham Harbour Ramsar site. These designations are detailed in **Table 6.1** and illustrated in **Figure 6.1**. The proposed works are located within the boundaries of both international designations.

There are no designated Special Areas of Conservation (SACs) within the Pagham Harbour area.

6.3 International Bird Areas

6.3.1 Pagham Harbour Important Bird Area

The Important Bird Areas (IBA) Programme of BirdLife International is a worldwide initiative aimed at identifying and protecting a network of sites considered to be critical for the conservation of the world's birds.

Within Europe, 3,619 IBAs have been identified and published in Important Bird Areas in Europe: Priority Sites for Conservation, sponsored by the RSPB (Heath and Evans, 2000). These sites are selected because of the bird numbers and species they contain. IBAs are particularly important for species that congregate in large numbers, such as wintering and passage waterbirds and breeding seabirds. Many sites have also been identified for species of global and European/EU conservation concern. Within the UK, 287 IBAs have been identified.

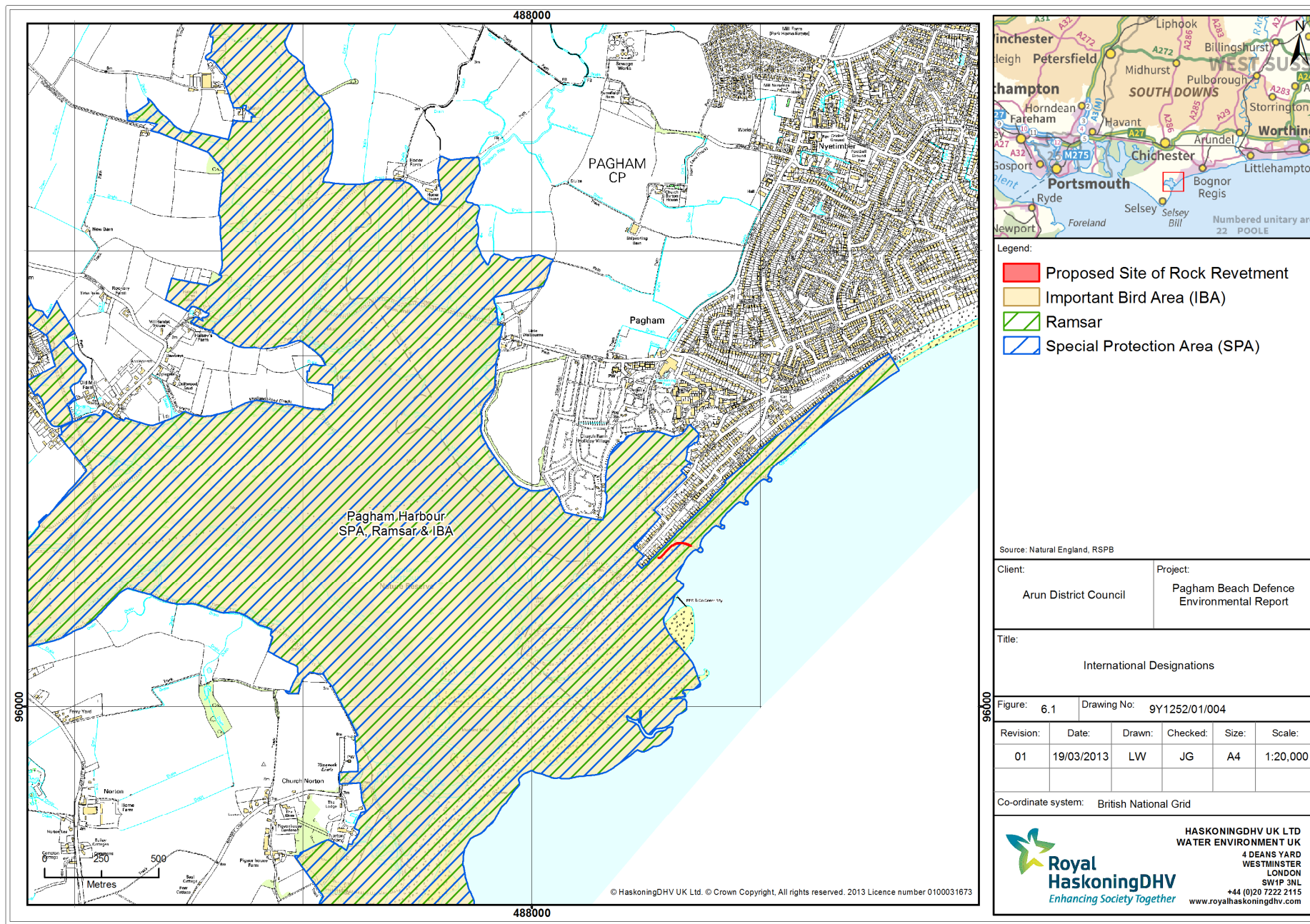
BirdLife International describes the Pagham Harbour IBA as a central area of mudflats and saltmarsh, and surrounding brackish marsh and pasture (BirdLife International, 2013). The site is approximately 627ha in size and supports large numbers of wintering wildfowl. It is nationally important for wintering great cormorant *Phalacrocorax carbo*, northern pintail *Anas acuta*, grey plover *Pluvialis squatarola*, black tailed godwit *Limosa limosa*, and for passage grey plover *Pluvialis squatarola*. The location of Pagham Harbour IBA is illustrated in **Figure 6.1**.

6.4 European marine site

Pagham Harbour European marine site is designated under Regulation 33(2) of the Conservation (Natural Habitats &c.) Regulations 1994. European marine sites are defined as any part of a European protected site, in this case the Pagham Harbour SPA, which is covered, either continuously or intermittently, by tidal waters or any part of the sea in or adjacent to Great Britain.

Table 6.1: International and European Protected Sites

Site	Habitat Feature	Species Feature	Distance from proposed works	Potential for impact?	Scoped out?
Pagham Harbour SPA (JNCC, 2001)	The habitat features which support the SPA include: - Saltmarsh; - Intertidal mud-flats; - Lagoons; - Shingle; - Open water; - Reed swamp; and - Wet permanent grassland.	The species which are a key feature of the site are: During Breeding season - Little Tern <i>Sterna albifrons</i>. Over winter - Ruff <i>Philomachus pugnax</i>; and - Pintail <i>Anas acuta</i>. Nationally important numbers of - wintering pintail <i>Anas acuta</i>; - grey plover <i>Pluvialis squatarola</i>; and - black tailed godwit <i>Limosa limosa</i>.	0km	Yes	No
Pagham Harbour Ramsar site (JNCC, 1988)	The habitat features which support the Ramsar site include: - Saltmarsh; - Intertidal mud-flats; - Lagoons; - Shingle; - Open water; - Reed swamp; and - Wet permanent grassland.	The species which are a key feature of the site are: - Dark-bellied Brent goose, <i>Branta bernicla bernicla</i> Species identified for possible future designation: - Black-tailed godwit, <i>Limosa limosa islandica</i>	0km	Yes	No



6.5 Nationally Protected Sites

The proposed works at Pagham Beach are located within the Pagham Harbour SSSI. The works are also approximately 1.2km south of the Bognor Reef SSSI. **Table 6.2** provides a summary of the SSSIs within the vicinity of the proposed works and the sites are illustrated in **Figure 6.2**. As described above, SSSIs are designated under Section 28 of the Wildlife and Countryside Act 1981.

There are no national landscape designations for the area. The closest site is the Sussex Downs Area of Outstanding Natural Beauty (AONB), approximately 6km to the north-west. Although Pagham Harbour is not covered by any national landscape designations, it is relatively un-spoilt by development and enjoyed by visitors as a peaceful and scenic coastal retreat.

There are no National Nature Reserves (NNR) in the Pagham Harbour area.

6.5.1 Pagham Harbour SSSI

Pagham Harbour SSSI is nationally important for its wintering wildfowl and waders as well as breeding birds, which are found within the Harbour and the surrounding grazing pastures. The site also supports nationally important communities of plants and invertebrates (see **Table 6.2** and **Figure 6.2**) (Natural England, 1980).

Pagham Harbour SSSI is also a key site for coastal geomorphology. It is important for both the classic shingle spit landform and for the demonstrated links between the coastal nearshore and offshore forms and sediments. The weed rafting of shingle is a unique feature of the area. The site is also key in its north-eastern extent, for plant fossils from the London Clay and is an outstanding palaeobotanical site of great importance to studies of Tertiary Period flora (Natural England, 1980).

6.5.2 Bognor Reef SSSI

Bognor Reef SSSI comprises a long stretch of foreshore of great geological interest and an extensive area of vegetated shingle, a rare habitat in Britain (see **Table 6.2** and **Figure 6.2**). In the SSSI's western extent there is a small area of old sand dune which supports interesting flora including protected species listed on Schedule 8 of the Wildlife and Countryside Act 1981 (Natural England, 1988).

The SSSI is also important for its display of geologically interesting features. It is possible to study in sequence the whole thickness of the London Clay. As with the Pagham Harbour SSSI, Bognor Reef SSSI is also a key site for plant fossils from the London Clay and a site of great importance to studies of Tertiary Period flora. On the foreshore at Aldwick, within the SSSI, is the most important site in the world for pyritised fossil insects, especially beetles (Natural England, 1988).

The dominant families of plant fossils include the Vitaceae, Menispermaceae and Burseraceae. It is only at the Bognor Reef SSSI that the genera *Bognoria* and *Aldwichia* are found and there are about thirty species present. These components combined make the SSSI an outstanding palaeobotanical site of great importance to the study of Tertiary Period floras (Natural England, 1988).

6.6 Marine Conservation Zones

The Marine and Coastal Access Act (2009) created a new type of Marine Protected Area (MPA) called a Marine Conservation Zone (MCZ). MCZs will protect nationally important marine wildlife, habitats, geology and geomorphology. The development of proposals for MCZs has taken place over the past two years through four regional MCZ projects. The regional teams recommended 127 sites (rMCZs), including 65 recommended reference areas (rRAs), to the Statutory Nature Conservation Bodies (SNCBs), Natural England and the Joint Nature Conservation Committee (JNCC) in September 2011. Ministers have examined all of the advice and evidence and have proposed that up to 31 sites are suitable for designation in the first tranche in 2013, however, no rRAs are currently being taken forward. The 31 sites to be considered in the first tranche are referred to as proposed MCZs (pMCZs). Public consultation on the proposals was launched on 13th December 2012 and closed at midnight on 31st March 2013. Pagham Harbour is included as one of the 31 proposed sites in Tranche 1 and may be designated in 2013.

6.6.1 Pagham Harbour pMCZ

The Pagham Harbour pMCZ is located approximately 0.5km west from the proposed works (refer to **Figure 6.2**). The pMCZ is identified as having seagrass beds, Defolin's lagoon snail *Caecum armoricum* and Lagoon sand shrimp *Gammarus insensibilis* (Balanced Seas Regional Stakeholder Group, 2011a). The potential impacts of the proposed works on these features are assessed in **Section 9**. It was confirmed through discussions with Natural England that the European eel *Anguilla anguilla* is no longer considered a feature of the Pagham Harbour pMCZ and, therefore, does not need to be considered within this ER.

6.6.2 Church Norton Spit recommended Reference Area

Within the boundaries of the Pagham Harbour pMCZ is the Church Norton Spit rRA no.11 (refer to **Figure 6.2**). The rRA site covers 3ha and is identified for its A2.3 intertidal mud habitat and also for the rare Defolin's Lagoon Snail *C.armoricum* (Balanced Seas Regional Stakeholder Group, 2011b). The site recommendation has received strong opposition from local residents and stakeholders and was not included within the 31 proposed sites for Tranche 1.

6.7 Locally Protected Sites

The Pagham Harbour SSSI is a proposed National Conservation Review (NCR) site and contains Pagham Harbour Geological Conservation Review (GCR) site. Pagham Harbour SSSI is also part of Bognor Regis (Palaeobotany) GCR site.

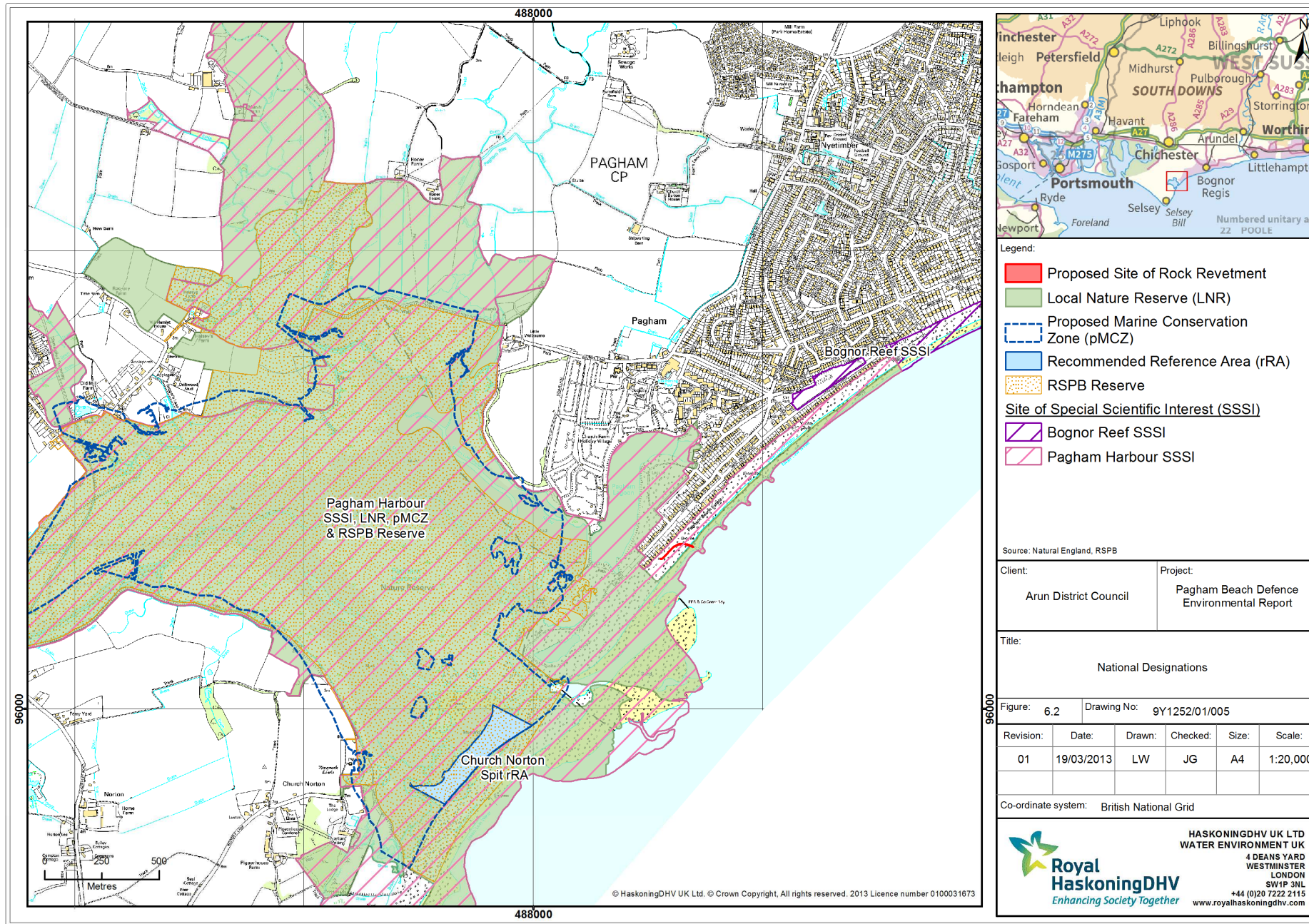
6.7.1 Pagham Harbour Local Nature Reserve

A Local Nature Reserve (LNR) is a statutory designation which is made under Section 21 of the National Parks and Access to the Countryside Act 1949, and amended by Schedule 11 of the Natural Environment and Rural Communities Act 2006, by principal local authorities. To qualify for LNR status, a site must be of importance for wildlife, geology, education or public enjoyment. Some LNR sites are also nationally important SSSI's.

Table 6.2: Nationally Protected Sites

Site	Habitat Feature	Species Feature	Distance from proposed works	Potential for impact?	Scoped out?
Pagham Harbour SSSI (Natural England, 1980)	The habitat features which support the SSSI include: - Saltmarsh; - Tidal mudflats; - Shingle; - Open water; - Reed swamp; and - Wet permanent grassland.	The species which are a key feature of the site are: - Hybrid common cord-grass <i>Spartina anglica</i>; - Glassworts <i>Salicornia</i> spp; - Sea-purslane <i>Halimione portulacoides</i>; - Sea aster <i>Aster tripolium</i>; - Sea-spurrey <i>Spergularia media</i>; - Sea lavender <i>Limonium vulgare</i>; - Sea couch <i>Elymus pycnanthus</i>; - Childing pink <i>Petrorhagia nanteuilli</i>; - Uncommon sea-kale <i>Crambe maritima</i>; - Yellow-vetch <i>Vicia lutea</i>; - Starlet sea anemone <i>Nematostella vectensis</i>; - Sand dart <i>Agrotis ripae</i>; - Matthew's wainscot moth <i>Mythimna favicolor</i>; and - Long-winged conehead grasshopper <i>Conocephalus discolor</i>	0km	Yes	No
Bognor Reef SSSI (Natural England, 1988)	The habitat features which support the SSSI include: - Foreshore of great geological interest; - Vegetated shingle; and - Old sand dune which is home to interesting flora.	The species which are a key feature of the site are: Flora - Yellow horned poppy <i>Glaucium flavum</i>; - Sea beet <i>Beta vulgaris</i>; - Uncommon sea kale <i>Crambe maritima</i>; - False oat-grass <i>Arrhenatherum elatius</i>; and - Red fescue <i>Festuca rubra</i>. Invertebrates	Approximately 1.2km	Yes	No

Site	Habitat Feature	Species Feature	Distance from proposed works	Potential for impact?	Scoped out?
		- Long-winged conehead grasshopper <i>Conocephalus discolor</i>; and - Childing pink <i>Petrorhagia nanteulii</i>			



The Pagham Harbour LNR covers 599ha and is classified as an 'urban fringe' type by Natural England (2013). The site is owned by the Environment Agency, West Sussex County Council, the Sussex Wildlife Trust and other private land owners. The Pagham Harbour LNR is also designated as a SSSI (see **Section 6.5.1**).

Habitats found at the Pagham Harbour LNR include intertidal mudflats, saltmarsh, saline lagoons and vegetated shingle. There are up to 10,000 waders and wintering wildfowl including; Brent geese *Branta bernicla*, northern pintail *Anas acuta* and black-tailed godwit *Limosa limosa* present in national and international numbers. The site also exhibits spring and autumn migratory species including; osprey *Pandion haliaetus*, marsh harrier *Circus aeruginosus*, honey buzzard *Pernis apivorus*, hobby *Falco subbuteo* and Montagu's harrier *Circus pygargus*.

Pagham Harbour LNR is home to the passerines, also known as perching birds; redstart *Phoenicurus phoenicurus*, wheatear *Oenanthe oenanthe*, whinchat *Saxicola rubetra*, ring ouzel *Turdus torquatus*, pied flycatcher *Ficedula hypoleuca* and occasional red backed shrike *Lanius collurio*. Waders present at the site include; curlew *Numenius arquata*, sandpiper *Scolopacidae*, little stint *Calidris minuta*, wood sandpiper *Tringa glareola*, little ringed plover *Charadrius dubius*, yellow browed warbler *Phylloscopus inornatus*, Pallas's warbler *Phylloscopus proregulus* and wryneck *Jynx torquilla*.

The LNR also exhibits purple hairstreak butterfly *Neozephyrus quercus*, Chiding pink *Petrorhagia nanteuilii*, water voles *Arvicola amphibius* and numerous species of dragonflies (Natural England, 2013)..

6.7.2 Pagham Harbour RSPB Reserve

The Pagham Harbour RSPB Reserve is an undeveloped stretch of the Sussex coast and an internationally important wetland site for wildlife (RSPB, 2013). Species which are resident at the site include; little egrets *Egretta garzetta*, ringed plovers *Charadrius hiaticula* and lapwings *Vanellus vanellus*. Species which breed at the site in the summer, include; lapwings *Vanellus vanellus* and little terns *Sternula albifrons*.

The reserve was formally operated by West Sussex County Council but the management has recently been passed to the RSPB.

6.7.3 Pagham Harbour Geological Conservation Review (GCR) site

The GCR was created to identify sites of national and international importance which exhibit all the key scientific elements of the Earth heritage of Britain. The designated sites display; sediments, rocks, fossils, and features of the landscape that make a special contribution to the understanding and appreciation of Earth science and the geological history of Britain. The Pagham Harbour GCR, site number 1851, is one of 46 sites within Britain that sit in the GCR block - Coastal Geomorphology of England (CST-GME-EG) (JNCC, 2013).

6.7.4 Pagham Harbour National Conservation Review (NCR)

It is understood that within the area of Pagham Harbour there is a proposed NCR site.

6.8 Habitats Regulations Assessment

Within the Environmental Scoping Report information was provided with regard to Habitats Regulations Assessment (HRA). It was concluded at the initial stage that the proposed works would be unlikely to have a significant effect on the European designated sites detailed above (Pagham Harbour SPA and Ramsar site), i.e. a likely significant effect would not arise. The works are proposed to be undertaken outside of the breeding bird season for little tern which would be a potential concern and, therefore, any disturbance related impacts would be avoided.

No further information with regards to HRA is provided within this ER.

6.9 Identification of Key Issues

The marine ecology and ornithological interests of Pagham Harbour are based on a number of interrelated biological, chemical and physical parameters, such as food availability, water quality and the supply of sediment. Consequently any activities that could lead to changes in these parameters could have an impact on sensitive marine and ornithological receptors.

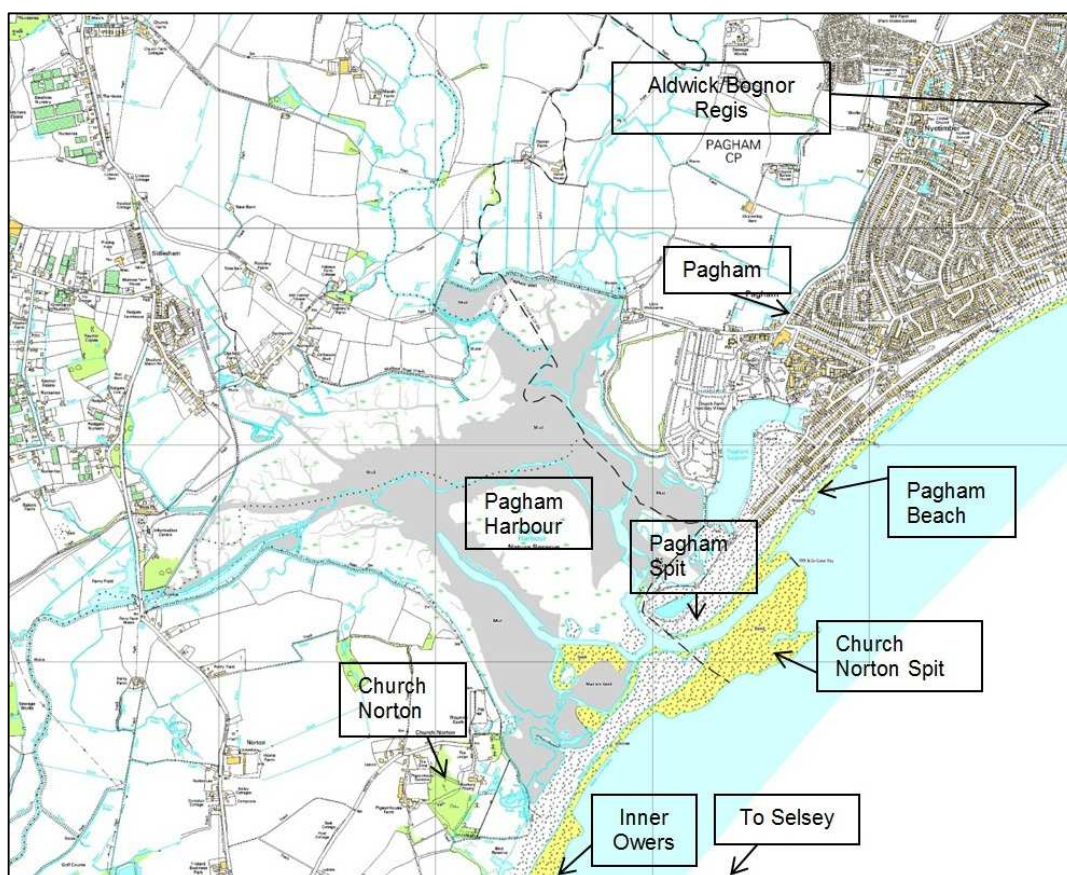
The following sections provide an outline of the potential impacts that could arise from the proposal scheme on each relevant environmental parameter.

7 COASTAL PROCESSES AND HYDRODYNAMICS

7.1 Introduction

Pagham Harbour is situated to the north-east of Selsey in West Sussex (**Figure 7.1**). It is a tidal inlet with an area of approximately 2.8km² at MHWS tides (Mitchell et al., 2008). The inlet is fronted by a dynamic shingle beach and spit complex which provides shelter from open-coast wave action. Pagham Harbour comprises an extensive central area of saltmarsh and intertidal mudflats, surrounded by lagoons, shingle, open water, reed swamp and wet permanent grassland.

Figure 7.1: Regional Location map of Pagham Harbour



7.2 Existing environment

7.2.1 Geology and geomorphology

The geology of Pagham Harbour is dominated by Pleistocene deposits (2.5 million to 10,000 years ago) which were subsequently reworked under a rising Holocene (10,000 years ago to present) sea level regime. At the base of the geological sequence lies the Eocene London Clay (56-34 million years ago). Above the London Clay are the Bracklesham Beds, comprising up to 100m of medium to fine-grained sand, which dip gently to the south. These Eocene formations are overlain by the Pleistocene deposits.

Pagham Harbour is the easternmost example of a series of drowned river valleys and shallow estuaries which occur along the coastline of southern England. These estuaries are characterised by the presence of sand and/or shingle spits at their mouths.

The geological and geomorphological importance of Pagham Harbour is recognised by the Pagham Harbour SSSI designation (see **Section 6.5.1**). It is designated both as a classic shingle spit landform and for the links that have been demonstrated between the coastal nearshore and offshore forms and sediments.

The geomorphological features in the Pagham Beach and Pagham Harbour vicinity are shown in **Figure 7.2**. Pagham Beach is orientated north-east to south-west, linked to Pagham Spit towards its south-westerly extent. Pagham Spit extends south-west from Pagham Beach, sheltering saltmarsh and intertidal mudflats to the north-west. Church Norton Spit is orientated south-west to north-east and extends from Church Norton to the most south-westerly groyne on Pagham Beach. Church Norton Spit has grown/extended since 2003/4 over the previous ebb-tidal delta which fanned out seaward of the Pagham Harbour entrance channel. The current Pagham Harbour inlet channel is orientated north-east to south-west and flows between Pagham Spit/Pagham Beach and Church Norton Spit. An ebb-tidal delta is located seaward of the inlet channel.

7.2.2 Tidal regime

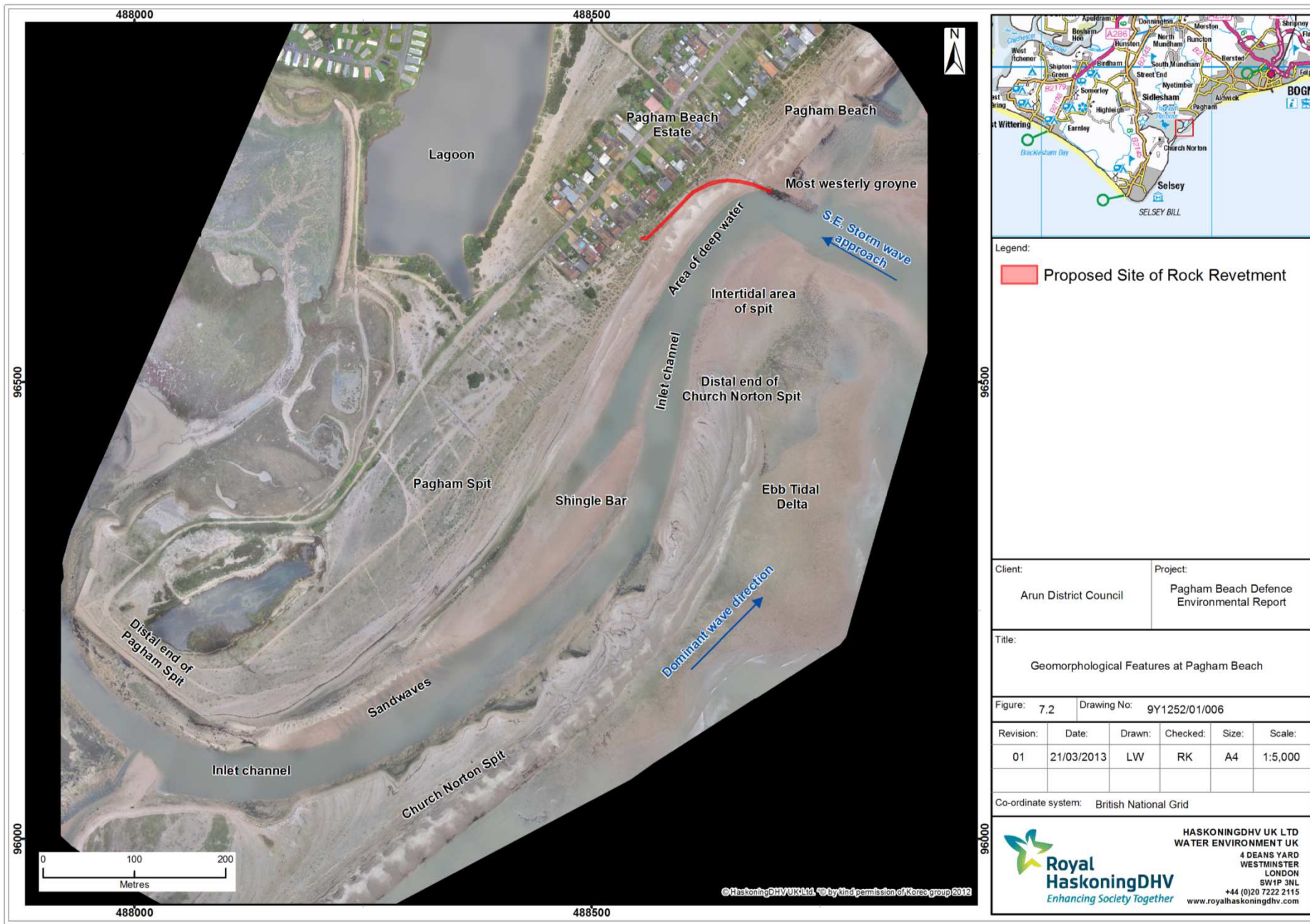
Tides in the Pagham area are semi-diurnal, with a mean spring range of 5.1m and mean neap range of 2.5m (**Table 7.1**). Tidal elevations measured outside of the inlet are slightly higher than those measured within the inlet. This suggests that the shape of the tidal inlet channel is restricting tidal flow into Pagham Harbour.

Table 7.1: Tidal levels for Pagham Harbour

Datum	Water Level (mCD)
Mean High Water Spring	5.6
Mean High Water Neap	4.3
Mean Low Water Neap	1.8
Mean Low Water Spring	0.5

The amount of water entering and leaving the inlet during each tide varies considerably over different timescales (e.g. the spring-neap tidal cycle), and can be significantly affected by weather conditions (e.g. surges). In addition, there are longer-term changes within the inlet that affect its tidal prism, such as erosion-accretion trends, sedimentation rates across intertidal areas and gradual changes in sea level.

Maximum nearshore tidal current velocities are between 0.5m/s and 0.75m/s. The dominant tidal current flow is from the south-west and flows parallel with the Pagham frontage. Pagham Harbour itself experiences tidal asymmetry, with shorter faster flood tide currents and longer weaker ebb tide currents. This results in an ebb-dominated tidal regime, with tidal currents generated by tidal exchange at the Pagham Harbour entrance.



7.2.3 Relative sea-level rise

Changes in global sea level, observed or projected, take into account the elevation of the water surface, caused by changes in the volume of the oceans, but do not take into account changes in land level. At a local scale, the elevation of the sea surface relative to the land is known as relative sea level.

Global sea level has risen approximately 1–2mm/year in the last one hundred years (IPCC, 2007). Haigh *et al.* (2009) analysed tide gauge records for sites along the UK south coast and estimated relative sea-level rise of 1.19-2.33mm/year (**Table 7.1**). By comparison, Shennan and Horton (2002) suggested a late Holocene (4,000 years ago to present day) relative sea-level rise (based on geological data) of approximately 0.6mm/year. This indicates that relative sea-level rise has increased in recent times compared to its rate over the geological long term.

Table 7.2: Relative sea-level rise for three UK south coast sites (Haigh *et al.*, 2009)

Site	Years of Data	Relative Sea-Level Rise (mm/year)
Southampton	1935-2005	1.19 +/- 0.24
Portsmouth	1962-2007	1.73 +/- 0.32
Newhaven	1942-2006	2.33 +/- 0.28

Lowe *et al.* (2009) combined estimates of global sea-level change around the UK coast (for a medium carbon emissions scenario) with vertical land movements to predict future relative sea-level rise over the 21st century. For the Pagham Harbour area they predicted a relative sea-level rise of approximately 0.5m by 2095. The Intergovernmental Panel on Climate Change's (IPCC) best estimate for relative sea-level rise in south-east England is 6mm/year (approximately 0.42m by 2080).

7.2.4 Wave climate

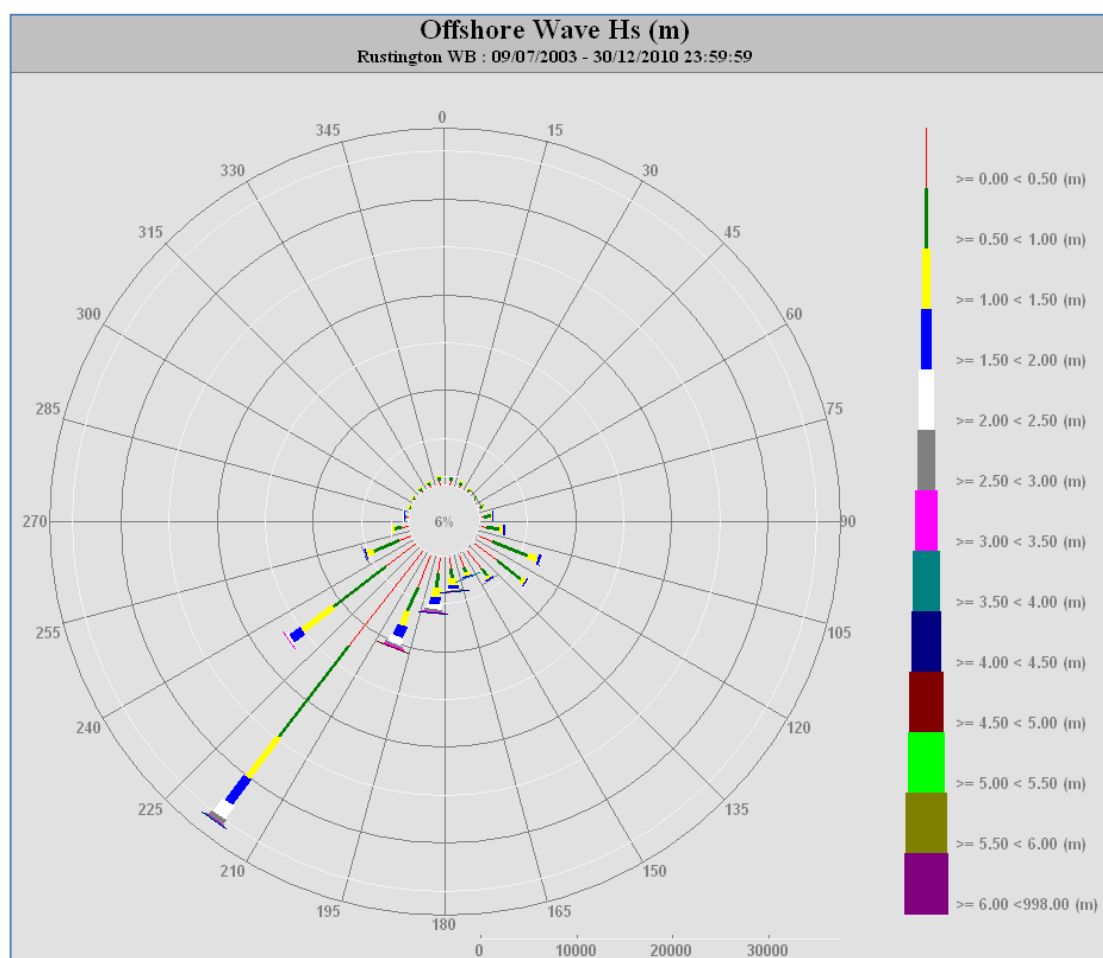
The Pagham coastline is orientated south-west to north-east. The offshore wave climate is dominated by waves from the south and south-west with periodic episodes of less energetic waves from the south-east. Therefore, when wave approach is from the south-west, wave crests are frequently perpendicular to the nearshore contours and shoreline. The narrow nature of the English Channel leads to a fetch limited condition over most of the Pagham frontage. Only waves incident from south of 225° have sufficient fetch to produce fully developed seas (Barcock and Collins, 1991). The coastline is thus subject to both Atlantic swells and waves generated locally in the English Channel.

The wave climate for any one location along the Pagham frontage is a result of complex relationships between offshore to inshore transformation as a function of shoreface width and water depth, seabed bathymetry, wave approach angles and interaction between wave and tidally-induced currents in the breaker zone. Given this complexity, it has been difficult to develop a quantitative wave climate. Inshore breaking wave heights, and incident angle of approach, directly control potential rates of longshore sediment transport.

Data collected between 2003 and 2010 as part of the South-east Strategic Regional Monitoring Project at the Rustington waverider buoy, offshore from Littlehampton approximately 15km east of Pagham Harbour, was analysed by the Environment Agency (2011). The monthly maximum and averaged significant wave height (H_s) data shows seasonal variability with higher waves recorded during winter months and lower waves during summer months. The data collected shows that the predominant wave direction during that period was from the south-west sector (**Figure 7.3**). The majority of waves originating from the south-west during this period, were under 1m in height. The highest waves recorded at the Rustington wave buoy were greater than 6m and originated in the south-south-west and the south-west.

The Pagham Harbour inlet channel is relatively deep in comparison to the water in front of Pagham Beach north of the groyne. Most of the inlet channel is oriented south-west to north-east, but changes direction to the south-east, where it is constrained by the most south-westerly groyne on Pagham Beach. As the tide rises, waves travel through the inlet channel opening, reaching the deep water within the inlet channel. Therefore, the energy which reaches the beach south-west of the groyne is greater than that to the north-east.

Figure 7.3: Wave rose showing wave heights, frequencies and directions recorded at the Rustington wave buoy between 2003 and 2010 [source: pers. comms. with James Bovington, Worthing Borough Council in June 2013].



7.2.5 Recent storm events

In the winter of 2012/2013 Pagham Beach was subject to a series of storm events which eroded the beach crest between the end of Church Norton Spit and the most westerly rock groyne. The erosion took place in front of the Pagham Beach Estate (see **Figure 7.2**), reducing the width of the beach frontage between the properties and the sea from approximately 25m to 16m. Between each of the storm events, Arun District Council carried out beach recycling, however, the recycled sediments were subsequently eroded by the following storm.

The storm events are described below and, although uncommon, took place at high water on a spring tide and so were exacerbated by the relatively deep water that was present close to the crest of Pagham Beach. On the ebb tide, the waves interact with the outgoing current causing them to break further away from the beach.

17th-18th October 2012

A moderate storm event occurred 17-18th October 2012. The event took place over night, on high spring tides, and comprised a moderate surge with waves of moderate height (between 1.5m and 4m) with a very wide spectrum of wave periods. The event in the early morning originated from 188° and required less refraction and dissipation of wave energy than at midday, when waves originated from the more common 215°. The morning event can be characterised as a bi-modal event, with both wind wave and swell wave components. The midday event was characterised by a wide spectrum of wave periods, but was an event of longer duration. The high water levels enabled the moderate waves to reach the beach resulting in draw down of the beach crest.

14th December 2012

Spring tide water levels with a small surge and a storm from the south-south-east occurred simultaneously on 14th December 2012. The water level and wave direction combined to encroach on Pagham Beach. The relatively uncommon waves coming from a south-south-easterly direction were able to access the beach directly along the channel between the south-westerly groyne and the north-eastern end of Church Norton Spit.

16th December 2012

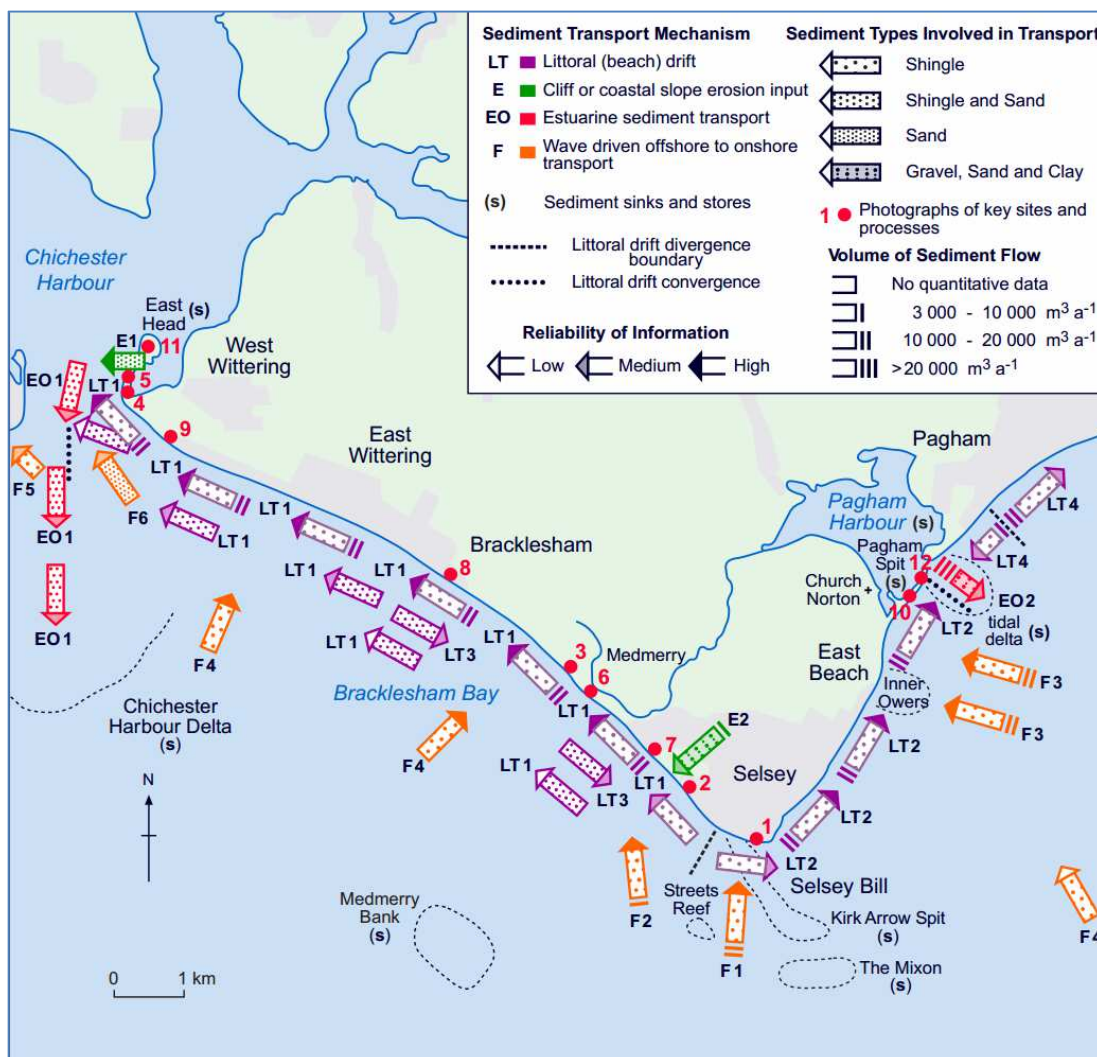
Although the event on 16th December 2012 had much lower wave heights than the event two days previously, and originated from the more common south-westerly direction, there was still a relatively wide spectrum of wave periods. The interaction of waves with different periods led to more energetic conditions.

7.2.6 Sediment transport

Longshore sediment transport between Selsey Bill and Pagham Harbour is to the north-east, driven by waves approaching predominantly from the south-west. There is also onshore transport which takes place south of the Pagham Harbour inlet channel. Bray et al. (2004) showed a divide in the longshore sediment transport along the Pagham Coast north-east of the inlet channel (**Figure 7.4**). The likely cause of the divide can be attributed to one or more of three dominant factors:

- refraction of waves around the end of Church Norton Spit causing divergence as they approach the shoreline;
- shelter provided by the spit and the ebb-tidal delta from waves approaching from the south-west resulting in a reversal of sediment transport direction; and
- differences in the annual balance of waves from the south and east.

Figure 7.4: East Head to Pagham sediment transport pathways (Bray et al., 2004)



The position and length of Church Norton Spit control the position of the divide, which is important to the morphology of Pagham Beach and to the risk of erosion and flooding for the properties landward of Pagham Beach. The coastline at the divide erodes because sediment is transported away to the south-west and north-east, resulting in a sediment deficit.

Church Norton Spit comprises a series of sub-parallel shingle ridges and re-curves, which mark the phased development of the landform. Church Norton Spit is a store for shingle supplied by longshore transport from the south-west and its position has fluctuated as this supply has changed. The spit crosses the entrance to Pagham

Harbour and extends to within approximately 40m of the south-westerly rock groyne on Pagham Beach. Some of the sediment transported into the inlet channel entrance by longshore sediment transport is mostly flushed seaward to form the ebb tidal delta.

The sediments which comprise Pagham Beach and Church Norton Spit are well-sorted sand and gravel (Geodata Institute, 1994). There are very low amounts of mud-sized sediment due to the high energy nature of the physical regime. The building of the shingle beach and migration of the spit is most likely the result of onshore-directed storm waves carrying large volumes of shingle from mostly offshore sources located between Selsey Bill and Church Norton (Bray *et al.*, 2004) followed by its transportation to the north-east. Offshore shingle sources to the beaches of this coastline include the Inner Owers; a series of mobile nearshore shingle banks between Selsey and Pagham (**Figure 7.1**). The shallow bathymetry of these offshore features subjects them to intense wave action, providing a mechanism by which shingle can be transported onshore.

The northern Pagham Spit is a product of counter transport, determined by the divide in the sediment transport routes north-east of the inlet (Bray *et al.*, 2004). Pagham Spit has previously been stabilised by a sheet pile retaining wall at what was its south-west end at the time, adjacent to inlet channel. The aim of the wall was to prevent migration of the spit towards the south-west, however, since the sheet pile wall was installed, the northern Pagham Spit has migrated and the retaining wall is now on the northern inside edge of the spit and the end of the spit is located further west into the Harbour.

The coastal structures already in place on Pagham Beach (east of the works area) constrain sediment transport. The most south-westerly groyne also constrains the Pagham Harbour inlet channel, which has been forced towards Pagham Beach by the Church Norton Spit as the spit has migrated north (see **Figure 7.8**). It appears that the Church Norton Spit is responsible for the formation of the bay on the northern bank of the Pagham Harbour inlet channel, as it has caused the beach to erode and consequently curve in shape (see **Section 7.2.8**). It appears that this process is mainly powered by tidal currents within the Pagham Harbour inlet channel, however, waves which enter the inlet channel during storm periods (as described in **Section 7.2.5**) exacerbate the erosion.

The shingle bar within the Pagham Harbour inlet channel has previously provided the source material for beach recycling activities carried out on Pagham Beach. The location of the shingle bar is shown in **Figure 7.2**.

7.2.7 Evolution of Church Norton Spit, the ebb-tide delta and Pagham Beach

A suite of digital terrain models (DTMs) for the coast at Pagham has been created by James Bovington of the Strategic Regional Coastal Monitoring Project Team at Worthing Borough Council (see **Figures 7.5 to 7.7**). The data was collected between March 2003 and February 2013 and focuses on the evolution of Church Norton Spit, the ebb-tide delta and Pagham Beach. The DTMs are compiled from various types of data and provide 'snap-shots' of the spits development over the 10 year period.

Between 2003 and 2005 the spit was fairly static (**Figure 7.5**). During this time a single inlet channel was located to the south-west of Pagham Beach Estate and the ebb-tidal delta was well developed. Church Norton Spit had not begun its advancement north-

east. After 2005, the spit grew rapidly to the north-east. Between April 2005 and January 2009 (**Figures 7.5 and 7.6**), the morphological development demonstrates a fairly linear extension to the north-east (parallel to the adjacent Pagham Beach shoreline) across the pre-existing ebb-tidal delta surface. The January 2008 and January 2009 DTMs show evidence for development of bifurcation of the inlet channel. The main 'northern' channel still ran parallel with Pagham Beach but a secondary 'southern' channel formed adjacent to the tip of Church Norton Spit (**Figure 7.6**).

A significant change to the spit took place between January 2009 and December 2009 (**Figures 7.6 and 7.8**). The December 2009 DTM shows that the direction of extension changed and the end of the spit began to migrate north towards southern Pagham Beach Estate in the form of a re-curve. The re-curve extension migrated over 100m north across the 'southern' channel blocking this as a passage for water entering and exiting Pagham Harbour. At the same time the northerly growth caused the 'northern' channel to curve inland towards Pagham Beach Estate. During 2010, 2011 and 2012 (**Figures 7.6 and 7.7**), and up to the latest DTM in February 2013, Church Norton Spit continued to migrate north forcing the inlet channel to migrate further to the north in front of the southern end of Pagham Beach Estate (**Figure 7.7**). In February 2013, the end of the spit was the closest it has been to Pagham Beach since the time series began in 2003.

7.2.8 Relationship between Church Norton Spit growth and width of Pagham Beach

James Bovington at Worthing Borough Council also undertook an analysis to determine how the northern growth of Church Norton Spit and the concomitant migration of the inlet channel to the north have caused narrowing of the beach berm in front of the southern part of Pagham Beach Estate. The distance from the mean high water contour to the front of the residential properties at Pagham Beach Estate has been compared with the rate of spit growth and its direction. The location of the analysis is shown in **Figure 7.9**, adjacent to the most westerly rock groyne.

The results (**Figure 7.10 and Table 7.3**) show that between 2003 and 2008 the average width of the beach berm in front of the residential properties was stable, varying from 73m to 83m. From 2009 to February 2013 the average width steadily decreased from 79m to about 47m in early 2013. This period of erosion correlates with the northerly growth of Church Norton Spit between 2009 and 2013.

Figure 7.5: Digital terrain models of Church Norton Spit and Pagham Beach, March 2003 to March 2007 [source: pers. comms. with James Bovington, Worthing Borough Council in June 2013].

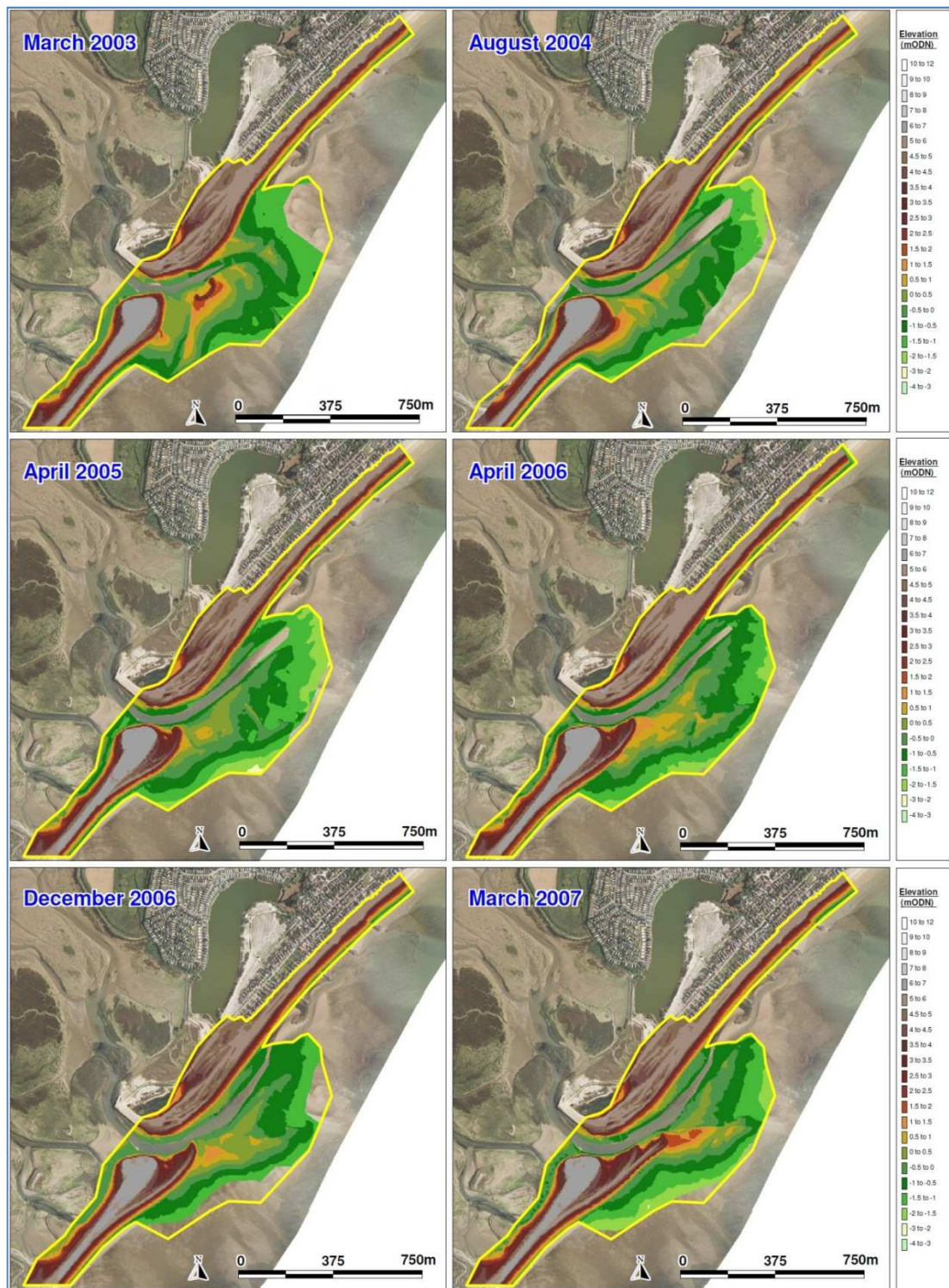


Figure 7.6: Digital terrain models of Church Norton Spit and Pagham Beach, January 2008 to February 2011 [source: pers. comms. with James Bovington, Worthing Borough Council in June 2013].

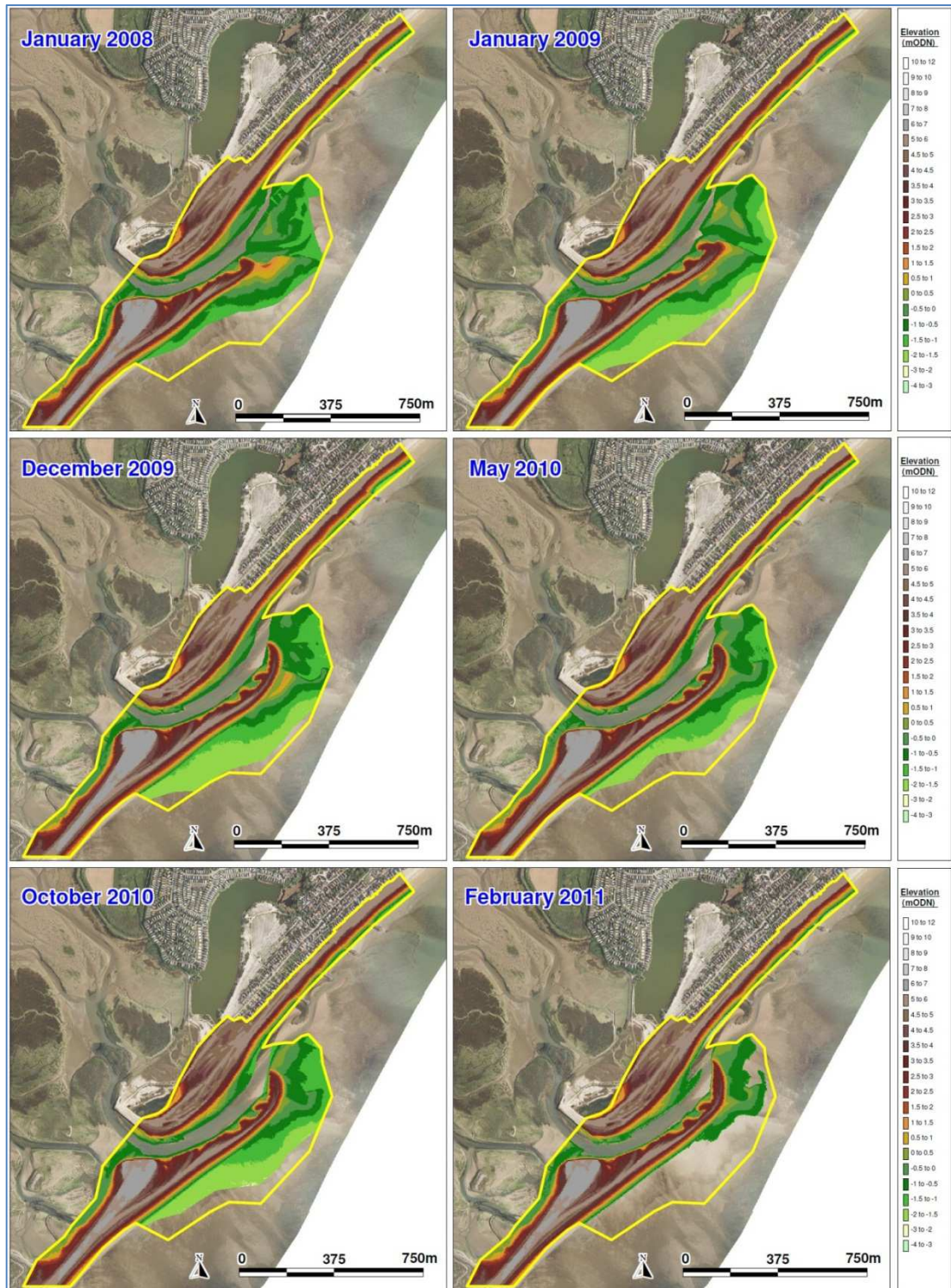


Figure 7.7: Digital terrain models of Church Norton Spit and Pagham Beach, September 2011 to February 2013 [source: pers. comms. with James Bovington, Worthing Borough Council in June 2013].

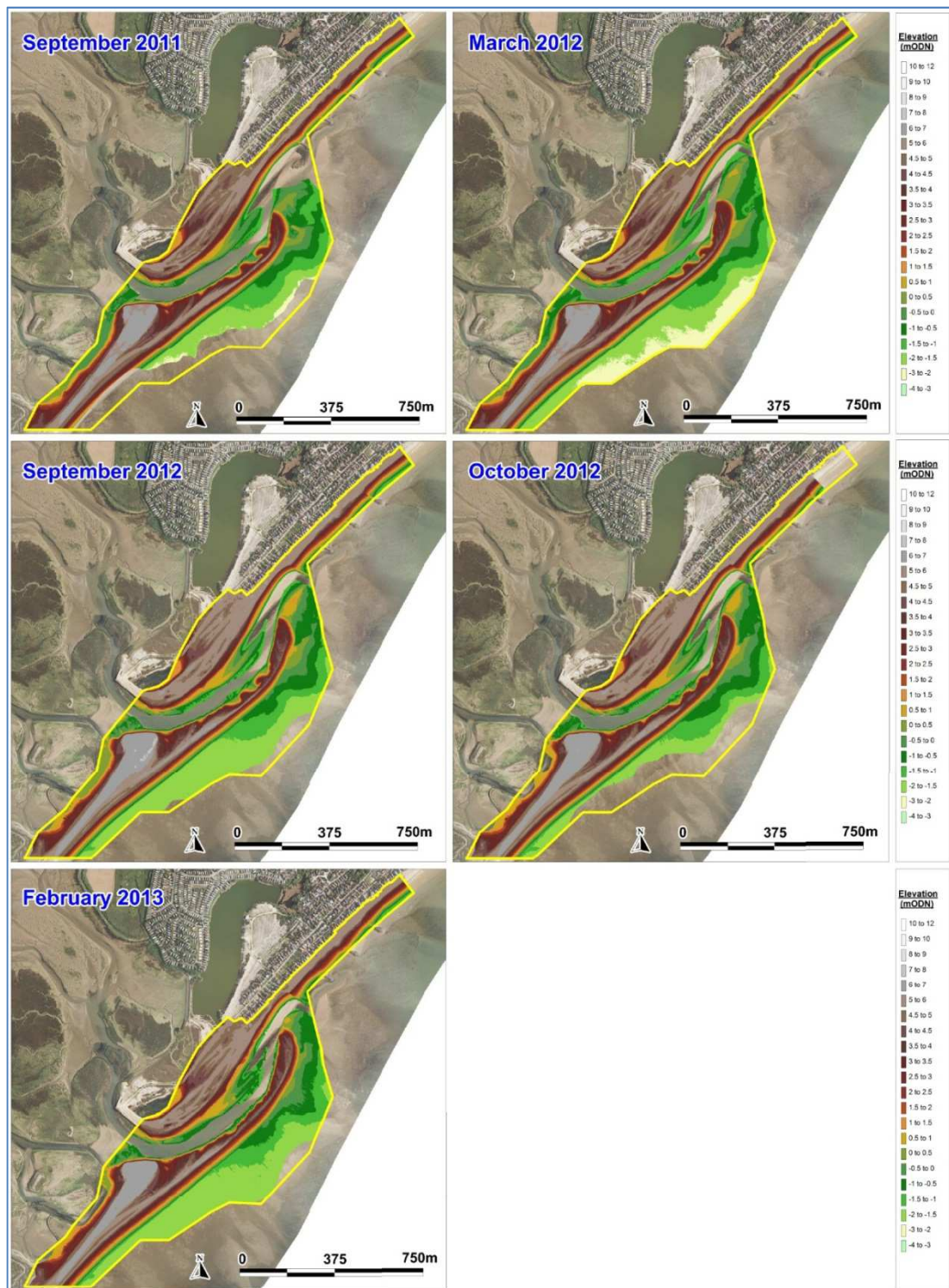


Figure 7.8: Growth of Church Norton Spit between 31/01/2009 and 01/12/2009 [source: pers. comms. with James Bovington, Worthing Borough Council in June 2013]

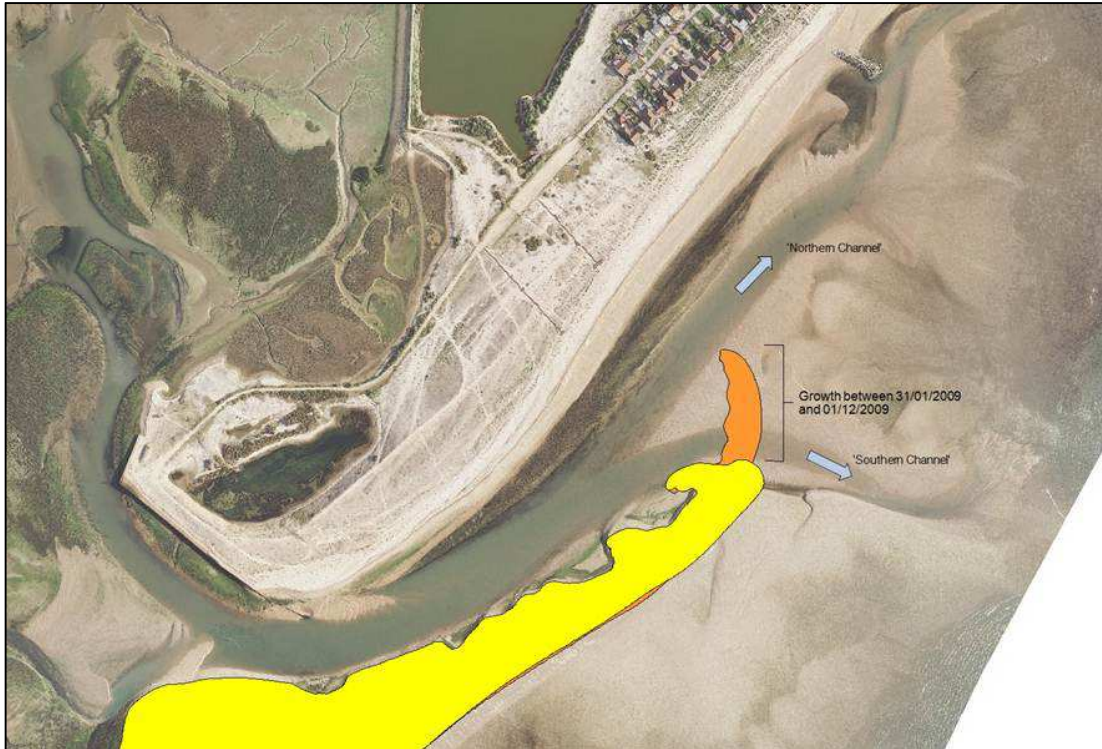
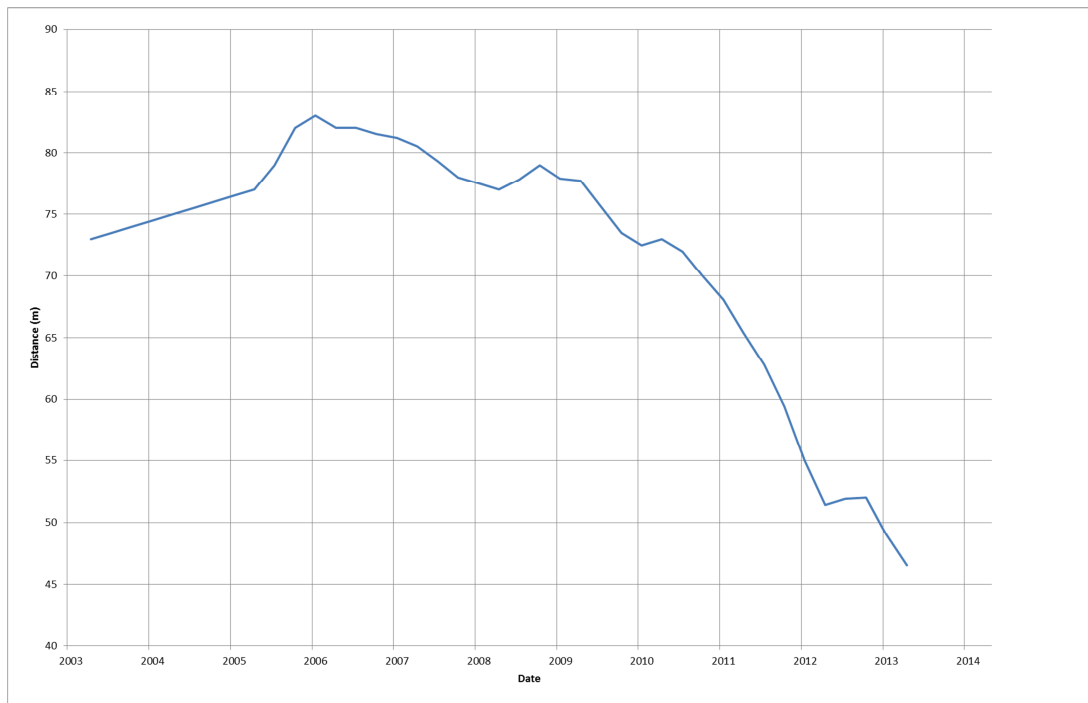


Figure 7.9: Location of analysis undertaken to determine the relationship between Church Norton Spit growth and the width of Pagham Beach [source: pers. comms. with James Bovington, Worthing Borough Council in June 2013].



Figure 7.10: Average distance in metres between mean high water and the residential properties at Pagham Beach between 2003 and 2013 [source: pers. comms. with James Bovington, Worthing Borough Council in June 2013].



7.3 Potential Effects during Construction

7.3.1 Changes to suspended sediment concentrations

Potential for increased suspended sediment concentrations due to construction traffic along Pagham Beach

During construction the potential exists for a temporary short-term increase in suspended sediment concentrations adjacent to Pagham Beach, north of the most westerly rock groyne. This is due to the proposed redistribution of the existing sand, shingle and gravel on Pagham Beach caused by the passage of construction vehicles and materials over the two middle groynes on the shorefront, as described in **Section 2.2.4**. However, the volume of fine sediment within the sediment on the beach is minimal and, as it would predominantly be coarse sediment which is redistributed, it is not anticipated that there would be any noticeable change in suspended sediment concentrations in the wider coastal area or within Pagham Harbour.

Table 7.3: Comparison of beach width and spit growth

Dates	Spit growth (m)	Growth direction (°N)	Comments on spit growth	Average berm width in front of houses (mean high water to front of properties) (m)	Comments on berm erosion
10/03/2003 to 22/08/2004	51	65	Growth to northeast	76	Berm width relatively stable
22/08/2004 to 22/04/2005	76	29		78	
22/04/2005 to 10/04/2006	62	52		83	
10/04/2006 to 08/12/2006	20	25		81	
08/12/2006 to 02/03/2007	139	55		81	
02/03/2007 to 06/01/2008	141	53		78	
06/01/2008 to 31/01/2009	130	55		79	
31/01/2009 to 01/12/2009	112	360	Change in growth direction to the north	73	Beginning of significant berm erosion due to northern growth of spit
01/12/2009 to 13/05/2010	6	21	Little growth	73	Erosion of berm continues
13/05/2010 to 11/10/2010	7	360		70	
11/10/2010 to 03/02/2011	44	350	Growth to north	68	
03/02/2011 to 28/09/2011	-43	142	Reduction to south	61	
28/09/2011 to 08/03/2012	56	15	Growth to north	52	
08/03/2012 to 05/09/2012	45	7		52	
05/09/2012 to 29/10/2012	13	13		52	
29/10/2012 to 26/02/2013	56	20		47	

Potential for increased suspended sediment concentrations due to the construction of rock revetment

During construction the potential exists for a temporary increase in suspended sediment concentrations in the Pagham Harbour inlet channel due to the displacement of sediment during the excavation of material from the beach in order to place the rock revetment. The total amount of extra backfill material required to infill behind the completed rock revetment is estimated to be approximately 1,000m³; hence it is proposed that the excavated material from the footprint of the revetment would be stockpiled on the beach and then used as backfill once the rock revetment has been completed. Given that the majority of sediment on the beach is coarse sediment and that these works would be carried out at low tide, it is not anticipated that there would be any noticeable change to the suspended sediment concentration in the wider coastal area, Pagham Harbour or the inlet channel due to these works.

Potential for increased suspended sediment concentrations due to extraction of sediment from the inlet channel shingle bar

During construction the potential exists for a temporary increase in suspended sediment concentrations in the Pagham Harbour inlet channel during the extraction of sediment from the shingle bar (see **Figure 2.3**). It is proposed that sediment from the shingle bar would be used as supplementary backfill material behind the rock revetment (should it be necessary), as the shingle bar has previously been the source for recycling events. It would only be possible to collect this sediment when the shingle bar is exposed at low tide, due to its position in the intertidal zone, and therefore only minimal quantities of suspended sediment would be released into the water of the inlet channel. In addition, given that there would only be a limited proportion of fine sediment within the shingle bar (as it is predominantly coarse sediment), it is predicted that there would be no effect on suspended sediment concentration levels within the inlet channel.

7.4 Potential Effects during Operation

7.4.1 Changes to hydrodynamics and sediment transport within the Pagham Harbour inlet channel

Potential for changes in tidal currents due to extraction of sediment from the inlet channel shingle bar

During the operation of the rock revetment at Pagham Beach there is the potential for changes to the tidal hydrodynamics within the inlet channel. This is due to the potential increase in the channel's cross-sectional area and subsequent reduction in current velocities, through the extraction of shingle from the shingle bar during construction to provide backfill to the rock revetment. The small increase in channel cross-sectional area would potentially unbalance the equilibrium of the Pagham Harbour tidal prism. However, this would naturally right itself as all channels strive towards equilibrium. Additionally, the increase in cross-sectional area would be minimal as the shape of the extraction zone is proposed to be long and thin (in line with the current), and only a small amount of sediment would be removed, to a very shallow depth. The reduction in current velocities within the inlet channel may reduce the amount of sediment the inlet channel is able to transport, causing deposition of sediment within the channel, infilling the area of excavation of shingle. Due to the small quantity of sediment proposed to be being excavated the adjustments would be rapid and, therefore, the effect on

hydrodynamics in the inlet channel would be minimal and temporary. Previous extractions in this area have had minimal impact.

Potential for erosion of Church Norton Spit due to wave reflection from the revetment

During operation, the waves approaching the frontage from the south-west would not enter the inlet because of the protection afforded by Church Norton Spit. However, waves approaching from the south-east could impinge on the rock revetment after they enter the inlet channel. There is then potential for partial reflection of the waves off the revetment directing them back towards the distal end of Church Norton Spit. This reflected wave energy could rework (and potentially erode) sediment from the landward side of the spit. Given that the revetment does not form a solid wall, and that spaces between the rocks would allow dissipation of much of the wave energy, the resulting effect on the opposite bank of wave reflection would be small. In addition, the predominant wave direction is from the south-west with only limited waves from the south-east.

Potential for beach erosion due to wave refraction at the edge of the revetment

During the operation of the rock revetment at Pagham Beach there is the potential for wave energy to be refracted at the south-west end of the revetment. There is the potential for this refraction to focus waves on to the adjacent unprotected area of beach to the south-west, where increased erosion might take place. However, given the length of the revetment into the inlet channel and the protection of its western end afforded by Church Norton Spit, it is unlikely that waves of a size capable of erosion would impinge on the south-west end of the revetment.

8 WATER AND SEDIMENT QUALITY

8.1 Introduction

This section considers water and sediment quality and the potential impacts of the proposed scheme on these parameters. The study area in terms of water and sediment quality is considered to be Pagham Beach, Pagham Harbour, Pagham Lagoon and Church Norton Spit.

8.2 Legislation, Policy and Guidance

8.2.1 International legislation

Many standards for water quality are regulated at EU level through a range of environmental directives. The most relevant of these to the proposed development are the:

- Water Framework Directive (2000/60/EC);
- Priorities Substances Directive (2008/105/EC), which is to replace the Dangerous Substances Directive (76/464/EEC);
- Habitats Directive (92/43/EC);
- Marine Strategy Framework Directive (2008/56/EC);
- Bathing Waters Directive (76/160/EEC); and
- Urban Waste Water Treatment Directive (91/271/EEC).

Water Framework Directive (WFD)

The WFD provides for the protection of water quality and ecological status of inland and coastal waters. It also provides a mechanism by which regulatory controls on potential impacts on water quality may be managed effectively and consistently across the European Union. Marine waters are split into two categories; transitional waters (estuaries and lagoons) and coastal waters up to one nautical mile from mean low water.

In England and Wales the WFD is implemented by the Water Environment (Water Framework Directive (England and Wales) Regulations 2003 (the Water Framework Directive Regulations). Existing regulations that will eventually be subsumed by the WFD that have a bearing on transitional and coastal waters include the Freshwater Fish Directive (78/659/EEC), Shellfish Waters Directive (79/923/EEC) and the Dangerous Substances Directive (76/464/EEC).

UK surface waters have been divided into a number of discrete units termed 'water bodies', dependent on typologies that relate to physical and ecological characteristics. Based upon ecology and water quality, these water bodies have been assigned different status classes. The WFD requires that all inland and coastal waters must reach at least 'Good status' by 2015 and that the status of all surface water bodies should not deteriorate. Individual water bodies may be categorised as Heavily Modified Water Bodies (HMWB) which should achieve 'good ecological potential'.

Priority Standards Directive

The Priority Standards Directive is to replace the Dangerous Substances Directive and establishes environmental quality standards (EQS) for (initially) 33 priority and priority hazardous substances. Compliance with these standards forms the basis of Good surface water chemical status under the WFD.

In England and Wales, implementation of the EQS Directive is via the 'River Basin Districts Typology, Standards and Groundwater threshold values' (Water Framework Directive) (England and Wales) Direction 2010 and the 'River Basin Districts Surface Water and Groundwater Classification' (Water Framework Directive) (England and Wales) Direction 2009. As well as implementing the standards for Priority and Priority Hazardous Substances, these regulations also set standards for specific pollutants. These are substances not covered by Europe-wide regulation but have been identified by the UK government as requiring control.

Habitats Directive

The Habitats Directive is designed to promote biodiversity by requiring Member States to take measures to maintain or restore natural habitats and wild species. The Directive is transposed into UK law under the Conservation of Habitats and Species Regulations 2010.

The Habitats Directive requires Member States to:

- maintain or restore European protected habitats and species listed in the Annexes at a favourable conservation status as defined in Articles 1 and 2; and
- contribute to a coherent European ecological network of protected sites by designating SACs for habitats listed on Annex I and for species listed on Annex II.

Together with SPAs designated under the Birds Directive, SACs form an integral part of the Natura 2000 conservation network.

Under the Habitats Directive, it is necessary to consider whether an activity is likely to have a significant impact alone or in combination with other plans, projects and activities. An assessment should be made to determine if an application will adversely affect the integrity of the European site. For significant discharges to a water body it is necessary to assess whether any hazard identified is likely to affect the interest features of the European site. Where possible the aim should be to avoid rather than reduce any adverse impact on the integrity of the European Sites. Natural England and Environment Agency guidance lists the following types of hazards for habitats, species and birds:

- toxic contamination;
- pH;
- siltation;
- turbidity;
- nutrient enrichment;

- physical damage;
- salinity;
- thermal regime; and
- organic enrichment.

Further information regarding the Habitats Directive is presented in **Section 6**.

Marine Strategy Framework Directive (MSFD)

The objective of the MSFD aims to achieve 'good environmental status' in Europe's seas by 2020, enable the sustainable use of the marine environment and to safeguard its use for future generations.

The MSFD establishes a comprehensive structure within which European Union Member States are required to develop and implement the cost effective measures necessary to achieve or maintain "good environmental status" in the marine environment.

The Directive establishes European Marine Regions and requires Member States to apply an ecosystem based approach to the management of human activities. The timetable for implementation of the strategy is from July 2010 through to December 2016. The Directive is implemented via the Marine Strategy Regulations 2010 and the Regulations will ensure the definition of environmental targets and indicators for marine waters by July 2012. No further information was available at this time.

In coastal waters out to one nautical mile, both the WFD and the MSFD apply. However, in these areas the MSFD only applies for aspects of good environmental status that are not already addressed by the WFD. These include issues such as the impacts of marine noise and litter, and certain aspects of biodiversity but not water quality.

Bathing Waters Directive

Bathing water quality is assessed by standards listed in the EC Bathing Waters Directive. The Directive was adopted by the Council of the European Communities in 1975 and updated in 2006. It was transposed into law for England and Wales to form the Bathing Waters (Classification) Regulations 1991 – updated in 2008 to The Bathing Water Regulations 2008. The Directive is concerned with the quality of bathing waters for the purpose of protecting public health and requires monitoring of microbiological parameters and a small number of physical parameters, e.g. visible oil.

The proposed works are planned for 2013 which would be prior to the change-over period from the current Bathing Water Directive (cBWD) to the revised Bathing Water Directive (rBWD). Until 2015, the compliance scheme of the cBWD will continue to be used. However, in 2015 the first classification of the rBWD will take place, based on data taken between 2012 and 2015 inclusive. The rBWD sets more stringent water quality standards. The main changes will include:

- changes to the microbiological parameters measured and a reduction in the general parameters currently monitored;

- a change from measuring compliance using the pass/fail approach to classification based on four classes: poor/sufficient/good/excellent;
- the requirement for all bathing waters to be classed as 'sufficient' by 2015; and
- the development of bathing water profiles for all bathing waters, and a general description based on the profile to be displayed at the bathing water location.

Urban Waste Water Treatment Directive

This Directive was adopted by Member States in May 1991 and transposed into legislation across the UK in 1994 to form the Urban Waste Water Treatment (England and Wales) Regulations. These regulations were amended in 2003. Its objective is to protect the environment from the adverse effects of sewage discharges. It sets treatment levels on the basis of sizes of sewage discharges and the sensitivity of waters receiving the discharges.

Shellfish waters

There are no shellfish waters in the vicinity of Pagham. The nearest shellfish waters are in Chichester Harbour to the east – a distance of at least 16km. Shellfish waters have therefore not been considered further due to the distance involved and the size of the proposed works.

8.2.2 National legislation

The Environment Agency is the principal regulator of water quality in England and Wales and has regulatory authority under the following water-related legislation:

- Environmental Permitting Regulations 2010.
- Environment Act 1995.
- Water Resources Act 1991.
- Environmental Protection Act 1990.
- Pollution Prevention and Control Act 1999.
- Surface Waters (Dangerous Substances) Regulations 1989.
- Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (the Water Framework Regulations).
- Marine Strategy Regulations 2010.
- Water Act 2003.
- Control of Pollution Act 1974.

8.2.3 National Policy

Marine Policy Statement (2011)

Section 2.6.4 of the Marine Policy Statement (MPS) - Ecological and Chemical Water Quality and Resources recognises that developments and other activities at the coast and at sea can have adverse effects on transitional waters, coastal waters and marine waters. During the construction, operation and decommissioning phases of

developments, there can be increased demand for water, discharges to water and adverse ecological effects resulting from physical modifications to the water environment. There may also be an increased risk of spills and leaks of pollutants into the water environment and the likelihood of transmission of invasive non-native species, for example through construction equipment, and their impacts on ecological water quality need to be considered.

The MPS states that the marine plan authority should satisfy itself where relevant that any development will not cause a deterioration in status of any water to which the WFD applies, subject to the provision of Article 4.7 of that Directive, or prevent compliance with any WFD obligation and is consistent with the requirements of daughter directives of the WFD including those on priority substances and groundwater. Decision makers should also take into account impacts on the quality of designated bathing waters and shellfish waters from any proposed development.

8.2.4 Regional Policy

The South-East River Basin District Management Plan (Environment Agency, 2009) has been prepared for the south-east district's rivers and coastal areas under the requirements of the WFD. The plan describes the river basin district, the pressures that the water environment faces and the actions that will be undertaken in order to address these pressures. It sets out what improvements are possible by 2015 and how the actions will make a difference to the local environment – the catchments, the estuaries and coasts, and groundwater. The study area for this scheme covers a number of water bodies and these are described in **Appendix A**.

8.3 Methodology and Approach to Environmental Assessment

8.3.1 Scope of assessment

In the Scoping Opinion received from the MMO in July 2013 Cefas agreed with the potential impacts identified in the Environmental Scoping Report and advised that due to the temporary and localised nature of the works it is unlikely that significant adverse impacts would occur to marine environmental receptors, including water and sediment quality.

8.3.2 Impact assessment methodology

The assessment methodology adopted for this parameter reflects the low level of concern with regard to potential impacts from the works on sediment and water quality due to their size, nature and location, as well as the type of sediment that is likely to be disturbed and also the type of material proposed for use and the location of its deposition. No in depth chemical analysis or assessment has been undertaken with regard to either water or sediment quality, however, water quality data collected by the Environment Agency's monitoring programme has been obtained and this has been used during the assessment.

Therefore the assessment has been carried out on a qualitative basis for both sediment and water quality.

Assessment criteria for sediment quality

Although this assessment is not quantitative, the assessment criteria set out below is referred to.

Unlike water quality, there are no quantitative EU or UK EQS values for sediments. The only pertinent guidance for sediment quality is given for most of the EC Dangerous Substances Directive List 1 substances and is defined as 'standstill (no deterioration)'; though this is not carried through into the WFD regulations. In the absence of any quantified UK standards, common practice for characterising baseline sediment quality conditions is to compare against two separate criteria sets:

- Cefas Guideline Action Levels for the disposal of dredged material; and
- Canadian Sediment Quality Guidelines for the Protection of Aquatic Life.

Cefas Guideline Action Levels are used as part of a 'weight of evidence' approach to assessing material suitability for disposal at sea, but are not themselves statutory standards. The majority of the materials assessed against these standards arise from dredging activities. These Action Levels are used in conjunction with a range of other assessment methods (e.g. bioassays), and other data to assess risk to the environment. The current levels are set out in **Table 8.1**.

Table 8.1: Cefas Guideline Action Levels for the disposal of dredged material

Cefas Action Levels		
Contaminant/Compound	Action Level 1	Action Level 2
	mg/kg dry Weight (ppm)	
Arsenic	20	100
Cadmium	0.4	5
Chromium	40	400
Copper	40	400
DBT (dibutyltin)	0.1	1
DDT (dichlorodiphenyltrichloroethane)	0.001	No AL2
Dieldrin	0.005	No AL2
Lead	50	500
MBT (mono-butyltin)	0.1	1
Mercury	0.3	3
Nickel	20	200
PAHs (individual compounds)	0.1	No AL2
PCB's, sum of 25 congeners	0.02	0.2
PCB's, sum of ICES 7	0.01	No AL2
Total hydrocarbons	100	No AL2

Cefas Action Levels		
Contaminant/Compound	Action Level 1	Action Level 2
	mg/kg dry Weight (ppm)	
TBT (tributyltin)	0.1	1
Zinc	130	800

Note - PAH – Polyaromatic hydrocarbons, PCBs – Polychlorinated biphenyls

Cefas guidance indicates that, in general, contaminant levels below Action Level 1 (AL1) are of no concern and are unlikely to influence the licensing decision. Material with contaminant levels above Action Level 2 (AL2) is generally considered unsuitable for disposal at sea. Dredged material with contaminant levels between AL1 and AL2 requires further consideration and testing before a decision can be made. The action levels should not be viewed as pass/fail thresholds.

The Canadian Interim Sediment Quality Guidelines (ISQGs) were developed by the Canadian Council of Ministers of the Environment for evaluating the potential for adverse biological effects in aquatic systems. They have been derived from available toxicological information, reflecting the relationships between sediment concentrations of chemicals and any adverse biological effects resulting from exposure to these chemicals. ISQGs exist only for a few metals.

Again, the ISQGs are not statutory standards and should be used with caution, with the findings being treated only as indicative. They were designed specifically for Canada and are based on the protection of pristine environments. But, in the absence of suitable alternatives it has become commonplace for these guidelines to be used by regulatory and statutory bodies in the UK, and elsewhere, as part of a 'weight of evidence' approach.

The Canadian guidelines are presented in **Table 8.2**, and comprise two assessment levels. The lower level is referred to as the threshold effects level (TEL) and represents a concentration below which adverse biological effects are expected to occur only rarely (in some sensitive species for example). The higher level, the probable effect level (or PEL), defines a concentration above which adverse effects may be expected in a wider range of organisms. The three ranges of chemical concentrations (<TEL, between TEL and PEL, and >PEL) indicate those concentrations that are rarely, occasionally and frequently associated with adverse biological effects, respectively.

Table 8.2: Selected interim marine sediment quality guidelines (ISQG)

Contaminant	ISQG/TEL	PEL	Incidence of Adverse Biological Effects		
			% ≤ ISQG	% between ISQG and PEL	% ≥ PEL
Metals in mg/kg dry weight					
Arsenic	7.24	41.6	3	13	47

Contaminant	ISQG/TEL	PEL	Incidence of Adverse Biological Effects		
Cadmium	0.7	4.2	6	20	71
Chromium	52.3	160	4	15	53
Copper	18.7	108	9	22	56
Lead	30.2	112	6	26	58
Mercury	0.13	0.7	8	24	37
Zinc	124	271	4	27	65
PCBs in µg/kg					
Total PCBS	21.5	189	16	37	55
PAHs in µg/kg					
Napthalene	34.6	391	3	19	71
Acenaphthylene	5.87	128	7	14	51
Acenaphthene	6.71	88.9	8	29	57
Fluorene	21.2	144	12	20	70
Phenanthrene	86.7	544	8	23	78
Anthracene	46.9	245	9	20	75
Pyrene	153	1398	7	19	83
Benz[a]anthracene	74.8	693	9	16	78
Chrysene	108	846	9	19	72
Benzo[a]pyrene	88.8	763	8	22	71
Dibenz[ah]anthracene	6.22	135	16	12	65

Note: All values taken from the Canadian Council of Ministers of the Environment (1999)

Assessment Criteria for Marine Water Quality

Specific guidance is provided below on the determination of receptor sensitivity (see **Table 8.3**) and impact magnitude (see **Table 8.4**) with respect to marine water quality. For the purposes of this section, sensitivity is considered to better represent marine water quality (than value per se), as water quality contributes to the value of ecological receptors.

Table 8.3: Criteria used to determine the sensitivity of marine water quality receptors

Sensitivity	Guidelines
High	Water quality of specific receptor site supports or contributes towards the designation of an internationally or nationally important feature and has a very low capacity to accommodate any change to current water quality status, compared to baseline conditions.

Sensitivity	Guidelines
Medium	Water quality of receptor site supports high biodiversity (not designated) and has low capacity to accommodate change to water quality status.
Low	Baseline conditions define an environment that has a high capacity to accommodate proposed change to water quality status, due for example to large relative size of receiving water feature and effect of dilution. Baseline water quality status generally poor or provides an environment by which significant dilution is available or background concentrations of certain parameters exist.
Very low	Specific water quality conditions of receptor water feature likely to be able to tolerate proposed change with very little or no impact upon the baseline conditions detectable.

Table 8.4: Criteria used to determine the magnitude of marine water quality effects

Magnitude	Guidelines
High	Very significant change to key characteristics of the water quality status of the receiving water feature. Water quality status degraded to the extent that permanent change and inability to meet (for example) Environmental Quality Standards for a large area outside of the accepted mixing zone is likely.
Medium	Significant changes to key characteristics of the water quality status taking account of the receptor volume, mixing capacity, flow rate, etc. Water quality status likely to take considerable time to recover to baseline conditions.
Low	Noticeable but not considered significant changes to water quality status of receptor water feature. Activity not likely to alter local status to the extent that water quality characteristics change considerably or EQS' are compromised. Activities are likely to have an impact for a short time scale (e.g. relative to turnover of water feature) and baseline water quality conditions are maintained.
Very Low	Although there may be some impact upon water quality status, activities predicted to occur over a short period. Any change to water quality status will be quickly reversed once activity ceases.

Where relevant, the description of the baseline conditions provided and the assessment of potential impacts includes comparison to relevant water quality assessment criteria. In summary these are:

- pre-WFD EQSs for marine water quality parameters;
- WFD EQS' for marine water quality parameters in areas designated as a WFD water body; and
- Probable No Effect Concentrations (PNECs).

The majority of the environmental standards used to assess the marine water quality offshore in the study area are those provided within the Directions for Transitional and Coastal ('TRaC') Waters (see **Table 8.6** for those relevant to the development) as determined by the WFD.

In addition to those standards specifically listed in **Table 8.6**, water quality must be maintained or improved to satisfy the conservation objectives of Natura 2000 sites. The use of the WFD EQS criteria in this assessment is considered appropriate to achieve this objective and protect marine ecological receptors in the study area.

8.4 Existing environment

8.4.1 Sediment quality

Information on sediment quality within the study area is sparse, with a search of publically available sources failing to acquire any data. In the absence of sediment quality data, the sediment characteristics of the study area and potential sources of pollutants have been considered to determine the potential for impacts on sediment quality associated with the proposed scheme.

As discussed in **Section 7.2.6**, Pagham Harbour contains a range of sediment types from muds to shingle, with sand and gravel the predominant sediment type. Fine grained sediments high in organic matter more readily adsorb contaminants than coarser particles, however, the Harbour is not industrialised and pollutant inputs are not believed to be sufficient to result in elevated contaminant concentrations in fine sediments present within the Harbour.

Church Norton Spit and Pagham Beach are characterised by steep upper beaches and shallower mid-beaches mostly composed of a flint shingle, which grades to coarse sand and granules on the extensive low gradient foreshore (Wallace, 1990; Barcock and Collins, 1991; Posford Duvivier, 2001). Due to the coarse nature of these sediments, the potential for contaminant accumulation within them is low. In addition Pagham Beach is open to the sea and sediments are likely to be well flushed. The material that may be disturbed during the construction of the rock revetment is therefore anticipated to be relatively low in potential contaminants. The material that is anticipated to be used for the backfill to the rock revetment would be sourced from the entrance to Pagham Harbour (see **Figure 2.3**) and is also therefore anticipated to be relatively low in potential contaminants.

None of the sediment to be disturbed or to be used as backfill is anticipated to exceed Cefas AL1 or the Canadian TEL (see **Tables 8.1** and **8.2**).

8.4.2 Water quality

Water quality data is predominantly collected by statutory organisations in response to legislative requirements. Data are then assessed against EQS which are designed to protect the environment and human health. In the Pagham area there are a number of applicable EC Directives which trigger a requirement for monitoring. These are listed below:

- EC Water Framework Directive (2000/60/EC);
- EC Bathing Waters Directive (2006/7/EC); and
- EC Urban Waste Water Treatment Directive (91/271/EEC).

Water Framework Directive

Classification schemes for both estuarine and coastal waters out to one nautical mile have been developed in response to the WFD. The scheme classifies the status of transitional and coastal waters using information on the ecological, chemical and hydromorphological quality of a body of water.

The Directive came into force in December 2000 and became part of UK law in December 2003 under the Water Environment (Water Framework Directive) (England and Wales) Regulations, 2003. The Directive seeks to protect and enhance the quality of:

- surface freshwater (including lakes, streams and rivers);
- groundwaters;
- groundwater dependant ecosystems;
- estuaries; and
- coastal waters out to one mile from low-water.

The Environment Agency requires an assessment to be carried out with regard to the WFD for projects that could have a non-temporary effect on the status of a water body. The assessment for this project was progressed through Stage 1 (screening) and Stage 2 (scoping) and its findings reported within the Pagham Beach Coastal Defences' Environmental Scoping Report (Royal HaskoningDHV, 2013). The conclusions of the screening and scoping assessment concluded that the relevant WFD Environmental Objectives would be met by the scheme and there would be no deterioration of status of any associated water bodies. No further work regarding WFD assessment was therefore anticipated and the WFD assessment was scoped out of further in-depth assessment. The WFD Compliance Assessment has been included in **Appendix A**.

Bathing Waters Directive

Bathing water quality is assessed by standards listed in the EC Bathing Waters Directive. The Directive is concerned with the quality of bathing waters for the purpose of protecting public health and requires monitoring of microbiological parameters and a small number of physical parameters, e.g. visible oil.

There are two types of microbiological standards set out in the Directive, namely the mandatory standards and the more stringent guideline standards.

The mandatory (minimum) standards are:

- 10,000 total coliforms per 100 ml of water; and
- 2,000 faecal coliforms per 100 ml of water.

For a bathing water to comply with the Directive, 95% of samples collected within a bathing season (15th May to 30th September) must meet these and the other physical criteria.

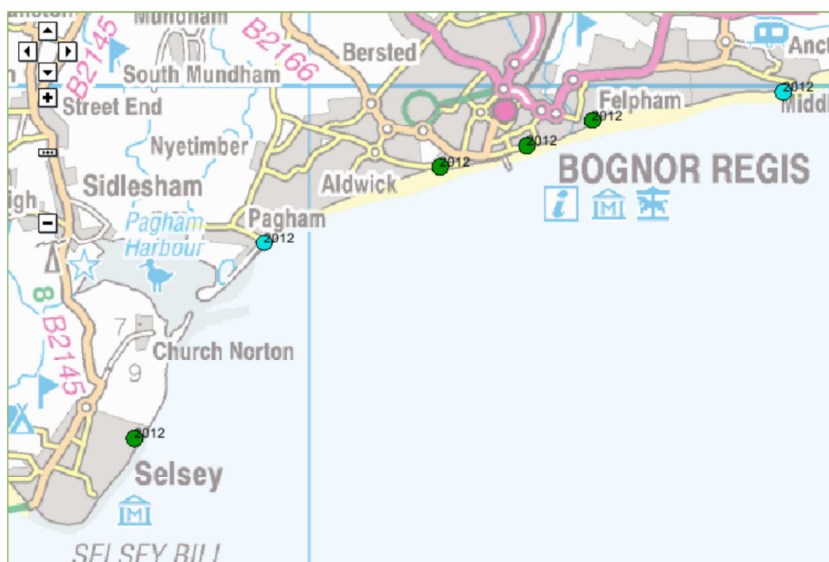
The guideline (higher) standards should be achieved where possible and are:

- 500 total coliforms per 100 ml of water (in 80% samples);
- 100 faecal coliforms per 100 ml of water (in 80% samples); and
- 100 faecal streptococci per 100 ml of water (in 90% samples).

Pagham Beach is a designated bathing water (see **Figure 8.1**) and the Environment Agency monitor water quality at a sampling location approximately 600m to the north-east of the proposed rock revetment. The bathing water faces south-east and is primarily a shingle beach but with some sand exposed at low water (Environment Agency, 2013). Since 2008 bathing water quality at this site has been classified as 'Higher'. Higher classification means that the bathing water meets the guideline standards.

There is a surface water outfall to the north of the bathing water which can adversely affect water quality in the area adjacent to the outfall after rainfall.

Figure 8.1: Bathing water designations in the vicinity of Pagham



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Key

Blue circles indicate higher quality where the bathing water meets the stricter Directive standards, and green circles indicate minimum quality where the bathing water meets the mandatory Directive standards.

Urban Waste Water Treatment Directive

The Directive's objective is to protect the environment from the adverse effects of sewage discharges. It sets treatment levels on the basis of sizes of sewage discharges and the sensitivity of waters receiving the discharges. Waters can be designated sensitive under the Directive for the following reasons:

- natural freshwaters, other freshwater bodies, estuaries and coastal waters which have a high level of nitrates. These can cause a high growth of algae and other plants which can affect species living in the water and the quality of

the water overall. These water bodies are called eutrophic. Areas which could become eutrophic if no action is taken are also covered. These are designated as Sensitive Areas (Eutrophic).

- surface freshwaters used for drinking water that could contain more nitrates than allowed by EC directive on drinking water. These are designated as Sensitive Areas (Nitrate).
- areas where the water needs treatment further to secondary treatment to fulfil the requirements of other EC directives. These are designated as Sensitive Areas (Bathing Waters) and Sensitive Areas (Shellfish waters).

Where areas are identified as sensitive (Eutrophic), additional treatment is required for discharges from sewage works serving communities with populations greater than 10,000. For discharges to estuarine waters, additional treatment usually involves reduction of nitrogen levels to standards set out in the Directive.

Pagham Harbour is designated as a sensitive area (Eutrophic). This means Pagham Harbour is either eutrophic or could become so in the near future without tertiary sewage treatment protection (Defra, 2012).

Shellfish waters

There are no shellfish waters in the vicinity of Pagham.

General water quality information

Pagham Beach is an open coastline dominated to the south-west by the advancing spit. Pagham Harbour is tidal and connects to the sea and Pagham Beach via a small channel highly influenced in shape and length by the spit.

Pagham Harbour provides land drainage for the surrounding river catchment via four main tributaries: Broad Rife; Bremere Rife; Keynor Rife; and Pagham Rife, supplemented by runoff from the surrounding agricultural land (Environment Agency, 2011). Pagham sewage treatment works and Siddlesham sewage treatment works discharge treated effluent into Pagham Harbour via Pagham Rife and Broad Rife respectively (Environment Agency, 2011). The Environment Agency reports that both are several kilometres from Pagham Harbour and the discharges are designed to present minimal risk to water quality.

The water quality data for Pagham and the surrounding area has been largely derived from monitoring carried out in response to the WFD, Bathing Water and UWWT Directives by the Environment Agency.

Environment Agency water quality data

The following overview is provided from the Environment Agency's water quality datasets from 2008 to 2013.

Salinity

Environment Agency Water Quality data for the years 2008 to 2013 found that the annual range in salinity in Pagham Lagoon and Pagham Harbour ranged from 22 to 35

ppt, with an average of 33.8 ppt. Salinity in the Pagham Beach area tends to remain at around 32 to 35 ppt.

Temperature

Environment Agency Water Quality data for the years 2008 to 2013 found that the annual range of water temperature for Pagham Lagoon and Pagham Harbour is bound by a lower limit of 4°C (winter) and an upper limit of 20°C (summer) with occasional values exceeding these limits. For the area of Pagham Beach the temperature range recorded during the bathing season (15th May to 30th September) is 11°C to 22°C.

Dissolved Oxygen (DO)

Measurements of oxygen in Pagham Lagoon and Pagham Harbour for the years 2008 to 2013 record dissolved oxygen concentrations of between 2.14 mg/l (August reading) and 15.4 mg/l (April reading). Percentage dissolved oxygen saturation varies throughout the year with a percentage saturation range of between 23% and 150%, with no discernible seasonal pattern.

No DO data is available for the Pagham Beach area but this would be anticipated to be relatively high due to the open nature of the coast and the lack of organic material and industrialisation.

Nutrients

Nutrient additions to estuaries and coastal waters occur both naturally and as a result of geological weathering, atmospheric deposition and nitrogen fixing by plants. Growth of human populations has led to increasing inputs of nutrients from sources such as agriculture, wastewater treatment plants, urban run-off and consumption of fossil fuels. As a result, elevated nutrient levels are now considered to be one of the greatest threats to coastal ecosystems as the associated phytoplankton growth can impact on dissolved oxygen levels, pH, and turbidity.

Nutrients are a particular problem for Pagham Harbour and it has been designated as a 'Sensitive Area' under the UWWT (England and Wales) Regulations. The wider Pagham Beach area is not identified as a 'Sensitive Area'.

Nitrogen and phosphate measurements for Pagham Lagoon and Pagham Harbour are recorded in several ways. Ranges are provided below for 2008 to 2013:

- nitrates (filtered) – range <0.063 mg/l (August reading) to 6.35mg/l (November reading) with an average reading of 0.55 mg/l.
- nitrites (filtered) – range <0.0007 mg/l (August reading) to 0.441 mg/l (February reading) with an average reading of 0.016 mg/l.
- dissolved inorganic nitrogen – range <0.014 mg/l (August reading) to 0.683 mg/l (January reading) with an average reading of 0.23 mg/l.
- ammonia - range <0.03 mg/l (August reading) to 2.16 mg/l (July reading) with an average reading of 0.29 mg/l.
- orthophosphates (filtered) - range <0.02 mg/l (August reading) to 0.336 mg/l (February reading) with an average reading of 0.035 mg/l.

Suspended sediments

Environment Agency Water Quality data for the years 2008 to 2013 show that the annual range of suspended solids for Pagham Lagoon and Pagham Harbour is bound by a lower limit of <3mg/l and an upper limit of 39mg/l, with occasional values exceeding the upper limit.

No suspended sediment data is available for the Pagham Beach area.

Metals

Water quality monitoring data collected for the period 2008 to 2013 is presented in **Table 8.6** below alongside the relevant Environmental Quality Standard for that parameter.

Table 8.6: Water quality standards used to assess marine surface waters in the study area and water quality data for Pagham Lagoon and Pagham Harbour and the wider Pagham Beach area (Environment Agency, 2013)

Parameter	WFD TraC EQS	Water Quality in Pagham Lagoon and Pagham Harbour 2008 - 2013	Water Quality in the wider Pagham Beach area 2008 - 2013
Dissolved arsenic (filtered) (µg/l)	25 A	<1 - 1.3	No data available
Dissolved cadmium (µg/l)	0.2A and 1.5 MAC	< 0.4 – 0.1	No data available
Dissolved chromium (filtered) (µg/l)	0.6A, 32MAC (P) for chromium VI	< 0.5 – 0.66	No data available
Dissolved copper (filtered) (µg/l)	5 A	2.9 – 4.6	No data available
Dissolved lead (filtered) (µg/l)	7.2 A	<0.04 - <2	No data available
Dissolved mercury (filtered) (µg/l)	0.05 A and 0.07 MAC	< 0.01 – <0.1	No data available
Dissolved nickel (filtered) (µg/l)	20 A	0.337 – 5.6	No data available
Dissolved zinc (filtered) (µg/l)	40 A	0.5 - 8.36	No data available

Parameter	WFD TraC EQS	Water Quality in Pagham Lagoon and Pagham Harbour 2008 - 2013	Water Quality in the wider Pagham Beach area 2008 - 2013
Un-ionised ammonia as N (mg/l)	21 A	0.03 - 2.16	No data available
Dissolved inorganic nitrogen (mg/l)	180-270 (P99)	0.014 – 0.683 with an average of 0.23	No data available

Notes: A – annual average; P95 95 percentile; P99 99 percentile; MAC – Maximum allowable concentration

Other Pollutants

Fossil fuel combustion, urban run-off, shipping, Sewage Treatment Works and various diffuse discharges from industrial areas are also sources of pollutants, such as hydrocarbon compounds (includes PAH). These generally associate with sediments, rather than the water, due to their low solubility. However, as already discussed it is anticipated that the sediments in the study area are relatively low in contaminants.

8.5 Potential Impacts during Construction

8.5.1 Potential impacts on sediment quality due to resuspension and deposition of sediment during the works

There is the potential for sediment to be resuspended during the works in terms of the construction of the rock revetment, the collection of the backfill material and also the backfilling behind the rock revetment.

Any resuspension of sediment caused by the works would be small in scale, short term and highly localised. The sediment has been qualitatively assessed as relatively low in contaminants and would be expected to be coarse in nature with a mixture of sands, shingle and gravels. The sediment is anticipated to contain a very low silt content.

The resuspended sediment, therefore, is not expected to be contaminated and due to the particle size of the material would quickly fall back out of suspension. The potential impact on sediment quality within the vicinity of the proposed works is therefore anticipated to be **negligible**.

8.5.2 Potential impact on water quality due to the resuspension of contaminants

The sediment has been described as relatively low in contaminants due to its location and particle size. Currently the water quality in Pagham Harbour and Pagham Beach is within the WFD EQS used by the Environment Agency to assess marine surface waters. Any resuspension of sediment would be highly localised, small in scale and short term. Hence it is not envisaged that the works would cause the WFD EQS to be exceeded or for the water quality in Pagham Harbour or Pagham Beach to decline as a result of the

proposed works. The potential impact on water quality as a result of resuspension of contaminants is therefore anticipated to be **negligible**.

8.5.3 Potential impact on water quality due to increases in suspended sediment

The amount of suspended sediment that is predicted to result during the construction phase of the works is very small in scale, short term and highly localised. Suspended sediment concentrations within Pagham Lagoon and Harbour typically range from <3mg/l to 39mg/l. No suspended sediment data is available for the Pagham Beach area.

Research indicates that suspended sediments resulting from large scale beach nourishment schemes would only be localised and temporary in seawater (Ciria, 2010a) and therefore, any suspended sediments arising from this rock revetments would be minimal.

Any elevations above these background levels, therefore, would be short term and highly localised. Given this the potential impact on water quality due to increases in suspended sediment is anticipated to be **negligible**.

8.5.4 Potential impact on water quality due to resuspension of nutrients

Pagham Harbour is an enclosed area of tidal water containing silty sediments and is a designated Sensitive Area with regard to the UWWT Directive, indicating that it is either eutrophic or could become eutrophic. Nutrient levels within the Harbour as opposed to the wider Pagham Beach area are detailed under Nutrients in **Section 8.4.2**.

The area of the works is not within Pagham Harbour itself but on the Pagham Beach, where the sediments are much coarser and the marine waters are fully flushed by the tide. It is not therefore expected that the sediments that would be disturbed by the works would contain high levels of nutrients. Any nutrients that may be contained within the disturbed sediments would be quickly mixed and diluted by the tidal waters. Any nutrients that might be suspended into the water column would either be taken out with the tide and mixed with the open sea, or mixed and diluted to such an extent by the time the water reaches Pagham Harbour as to be negligible in terms of increasing any nutrient concentrations already present. The potential impact on water quality due to resuspension of nutrients is therefore anticipated to be **negligible**.

8.5.5 Potential impacts on sediment and water quality through accidental spillages

As is the case for most construction works that take place in and near to the marine environment, there is the potential for accidental releases of substances into the environment to result in a pollution incident. For the proposed works, it is considered that the potential exists for spillages and leaks from construction machinery (e.g. oil, fuel, lubricants) to occur, which could result in the contamination of the adjacent sediments and water. The implications of a pollution incident are highly dependent on both the nature of the substance released and the species that would be affected.

As it is difficult to quantify the amount (and nature) of any spillages or leakages into the marine environment, it is not possible to predict the significance of the potential impacts.

However, the risk of a pollution incident occurring and impacting upon the sediments and water can be controlled through the implementation of the mitigation measures, outlined in **Section 8.7**.

8.6 Potential Impacts during Operation

Once the rock revetment is in place and the backfill completed no further impacts on water and sediment quality are anticipated.

8.7 Mitigation and Residual Impacts

All potential impacts have been predicted to be of negligible significance. For these impacts no mitigation is proposed and, therefore, the residual impacts would remain **negligible**.

In order to reduce the risk of accidental spillages and/or leaks the following mitigation measures are suggested.

Mitigation
- Construction works should be carried out in accordance with the Environment Agency's Pollution Prevention Guidelines (PPG) No. 5 on Works and Maintenance In or Near Water, PPG No. 6 on Working at Construction and Demolition Sites; PPG1 General Guide to the Prevention of Pollution, and; PPG8 Safe Storage and Disposal of Used Oils; - The Oil Care Code should be followed; - CIRIA's Environmental Good Practice on Site (CIRIA, 2010b) should be followed; - Ensure all wastes generated on site are removed in a timely manner; - Materials and containers giving rise to possible spills or contamination of the surrounding environment must be taken from site to be processed at a licensed facility; - Plant should be maintained regularly and drip trays used to prevent pollution from plant used near the sea; - Any pollution incidents should be reported immediately to the Environment Agency on the emergency hotline (0800 807060); - Ensure that the workforce is trained in preventing and dealing with pollution incidents; and - Ensure that machinery is moved onto the intertidal only where necessary and care should be taken to minimise the area of intertidal used for demolition and construction activities.

The risk of a significant spill and/or leak can be minimised by following standard good practice (as identified above) in line with the appointed contractor's environmental management plan. Appropriate implementation of the proposed mitigation would reduce the risk associated with accidental spillages and/or leaks to a negligible level.

9 MARINE ECOLOGY

9.1 Introduction

This section considers the proposed scheme in the context of marine ecology, namely benthic invertebrates. Fish and shellfish are considered within **Section 10**, marine mammals within **Section 11**.

The study area for marine ecology is considered to be a 2km radius from the site, which includes the Pagham Harbour and Bognor Reef designated sites along with Church Norton Spit, Pagham Lagoon and Pagham Beach, as well as the nearshore intertidal and subtidal communities.

9.2 Existing environment

Baseline conditions are described for the different areas around Pagham in order to identify the variety of habitats which are present. The location of these habitats is illustrated on **Figure 1.2**.

9.2.1 Pagham Harbour

Pagham Harbour is designated for its intertidal habitats of saltmarsh and mudflats with surrounding habitats including shingle, reed swamp and wet permanent grassland (Natural England, 1980). Pagham Harbour supports nationally important communities of plants and invertebrates. The mudflats are rich in algae and invertebrates and provide important feeding areas for birds. The saltmarsh habitat is dominated by common cord-grass *Spartina anglica* in the lower shore with patches of glassworts *Salicornia* spp. Above this zone, sea-purslane *Halimione portulacoides* covers large areas with other species such as sea aster *Aster tripolium* in the periphery (Natural England, 1980).

The lower levels of the intertidal flats at Pagham are occupied by algal mats of *Enteromorpha* spp., with a small area of seagrass at the southern end of Pagham Harbour which makes up a very small proportion of the national total (Sussex Biodiversity Partnership, 2004). Two species of seagrass are encountered, *Zostera. Noltii* and *Z. angustifolia* (Sussex Biodiversity Partnership, 2004).

The Harbour mudflats are rich in invertebrates, particularly polychaetes such as the lugworm *Arenicola marina* and the ragworm *Nereis diversicolor*, which provide important feeding areas for fish and birds.

Mobile species found within the Harbour include shore crabs *Carcinus maenas*, pipefish (Syngnathinae), gobies (Gobiidae), butterflyfish *Pholis gunnellus*, eels *Anguilla anguilla* and cuttlefish (Sepiida) (refer to **Section 10** for further details of fish species).

Pagham Harbour and Church Norton Spit also include 42.4 hectares (ha) of vegetated shingle (Randall, 1997). Vegetated shingle is a nationally rare habitat type, and is listed as a habitat of international conservation importance in Annex I of Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna (the EC Habitats Directive). Vegetated shingle is important for the unusual assemblages of species which it supports, including rare plants, invertebrates and ground nesting birds.

It also often borders and protects other important natural habitats, such as sandy beaches, salt marshes and saline lagoons.

Sussex has approximately 800ha of vegetated shingle (approximately 15% of the resource within Britain) including the fringing beaches at Worthing, Shoreham and Pevensey Bay, and structures such as Church Norton Spit and Pagham Spit, which fall within Pagham Harbour SSSI

9.2.2 Pagham Lagoon

Pagham Lagoon in the east of the Harbour is located within an in-filled palaeochannel of a former tidal inlet to the Harbour and is situated behind Pagham Beach, beyond the road and residential properties (see **Figure 1.2**).

Saline lagoons are listed on Annex I of the Habitats Directive and are also covered by a specific Habitat Action Plan under the UK Biodiversity Action Plan. They are important for both the plant and invertebrate communities that they support.

Pagham Lagoon possesses characteristic invertebrate fauna that show little regional variation, for example, the lagoonal snails *Hydrobia ventrosa* and *Littorina tenebrosa* and the lagoonal isopod *Idotea chelipes* (Bamber and Barnes, 1997). The nationally endangered starlet sea anemone *Nematostella vectensis* is also found in Pagham Lagoon. This species is protected under Section 5 of the Wildlife and Countryside Act 1981 and is a nationally important species within the Pagham Harbour Ramsar site (JNCC, 1988).

There is also another lagoon at Pagham, known as Pagham Little Lagoon, which is located at the end of Pagham Spit around the original Harbour entrance (refer to **Figure 1.2**). The species present within this lagoon are similar to those recorded within the Pagham Lagoon, with the exception of *Nematostella vectensis*.

9.2.3 Church Norton Spit and Pagham Beach

Church Norton Spit and Pagham Beach are characterised by steep upper beaches and shallower mid-beaches mostly composed of a flint shingle, which grades to coarse sand and granules on the extensive low gradient foreshore (Wallace, 1990; Barcock and Collins, 1991; Posford Duvivier, 2001). As the steep upper intertidal section of the shingle/gravel beaches are characterised by large interstitial spaces precluding the retention of water during low tide, there is little suitable habitat within the beach for organisms, particularly as the coarse sediments tend to be highly mobile.

The looping snail *Truncatella subcylindrica*, a nationally rare species (though not protected), is found in the upper sections of shingle beaches amongst plants and fine sediment at a depth of 15cm, and more rarely in muddy habitats under stones at the high water mark (Plaza, 1997). This rare species has been found at Pagham Beach, (although away from the proposed area of works) as well as in three other locations to date: the Isle of Wight, The Fleet in Dorset and St Mawes Bay in Cornwall (White, 2008).

The mid to lower intertidal sections of Pagham Beach (and in some locations on Church Norton Spit and the ebb tidal delta) consist of a range of sediments from muds to

shingle, predominantly sand and gravel, colonised by a diverse array of macroalgal species. The mid intertidal is covered in a wide band of green algae (e.g. *Ulva lactuca* and *U. intestinalis*), interspersed with tufts of brown fucoid species (e.g. *Fucus spiralis* and bladder wrack *F. vesiculosus*).

There are areas of the lower intertidal where the sediments are stable enough to be colonised by brown and red algal species, with shallow pools of water where there are undulations in the sediment. Brown algae such as bladder wrack and knotted wrack *Ascophyllum nodosum*, and red algae such as Irish moss *Chondrus crispus* and false Irish moss *Mastocarpus stellatus* are very common, providing shelter for marine fauna such as shore crabs, periwinkles, shrimps and gobies – all of which are prey items for feeding birds.

9.2.4 Coastal subtidal environment

From Selsey Bill to Bognor Regis, the nearshore subtidal seabed predominantly consists of mixed sediments and sand (Irving, 1997).

Typical species on mixed sediments and sand would include sandmason worms *Janice conchilega*, anemones *Urticina feline* and *Cerianthus lloydii*. Mobile species would include the predatory gastropod molluscs *Buccinum undatum* and *Hinia reticulata*, occasionally starfish (e.g. *Asterias rubens*) and brittle stars (e.g. *Ophiothrix fragilis*), and commercially important species such as the common lobster *Homarus gammarus*, the edible crab *Cancer pagarus* and the spider crab *Maja squinado*. Several sublittoral species reach their easternmost extent of their distribution within Sussex waters. These include the rocky reef species such as jewel anemone *Corynactis viridis*, the Devonshire cup coral *Caryophyllia smithii* and the bryozoan *Pentapora foliacea*. Several non-native species have also become established, such as slipper limpet *Crepidula fornicata* (large quantities of empty shells exist in the strandline on Pagham Beach) and the stalked ascidian *Styela clava* (Irving, 1997). The Solent and Isle of Wight Sensitive Marine Area (SMA) is a recognised site of importance within the region, and extends as far east as Pagham Harbour (English Nature, 1994).

9.3 Potential Impacts during Construction

The proposed construction of the rock revetment and associated works may lead to impacts upon the intertidal and subtidal marine ecology along the Pagham Beach frontage and the surrounding area. These are considered in the sub-sections below.

9.3.1 Potential loss of coastal habitat due to construction activities on the beach

Potential for habitat loss through the placement of rock on the foreshore

The proposed scheme planned at Pagham Beach would involve a small amount of excavation to prepare the ground prior to laying the rock revetment on the foreshore adjacent to the most westerly groyne on Pagham Beach (see **Figure 2.2**).

This excavation and then the subsequent placement of rock would result in the direct removal of the superficial layers of shingle in the intertidal area, redistribution of coarse sediment and direct smothering and/or permanent loss of benthic fauna at the placement site.

The upper section of the shingle beaches and shallower mid-beaches at Pagham currently represent suitable habitat for benthic fauna. . Specifically the project has the potential to impact on the nationally rare looping snail and the critically endangered starlet sea anemone. However, according to previous studies carried out for the Pagham Coastal Defence Scheme (Royal Haskoning, 2009b), the intertidal areas along Pagham Beach, though part of the designated site (see **Section 6.7**), are in themselves not considered to be highly sensitive (i.e. in terms of marine species present); and both the looping snail and the starlet sea anemone are located away from the direct footprint of the works and are unlikely to be impacted.

The area where the rock revetment would be constructed has been disturbed by the recent erosive storms occurring over the winter period (see **Section 1**) and by the previous shingle recycling work undertaken to support eroded defences (Arun District Council, 2013). The impact of placing the rock revetment, therefore, would have less impact than if the rocks were placed directly onto undisturbed functioning intertidal shingle sediment. In addition, the sediment has been eroded down to the consolidated sediment within the intertidal area. Consequently the presence of benthic fauna is expected to be diminished within this area. Should the rock revetment not be constructed, the erosion would continue, resulting in continued loss of habitat.

The area of intertidal likely to be damaged is small in the context of the overall area of colonised intertidal habitat and, hence, the impact of the proposed scheme upon the intertidal area is predicted to have a **negligible** impact.

Potential for loss of habitat through the excavation of shingle at Church Norton Spit

The sourcing of material from areas of accretion around the Harbour entrance (see **Figure 2.3**) to provide sediment for the backfill of the revetment would result in the loss of habitat in the immediate footprint of the excavation area. The material to be used for the work would consist of predominantly coarse sand. No more than 1,000 m³ of material would be excavated from the sediment source site.

Shingle excavation has taken place, with Natural England's agreement, on a number of occasions in the past. Any species directly with the footprint of the excavation would be unlikely to survive the excavation. However, due to previous excavations they would be opportunistic species that have moved into the area subsequent to each previous excavation and not atypical of the species in the wider area.

Given the small scale of the area impacted and the likelihood of this habitat being recolonised by opportunistic species following the excavation work, a **negligible** impact on benthic habitats is predicted as a result of the proposed excavation of the shingle.

9.3.2 Impacts to water quality affecting the benthic communities

The planned construction activities at sea, including offloading of rock from the barge to the intertidal area and the excavation of sand and shingle within the footprint of the rock revetment and to provide extra shingle for backfilling purposes, have the potential to increase the turbidity of the water column (see **Section 8**). These changes in water quality and sediment distribution are likely to be localised to the Pagham Harbour inlet

channel (refer to **Section 7.3.1**) and may indirectly impact the benthic community living there.

It is proposed that the excavation of beach material, both within the footprint of the rock revetment and for the infill material, would occur at low tide. This would avoid the potential for sediment plumes in the approach channel of Pagham Harbour. In addition, the risk of sediment dispersion would be limited as the sediment predominantly consists of coarse particles (i.e. there would be limited volumes of suspendable sediment which would settle out of suspension rapidly due to large particle size). Hence the potential for increased suspended sediment concentration in the water column is expected to be limited. If any suspended sediments were to occur, they are likely to be entrained and transported seaward from the source due to the high energy and highly dynamic nature of tidal and wave processes along the Pagham frontage.

It is also unlikely that the species known to occur in the area would be highly sensitive to small changes in suspended sediment concentrations.

Therefore, the impact of increased suspended sediment concentrations and associated deposition as a result of the proposed works in the intertidal zone is predicted to be **negligible**.

9.3.3 Impact on intertidal habitats through dumper truck movements and trampling

It is anticipated for the proposed scheme that two or three Moxy type trucks would be used to transport the material along the beach. It is estimated that there would be approximately 260 lorry loads in total over the six week period during September/October 2013. Transportation would be from the intertidal area where the rock would be unloaded along to the rock revetment area adjacent to the most westerly groyne. The activities would occur during low tide when the intertidal areas are exposed in order to be able to collect the rock from where it was unloaded.

It is anticipated that a track over and around the groynes would delineate the access to the revetment footprint, within which all machinery should remain for the duration of the construction works.

The fauna and flora present within the upper beach and the mid to low intertidal of Pagham Beach within the proximity to the entrance of Pagham Harbour would be trampled and damaged during the construction phase of the proposed works.

The current upper beaches and shallower mid-beaches at Pagham are mostly composed of a flint shingle whereas the intertidal section is characterised by shingle/gravel beaches. The vegetated shingle on the upper part of the beach is classified as nationally rare (Randall, 1997) and listed as a habitat of international conservation importance in Annex I. Based on site observations and the discussion held with Natural England in June 2013, the upper beach habitat is fairly disturbed by recreational disturbance and urban edge pressures. Alien plant species are a particular issue and have colonised significant areas of the vegetated shingle at Pagham Beach, especially the non-native red valerian *Centranthus ruber* (Natural England, 2010).

The intertidal areas in themselves are not considered to be highly sensitive in terms of the marine species present (see **Section 9.4.1**). Additionally, the intertidal habitats are characteristic of a high-energy environment and with nearby macroalgae species for sources of propagules the area is likely to recover from trampling effects within a year, two at most for slow-growing species (Royal Haskoning, 2009b).

The area of intertidal likely to be damaged is small in the context of the overall area of colonised intertidal habitat, and previous recycling events have been undertaken on the land behind the westerly groyne, which is adjacent to the proposed rock revetment area.

Overall, it is envisaged that the construction phase of the proposed scheme is likely to have a **minor adverse** impact upon the upper section of the beach and the intertidal habitat present in the area of the works.

9.3.4 Impact from noise and vibrational disturbance to marine invertebrates

During the construction phase the use of excavators, dumping of rock on the beach, use of a barge, and the offloading of material from the barge all have the potential to result in noise and seabed vibration which may disturb the benthic community.

The benthic community is typical of coarse sediment habitat (i.e. shingle) which is widespread along the coastline of Pagham. Little is known about the hearing capabilities and responses to noise and substrate vibrations of invertebrates (Cefas, 2009), however, the activities are not expected to generate high noise level during the activities (e.g. no piling work). In addition, it is unlikely that the species present within the area would be particularly sensitive to noise and vibration.

Impacts on the benthic community are likely to be localised to the area around the work footprint and short-term in duration. Overall the impact of noise and vibration on marine benthic invertebrates as a result of the proposed scheme is predicted to be **negligible**.

9.4 Potential Impacts during Operation

The operational phase of the proposed coastal defence works may impact upon marine ecology at the local scale of Pagham Harbour (predominantly Pagham Beach, Church Norton Spit and the ebb tidal delta). The main impacts associated with the operational phase of the proposed scheme are associated with the presence of the new rock revetment and changes in local habitat, as well as potential changes to the hydrodynamic regime and sediment transport pathways.

9.4.1 Long-term impact on marine ecology

During the operational phase, the rock revetment is expected to colonise with benthic epifaunal and infaunal organisms from adjacent areas. Although the benthic community would be removed in the revetment footprint, the presence of a new rocky structure partially submerged at high tide on the foreshore of Pagham is expected to have long-term benefits as well. Depending on the rock diameter, this substratum can provide a favourable habitat for attached benthic organisms such as diatoms, anemones and microalgae as well as mobile species. Colonisation timescales depend on the number of factors, including the type of substrate, the initial type of assemblage within the area

and inherent stability or mobility of the seabed sediments. For the proposed scheme, it is likely that the assemblage would be pre-adapted to regular natural disturbance.

The sediments around the revetment are also anticipated to recolonise following completion of the construction works. Recolonisation of the benthic assemblage tends to be more rapid in unstable dynamic environments (i.e. shallow water and mobile sands), (Tillin, H. M et al., 2011).

Given the prevailing environmental conditions (a high energy environment with frequent disturbance) along the groynes, the potential for colonisation of the rock revetment, and the potential for the local benthic community to recolonise the surrounding area over time, the impact of the proposed scheme on the intertidal environment would be of **negligible** adverse significance in the long-term.

9.4.2 Impacts on marine ecology due to changes in coastal processes

As outlined in **Section 7.4**, the proposed scheme is likely to increase turbulence and to reduce tidal current velocities within the inlet channel. This would potentially enhance sediment deposition on the seabed and water quality may alter as a result of changes to the water flows. Animals living in or on the seabed can be affected (e.g. smothered or buried) and the change in sediment composition may alter the character of associated benthic assemblage (Tillin, H. M et al, 2011). Species recorded in the area (see **Section 9.4.1**) known to be sensitive to changes in wave exposure include the looping snail *Truncatella subcylindrica* (high sensitivity) and the starlet sea anemone *Nematostella vectensis* (high sensitivity). The starlet sea anemone is also very sensitive to change in water flow rate (very high sensitivity) (MarLIN, 2013).

The presence of the new revetment is also predicted to lead to changes in the local wave pattern and potentially increase the risk of erosion at Church Norton Spit and the south-west end of the revetment. There is a possibility that these habitats could be starved of sediment and, consequently, this would have an impact on benthic fauna (Honkoop, 2006).

However, given the changing nature of the inlet channel, it is expected that the epifauna that live on the seabed surface, including colonial species that attach to hard surfaces and mobile epifauna found in this habitat, would be adapted to this dynamic environment which constantly changes as shown in **Figure 7.7**.

Although the proposed works have the potential to cause changes to the water flow rate and sediment deposition rates (as described above) the changes would be limited to the channel. The benthic invertebrates living within the channel would be accustomed to the dynamic environment and would be less sensitive to predicted changes. The looping snail and starlet sea anemone, both sensitive to such changes, are located away from the channel (primarily within Pagham Harbour), and it is not anticipated that these changes would extend into the Harbour.

Similarly, the predicted erosion of Church Norton Spit and the south-west end of the revetment would have an impact upon the benthic communities, however, the assemblages within the direct zone of impact are typical of the surrounding environment and are not considered to be particularly sensitive. The erosion would not extend into

the Harbour or further afield than the channel, and would therefore not impact upon the looping snail or starlet sea anemone.

Overall, it is predicted that the changes to hydrodynamics would be limited to the channel, therefore the particularly sensitive species would not be impacted. Consequently, the impact is predicted to be **negligible**.

9.5 Mitigation and Residual Impacts

The potential for impacts to arise on the marine ecology as a consequence of the proposed scheme is predicted to be low as changes to sediment distribution and water quality would not have a significant effect upon the benthic communities. In general, the main impacts in relation to marine ecology would be associated with habitat loss due to the rock placement during the construction phase and more permanent habitat loss during operation, but the impacts would be localised and of negligible significance in the context of the wider resource (**Figure 7.1**).

Only the potential impact on the beach and intertidal area due to dumper truck movements and trampling, assessed to be of minor adverse significance, has been considered with respect to mitigation.

In order to reduce the potential impact on the intertidal ecology and vegetated shingle associated with the construction phase to environmentally acceptable levels, the following mitigation measures are proposed.

Mitigation
- At the start of works, construction workers should be made aware of the potential for damage to the flora and fauna; - Working area – a clearly defined working area should be identified to ensure that shingle is not deposited onto existing vegetated shingle; - When heavy machinery are crossing from the intertidal area to Pagham Beach care should be taken to minimise the intertidal crossing area, with the temporary access ridge clearly marked to minimise the extent of any damage.

Implementation of the above mitigation measures would reduce the significance of the potential adverse effects of dumper truck movements and trampling on the intertidal ecology and upon the vegetated shingle resource to environmentally acceptable levels. The residual impact is predicted to be a **negligible**.

9.6 Habitat Enhancement

Following the completion of the proposed works, Arun District Council are willing to work with Natural England to find a practical way forward with regards to reinstatement of the vegetated shingle, that is suitable in terms of the scale of works and the current state of the vegetated shingle in the area. It is known through consultation with Natural England that there are a number of invasive species existing within the vegetated shingle.

It is proposed that the vegetated shingle in the localised area around the footprint of the proposed works and previously disturbed areas would be improved, as far as practical, including the removal of invasive species. Along with consultation with Natural England,

the Guide to the Management and Restoration of Coastal Vegetated Shingle (Natural England, 2003) would be referred to for guidance.

10 FISH AND FISHERIES INTERESTS

10.1 Introduction

This section describes baseline conditions with respect to the fish and fisheries interests in the area around Pagham and identifies and assesses any impacts which may arise as a result of the proposed works. Fish and shellfish ecology, recreational fishing and the commercial fisheries sector in the study area are considered. Other related sections include marine ecology (**Section 9**) and marine mammals (**Section 11**).

In order to establish baseline conditions, the study area for fish and shellfish is taken to include the intertidal and subtidal areas at both a regional and local scale. The local area includes Pagham Harbour, Pagham Beach, Church Norton Spit, Pagham Lagoon and Pagham Little Lagoon. On a regional scale the study area covers the coastal region between Chichester Harbour and Bognor Regis.

10.2 Existing environment

10.2.1 Introduction to the area

Between Selsey Bill and Bognor Regis the nearshore subtidal seabed predominantly consists of mixed sediments and sand, predominantly consisting of sands and gravels (Irving, 1997).

10.2.2 Fisheries ecology

Pagham Harbour

The marine environment at Pagham has a variety of habitats from offshore sand and shingle to the muds of the Harbour. A fish survey of the intertidal habitats of Pagham Harbour showed that large areas of upper intertidal saltmarsh are being used by both marine and estuarine fish (Environment Agency survey, 2007; Pagham Harbour Local Nature Reserve (LNR) Advisory Board, 2009). Bass *Dicentrarchus labrax* and grey mullet (*Mugilidae* sp.) are the predominant species that use Pagham Harbour, both as nursery and feeding grounds, before moving offshore to spawn in deeper water in the winter months.

Furthermore, the first records of golden mullet *Liza aurata* in the Harbour have been attributed to the improved water quality following the upgrade to the Sidlesham treatment facility (Pagham Harbour LNR Advisory Board, 2009). Other species identified during the survey were thick and thin lipped mullet *Chelon labrosus* and *Liza ramada* respectively, black seabream *Spondyliosoma cantharus*, lesser sandeel *Ammodytes tobianus*, sand smelt *Atherina presbyter*, sand goby *Pomatoschistus minutus*, flounder *Platichthys flesus* and corkscrew wrasse *Crenilabrus melops* (Labridae). Inundation of these habitats on each high tide provides a refuge for juvenile fish as well as access to productive intertidal creeks.

Inshore areas

The inshore waters in this area are known to support a variety of pelagic species of fish, including herring *Clupea harengus*, mackerel *Scomber scombrus*, sprat *Sprattus*

sprattus and whiting *Merlangius merlangius*. Sprat and whiting are known to spawn in the eastern English Channel including sites around Pagham (Pawson and Robson, 1997). **Table 10.1** displays the spawning times of relevant species to the Pagham area, based on information presented in Coull *et al.* (1998) and Ellis *et al.* (2012).

Herring found in this area are known to be part of the 'Downs' herring stock which move into the eastern English Channel, including areas to the south-east of Pagham, in late November and spawn from December to February. Ripe adults have also been found at other sites between autumn and spring which suggests there is a potential for the spawning period to be extended (pers. comms. Sussex Inshore Fisheries and Conservation Authority (IFCA)). Herring are substrate specific spawners and eggs are attached to coarse gravel (0.5-5cm) and stone (8-15cm) substrates and often on the crest of a ridge rather than hollows. Due to the very specific substrate requirement, spawning occurs in small discrete areas (ICES, 2010). Larval stages move inshore to shallower waters and estuaries and remain between 6 to 12 months after which they migrate offshore to join the adult group. Another pelagic species, mackerel, is a broadcast spawner. Although spawning is widespread, there is little evidence that this takes place along the Sussex coastline (Ellis *et al.*, 2012).

Table 10.1: Spawning periods of fish species relevant to the Pagham area (Sources: Coull *et al.* 1998; Ellis *et al.* 2012)

Species	Spawning Periods (Month)											
	J	F	M	A	M	J	J	A	S	O	N	D
Sprat												
Whiting												
Cod												
Herring												
Plaice												
Sandeel												
Sole												
Lemon sole												

The proposed works are within a broad area used as a spawning ground by cod, plaice, sandeel, sole, lemon sole and sprat and as nursery grounds by plaice, sole, thornback ray, undulate ray and lemon sole (Cefas, 2013).

Within the eastern English Channel there are numerous demersal species of fish, many of which are of commercial importance. Plaice *Pleuronectes platessa* and dab *Limanda limanda* are the most abundant flatfish species within the region, with plaice typically spawning in the centre of the English Channel. Plaice eggs are pelagic and spawning takes place from December to March with a peak in January and February. Data from ichthyoplankton surveys indicate the importance of the eastern English Channel as a spawning and nursery ground (Ellis *et al.*, 2012) and tagging studies have shown there are three groups of plaice present in the English Channel with one being a resident population in the eastern channel. Hydrographic studies have shown that there is a

general movement of eggs and larvae eastwards, thus juvenile plaice spawned in the western English Channel are recruited into nursery grounds in the eastern English Channel (Deniel, 1990).

Sole *Solea solea* tend to spawn along and offshore of the region's coastline, with the main nursery areas for plaice and Dover sole being predominantly around Chichester Harbour (Pawson, 1995). Turbot *Scophthalmus maximus* and brill *Scophthalmus rhombus* have a similar life cycle to plaice, dab and Dover sole but are much less abundant within the region (Pawson and Robson, 1997). Black bream and the grey mullet species (e.g. *Chelon labrosus*) are seasonally abundant inshore within regional waters and arrive in early spring from warmer areas further west. Black bream are demersal spawners and actively seek specific types of seabed on which to spawn; this tends to be on hard surfaces covered with a thin layer of mobile gravel in areas such as Selsey Bill and the Sovereign Shoals near Eastbourne. Habitats known to attract spawning black beam include open gravel, gravel close to chalk reefs, gravel in sandstone reefs and associated with ship wreckage. Males form nests in the gravel in which the females lay the eggs after which the male protects the eggs from predation. Juvenile black bream at first remain close to the nest then move to inshore areas until they join the main adult stock after two to three years. Black bream display hermaphroditism and this in turn affects the sex ratio within a population (Lythgoe and Lythgoe, 1971). However, the extent that this may affect recruitment is not understood.

Bass are also seasonally abundant and known to spawn in the eastern English Channel between the Isle of Wight and Beachy Head when temperatures exceed 9°C. Bass are broadcast spawners and the planktonic eggs hatch within a few days. Juvenile bass (age 0-1) move into the shallow creeks and margins in summer to areas of less than 0.5m water where temperatures range between 20-25°C (Kelley, 2002). Young bass may remain in nursery areas for up to two years before moving to deeper overwintering grounds offshore, although some also remain in larger estuaries. The annual Solent Bass survey carried out by Cefas in and around core survey areas of Chichester, Langstone and Portsmouth Harbours since 1981, indicates that bass over the age of five years are not normally found in the shallower waters, indicating the movement of adults offshore to pre-spawning and spawning areas (Pawson, 2007).

Other demersal fish of commercial importance are red mullet *Mullus surmuletus* and monkfish *Lophius sp.* Sandeel are distributed throughout the region, common in shallow Harbours and bays, and are particularly associated with coarse sand where they burrow at night; they are an important food resource for many other exploited fish species (Pawson and Robson, 1997).

Shellfish species found in the area

In the spring and early summer cuttlefish *Sepia officinalis* migrate from overwintering grounds in the central Western English Channel to inshore waters for breeding. Eggs are attached to seaweed, seagrass, debris, shells and mooring lines or fishing pots. Juveniles remain close inshore in sandy substrates in which they burrow during the day, only emerging to feed at night. They then move offshore once they are 6cm in mantle length and only return inshore to breed in their second winter.

Lobster breed annually and berried females appear in September through to December. Planktonic larvae appear in spring and take three weeks before settling on the seabed

(Sussex IFCA, 2013a). Small migrations are undertaken for feeding and to change habitats as size increases and adults are found in the Selsey area in rocky habitats.

Scallop *Pecten maximus* are hermaphrodite and spawn twice a year in spring and autumn. Larvae remain in their planktonic veliger form for about 30 days after which they attach to the substrate until 4-13mm in length. After this they detach and settle on the seabed often up to a depth of 100m on fine sand (Mason, 1983).

The common whelk *Buccinum undatum* is widespread throughout British coastal areas and spawns when water temperature falls below 9°C (Sussex IFCA, 2013b). Eggs are laid together in a mass within capsules and up to 2,000 eggs may be found within each capsule. They are found at the low water mark but more often in the sublittoral zone on a wide variety of substrates i.e. rock, cobble, gravel, coarse and muddy sand.

Edible crab *Cancer pagurus*, velvet crab *Necora puber*, and spider crab *Maja squinado* are all found in the area. Mating between edible crabs occurs inshore and then berried females remain in rocky areas or pits in the sediment. In spring/summer the planktonic larval stage is released and then settles about 2 months later as juveniles in the intertidal zone. The majority of the south coast has been identified as a crab nursery ground.

Squid *Loligo sp.* are thought to live offshore in deeper waters on the Atlantic edge of the continental shelf. The movement inshore is seasonal and associated with the breeding cycle. Female squid spawn in their second year when the mantle reaches a length of up to 18cm, and then die. The males can be 50cm long when 2 years old. The life span of squid is seldom more than 2-3 years. Juveniles feed primarily on plankton but adults are active predators feeding on crustaceans, fish and other squid. In the UK squid are found in most coastal waters and are landed at most ports, although annual catch rates fluctuate. The main fishing season in the English Channel is September to December. Since squid have a short life span abundance is proportional to the success of each breeding season.

Chichester Harbour was once internationally known for its native oysters *Ostrea edulis*, however, production has suffered through a recruitment failure in 2008-2009. The definitive cause is unknown but could have been due to heavy predation by the slipper limpet *Crepidula fornicata* or winkle *Littorina littorea* or an increase in the disease *Bonamia*. Other factors could include low numbers of reproductive individuals and a decline in water quality (pers. comms. Sussex IFCA). As a result of this decline the formation of a stakeholder partnership – the Chichester Harbour Oyster Partnership Initiative (CHOPi) – took responsibility to re-lay sexually mature broodstock in three areas within the Harbour during 2010-2011. Early results show that breeding has been successful and there may be an increase in recruitment for 2013. Oysters rely on good water quality for growth and maturity and high suspended sediments concentrations can cause poor growth and, at high levels, increased mortality due to smothering. There are no commercial oyster beds in Pagham Harbour.

10.2.3 Commercial fisheries

Pagham is located in International Council for the Exploration of the Seas (ICES) map division VIId and the coastal area between Rye and Chichester is under the jurisdiction

of the Sussex IFCA. In this area there is a mixture of commercial and recreational fisheries activity and many of the vessels in the region are beach boats which set nets from the low water mark out to the 6 nautical mile (nm) limit. The Sussex IFCA operates a byelaw under which boats over 14m are prohibited from fishing within the 6 nm limit. Fishing gear used by the beach boats, including those operating offshore from Pagham, include fixed gill and trammel nets mainly targeting Dover sole, plaice, cod, bass, some rays and to a lesser extent brill, turbot and cuttlefish. Since 2005 the Dover sole trammel net fishery for boats under 10m has been certified by the Marine Stewardship Council (MSC) as sustainably fished.

The larger trawlers in the inshore fleet operate up to 20 miles offshore and target species include black bream and bass during the spring months as well as red mullet, squid and scallop. The common cuttlefish is caught in traps from the inshore reefs off Selsey and Pagham (Robson, 1997). The under 10m drift netters target mackerel and herring within the 6nm limit and since 2005 both these fisheries have been certified as sustainable by the MSC.

There is also an important potting fishery for lobster, edible crab, spider crab, velvet crab and whelk, for which the extensive gravel habitats of this area are an ideal substrate. Edible crab are often the bycatch of the lobster fishery which are caught in spring and autumn using parlour pots in the rocky areas around Selsey and Eastbourne. Both species are transported and sold live with lobster sold predominantly to the local restaurant market (Walmsley and Pawson, 2007).

The native oyster is caught with specially designed dredgers and only in specific areas in Chichester Harbour, with both seasonal and daily restrictions. The failure of recruitment to the native oyster beds since 2008 has caused a decline in the fishery but the work of CHOP, as discussed above, has seen improvements in reproduction through the re-laying of adult broodstock. The hope is that the fishery will recover over the next few years. Most catch is either sold via local fish stalls or at Brighton, Hastings or Rye markets.

10.2.4 Recreational fishermen

Though the area around Pagham itself is not used heavily by commercial fishermen, since there is no harbour or beach landing location, there are a small number of shore anglers who fish from Pagham Beach and use the beach for storing boats. It is thought that these are primarily recreational fishermen, and the number of boats using the beach is thought to be low.

10.3 Potential Impacts during Construction

10.3.1 Increased suspended sediment concentrations affecting water quality and fish ecology

As described in **Section 8** there is potential for the works to cause sediment to be mobilised into the water column where it would remain in suspension for a short period of time during and immediately after works associated with the rock revetment, the collection of the backfill material and also the backfilling behind the rock revetment. However, due to the nature, position and scale of the works any resulting sediment suspension would be small in scale, short term and highly localised. The majority of the

works would take place above MLWS and in 'dry' conditions. Therefore, there is little opportunity for the sediment to go into suspension, except for when the tide comes in and flushes out the minimal amount of fines into the sea.

Pagham Beach and Church Norton Spit are comprised of well-sorted sand and gravel (Geodata Institute, 1994). There are very low amounts of fine sediments present due to the high energy nature of the physical environment. The sediment has been qualitatively assessed as relatively low in contaminant concentrations (see **Section 8.4.1**).

Due to the coarse nature of the beach sediments there is limited potential for sediment suspension to occur during the construction works as any sediment disturbed would rapidly resettle. The EIA screening opinion provided by Cefas advised that the works would be unlikely to result in a significant adverse impact upon local fish resources through sediment suspension (Cefas, 2013).

Due to the very limited and temporary nature of any sediment suspension resulting from the proposed works, and the limited opportunity for any fine sediment to go into suspension due to the majority of the work occurring at low tide, the impact of increased suspended sediment concentrations to fish and shellfish is considered to be **negligible**.

10.3.2 Restricted access to beach for recreational fishermen

As stated above there are a small number of recreational shore anglers who fish from Pagham Beach.

There is potential for the proposed works to restrict access by recreational fishermen to part of Pagham Beach for health and safety purposes during the works. Temporary restrictions to the beach have occurred in the past during the previous recycling and renourishment activities undertaken by Arun District Council.

The delivery of the rocks on the barges is proposed to occur for 24 hours a day, but would only last for a few days. The rock would be offloaded to the intertidal areas and may be left for short periods until it is collected by the dumper trucks. Then the movement of the rock along the beach from the offloading site to the rock revetment placement area would occur between Monday and Saturday, from 7am to 7pm. It is not proposed that any work would occur on Sundays. It is anticipated that works would last for approximately four to six weeks and would occur in September to October 2013. This could all result in restricted access to the beach and intertidal for recreational fishermen.

Due to the temporary nature of the works, and the availability of alternative areas of beach for use by recreational fishermen during the works (e.g. approximately 5km of beach area running north-east of the rock unloading site towards Bognor Regis), the impact of restricted access on recreational fishermen fishing from shore is considered to be **negligible**.

10.3.3 Potential snagging of lines and nets

Following delivery of the rocks to the beach by the barges, it is possible that the rocks may be sat on the foreshore for up to a day before the dumper trucks arrive to transport the rocks to the revetment site (i.e. over a weekend due to no work occurring on Sundays). This could potentially result in a snagging hazard for commercial fishing lines and nets and recreational fishing lines, where the rocks are underwater at high tide.

The footprint of the rocks would be relatively small in relation to the wider fishing area available, and would be located inshore away from the deeper water. The rocks would only be left temporarily for very short periods of time, and it is anticipated that there would be a **negligible** impact on fishermen in terms of snagging nets and lines.

10.4 Potential Impacts during Operation

No impacts to fish and commercial fisheries are predicted during the operation phase of the project.

10.5 Mitigation and Residual Impacts

The impacts in relation to fish and fisheries interests are assessed as being negligible, therefore, no mitigation would be required. However, it is proposed that signage would be displayed around the beach area to inform the local residents and fishermen of the proposed works and in particular the placement of rocks, to avoid any fishing gear getting snagged on the rocks. In addition, as outlined in **Section 13**, Notices to Mariners would be issued to inform fishermen of the proposed works.

Residual impacts would remain as **negligible**.

11 MARINE MAMMALS

11.1 Introduction

This section considers the marine mammals present in the Pagham area and in the wider English Channel region. The baseline environment has been drawn from existing literature and studies and impacts associated with the proposed works have been identified and assessed.

11.2 Existing environment

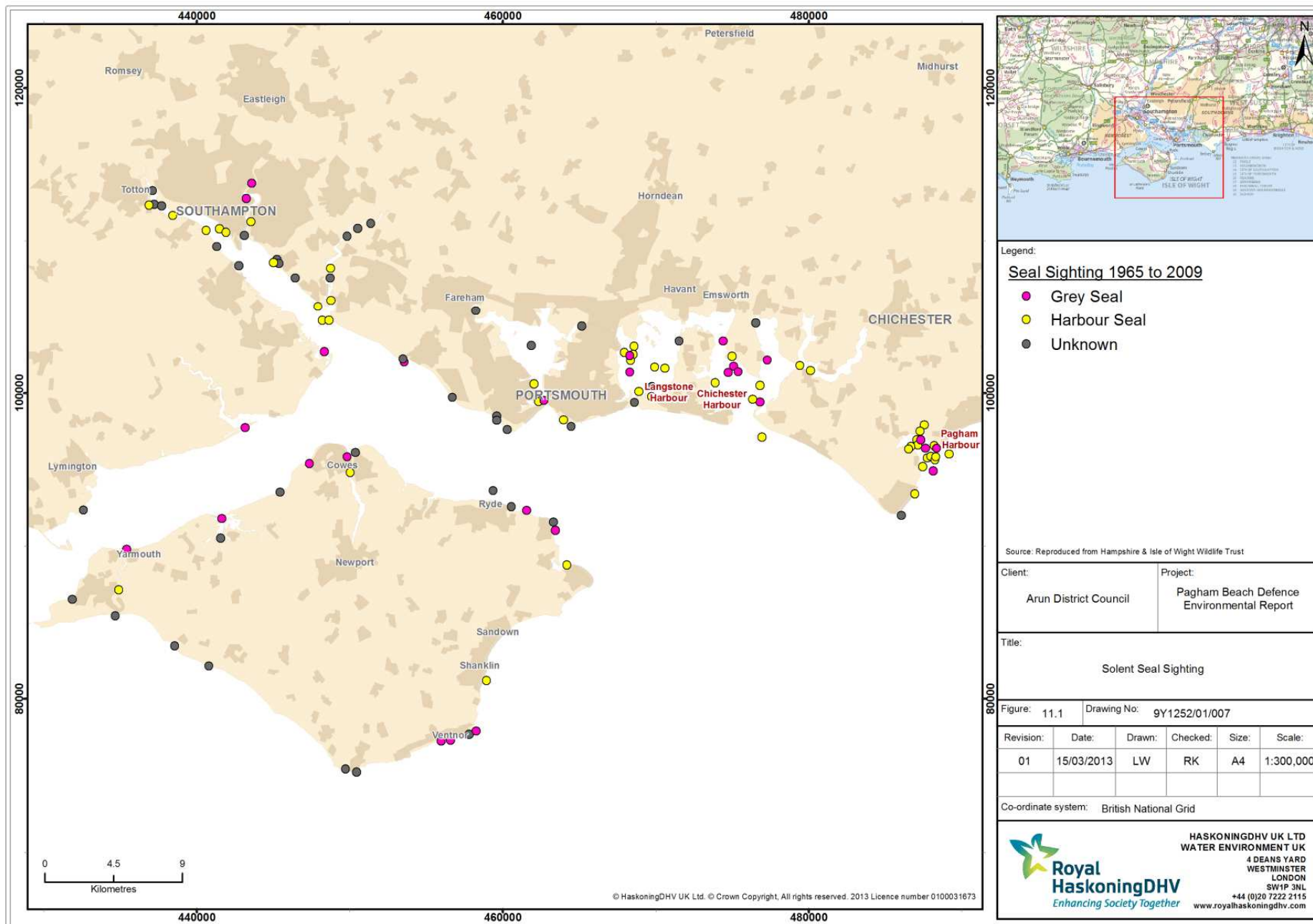
11.2.1 Pinnipeds

Grey seals *Halichoerus grypus* and Harbour (or common) seals *Phoca vitulina* are often sighted in Pagham Harbour, with some seen basking on the islands in winter (Wildlife Trusts, 2010). The distribution of seal sightings in the Solent and along the south coast is provided in **Figure 11.1**.

Two significant haul-out sites exist for seals within the Solent region; one in Langstone Harbour and one in Chichester Harbour. Both haul-out sites are used on a more or less daily basis but Chichester Harbour (located approximately 20km away from the proposed works) records a higher abundance. Surveys and monitoring of seals in the south-east estimate the presence of approximately 23-25 individual Harbour seals within the Solent area. This is a small population which is therefore more vulnerable to impacts (Wildlife Trusts, 2010).

Surveys undertaken offshore around the Rampion Offshore Wind Farm recorded some sightings of grey seal and Harbour seal (refer to **Section 10.2.3**).

Grey seals and Harbour seals are classified as species of 'Least Concern' by the IUCN, which indicates that there are large and either stable or increasing populations on a global scale (IUCN, 2013a and 2013b). In the UK Harbour seal populations have declined dramatically in some areas in recent years (UKMMAS, 2010). Grey seal populations appear to be stabilising in the UK, after decades of increase following the end of culling (UKMMAS, 2010).



11.2.2 Cetaceans

Information on cetacean numbers has been collected during marine surveys along the Sussex Coast for the Rampion Offshore Wind Farm Project located in the English Channel, 13km offshore from Worthing (refer to **Figure 11.2**). A total of 28 marine surveys were conducted on a monthly basis from March 2010 to January 2012 to inform the Rampion project ES. **Figure 11.2** indicates the extent of the survey area for the Rampion Offshore Wind Farm (E.ON Climate and Renewables, 2012).

During the surveys, six species of marine mammals were positively identified during 112 encounters with approximately 210+ individuals during line transect surveys. These species were Harbour porpoise *Phocoena phocoena*, Bottlenose dolphin *Tursiops truncatus*, White-beaked dolphin *Lagenorhynchus albirostris*, Minke whale *Balaenoptera physalus*, Common seal and Grey seal.

Harbour porpoise was the most abundant species recorded during these surveys. There was a significant difference in the number of Harbour porpoise in the area during the seasons with few or no sightings during the autumn and winter months and the highest numbers recorded in March 2011 (E.ON Climate and Renewables, 2012).

The paragraphs below focus on the species that are most likely to be encountered along the south-east coast of England.

Bottlenose dolphins

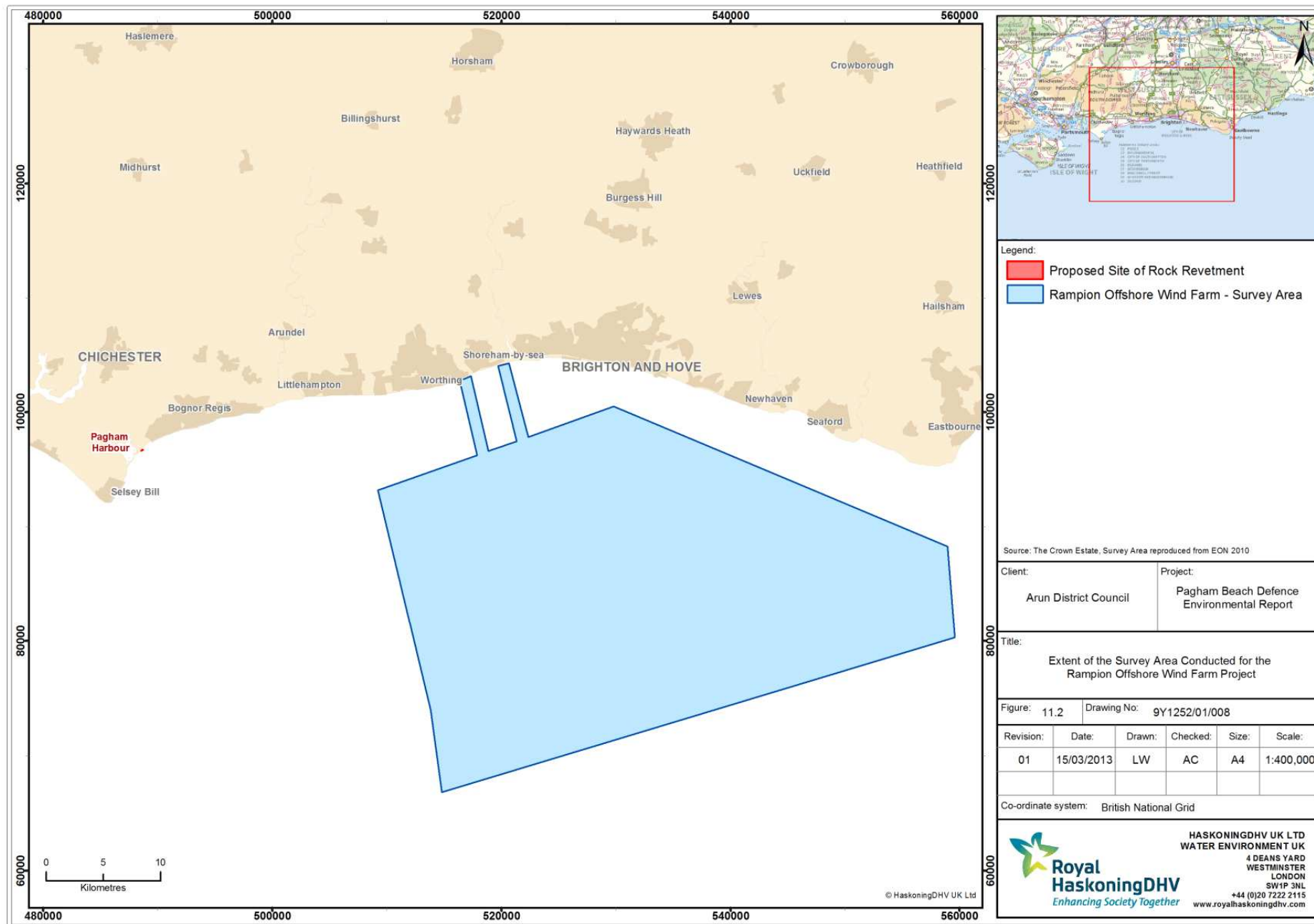
Bottlenose dolphins are typically the most frequently recorded cetacean off the coast of south-east England. This species is observed most commonly during summer (July to September), the majority of sightings being around the Solent, and also the West and East Sussex coast in late summer (August-September) (Jones *et al.*, 2004).

Common dolphins

Common dolphins are observed mostly offshore, however, small numbers have been observed around Durlston Head (approximately 92.5km away) and Poole Bay (approximately 85.6km away) between October and January (Jones *et al.*, 2004).

Harbour porpoises

Harbour porpoises are observed occasionally nearshore (Evans, 2006). Harbour porpoises have declined in population as a consequence of a range of factors such as overfishing, by-catch, pollution and an increase in anthropogenic noise. The population appears to have responded to this decline by changes in distribution, although this is poorly understood. Harbour porpoises rely heavily on their sense of hearing to locate prey and are therefore particularly sensitive to noise-related impacts. Harbour porpoises are seen in nearshore areas during April, and between the months of August and October (Jones *et al.*, 2004).



11.2.3 Other cetaceans

Other cetacean species known to occur off the coast of south-east England (waters deeper than 50m) include Killer whale *Orcinus orca*, Fin whale *Balaenoptera physalus*, Sei whale *Balaenoptera borealis* and Humpback whale *Magaptera novaeangliae*. However, these species are not considered to be regular visitors to the south coast (Evans, 2006) and it would be highly unlikely to find them close to the proposed works due to the restricted water depth.

11.3 Potential Impacts during Construction

11.3.1 Displacement/interruption of natural behaviour of marine mammals due to underwater noise

There is some potential for underwater noise impacts to occur during the construction phase of the proposed works, however, the majority of the works would be undertaken at low water and in 'dry' conditions. Therefore, there would only be limited opportunity for underwater noise to occur, associated with the delivery of rock by the barges.

The operation of the barge delivering rocks would generate underwater noise via its propulsion systems. The delivery of rocks to the beach at high tide would also create underwater noise through impacts between the rocks and the seabed as they are dumped over the side of the barges.

The barge would be operating within the busy English Channel, which is subject to high levels of background underwater noise from shipping, and its propulsion systems would not be expected to generate underwater noise at levels above those generated by vessels which typically transit this area of the English Channel. It is anticipated that only a small number of barge loads (one to four) would be required to deliver the rock to the beach.

Neither of the two noise sources would be anticipated to create underwater noise at levels which could give rise to potential impacts to any marine mammals within the vicinity of the barge or in waters adjacent to the location of rock placement.

Due to the temporary nature of the works and the low intensity of underwater noise anticipated the impact of underwater noise on marine mammals is considered to be **negligible**.

11.3.2 Increased collision risk due to barge operation

As discussed in **Section 2.2.3** the rock for the revetment construction may be sourced from France or Norway. Regardless of the collection location it is predicted that the barge would transit busy shipping channels in its route to Pagham. The presence of the delivery barge would only marginally increase the level of vessel activity within the already busy English Channel. There is evidence in the UK that marine mammals are more at risk from high speed leisure boats than from slower moving commercial vessels (UK Marine SACs Project, 2013). In this context, the impact of increased collision risk on marine mammals due to barge operation is considered to be **negligible**.

11.3.3 Impacts on marine mammal habitat/prey caused by the indirect effect of construction activities

There is potential for the indirect effects of construction activities to impact marine mammal habitat/prey species. Following review of the assessments made in **Sections 7 to 10** this is considered to be limited to the effect of suspended sediment on fish and shellfish, which has been assessed as a negligible impact (see **Section 10.3.1**). Therefore, the potential for impacts to marine mammal habitat/prey through the indirect effects of sediment suspension is considered to be **negligible**.

11.4 Potential Impacts during Operation

No impacts to marine mammals would be anticipated during the operation phase of the project.

11.5 Mitigation and Residual Impacts

The potential impacts on marine mammals have been assessed as negligible. No mitigation measures are proposed and the impacts would remain **negligible**.

12 ORNITHOLOGY

12.1 Introduction

This section considers the ornithological features of the area around the proposed scheme; including the nature conservation designated sites at Pagham Harbour which have bird interest features, and identifies any potential impacts to the bird species which may arise as a result of the proposed works.

12.2 Existing environment

12.2.1 Internationally protected sites

Pagham Harbour and the area within the scope of the proposed coastal works are designated as a SPA (see **Section 6.5.1** for further information on this designation). The site qualifies under Article 4.1 of the Birds Directive for supporting breeding little tern *Sterna albifrons* and common tern *Sterna hirunda*, and overwintering ruff *Philomachus pugnax*. The site also qualifies under Article 4.2 of the same Directive for supporting overwintering pintail *Anas acuta* and dark-bellied Brent geese *Branta bernicla bernicla*.

This area is also designated as a Ramsar site under the international Ramsar Convention for the presence of dark-bellied Brent geese and is an Important Bird Area for pintail (BirdLife International, 2007). **Table 12.1** presents details of the species of national importance that are present in the Ramsar site.

Table 12.1: Species of national importance present in Pagham Harbour Ramsar site

Species currently occurring at levels of national importance	Peak counts
Spring/autumn	
Little egret, <i>Egretta garzetta</i>	60 individuals, representing an average of 3.6% of the GB population (5 year peak mean 1998/9- 2002/3)
Whimbrel, <i>Numenius phaeopus</i>	104 individuals, representing an average of 3.4% of the GB population (5 year peak mean 1998/9- 2002/3 - spring peak)
Common greenshank, <i>Tringa nebularia</i>	20 individuals, representing an average of 3.3% of the GB population (5 year peak mean 1998/9- 2002/3)
Winter	
Slavonian grebe, <i>Podiceps auritus</i>	14 individuals, representing an average of 1.9% of the GB population (5 year peak mean 1998/9- 2002/3)
Pintail	462 individuals, representing an average of 1.6% of the GB population (5 year peak mean 1998/9-2002/3)
Grey plover, <i>Pluvialis squatarola</i>	704 individuals, representing an average of 1.3% of the GB population (5 year peak mean 1998/9- 2002/3)
Spotted redshank, <i>Tringa erythropus</i>	5 individuals, representing an average of 3.6% of the GB population (5 year peak mean 1998/9- 2002/3)

12.2.2 Nationally protected sites

Pagham Harbour is also designated as a SSSI. The site is of national importance for wintering wildfowl and waders and also for breeding birds, both within the Harbour and the surrounding grazing pasture. The small amount of woodland at Pagham Harbour is known to support a small heronry (Natural England, 1980). In addition, the damp unimproved grassland surrounding the Harbour is used as a major wader roost and is grazed by large numbers of dark-bellied Brent geese. As an overwintering site, the Harbour is known to support over 120 bird species. The mudflats also provide food for a diverse breeding community of birds including oystercatcher *Haematopus ostralegus*, shelduck *Tadorna tadorna* and redshank *Tringa totanus*.

12.2.3 Locally protected sites

Pagham Harbour is also a LNR (refer to **Figure 4.2**) which is managed by the RSPB. A five year management plan (2013 to 2018) has been produced for the site which aims to protect and enhance the environmental features of the site. This includes monitoring breeding species on site. In 2012, the following species were recorded: lapwing *Vanellus vanellus*, redshank, avocet *Recurvirostra avosetta*, oystercatcher, ringer plover *Charadrius hiaticula*, little tern, common tern, sandwich tern *Sterna sandvicensis*, black-headed gull *Chroicocephalus ridibundus*, skylark *Alauda arvensis*, little egret and grey heron *Ardea cinerea* (Pagham Harbour LNR Local Communities Forum, 2012). **Section 6.7.1** has further information on this designation.

12.2.4 Wetland Bird Survey data

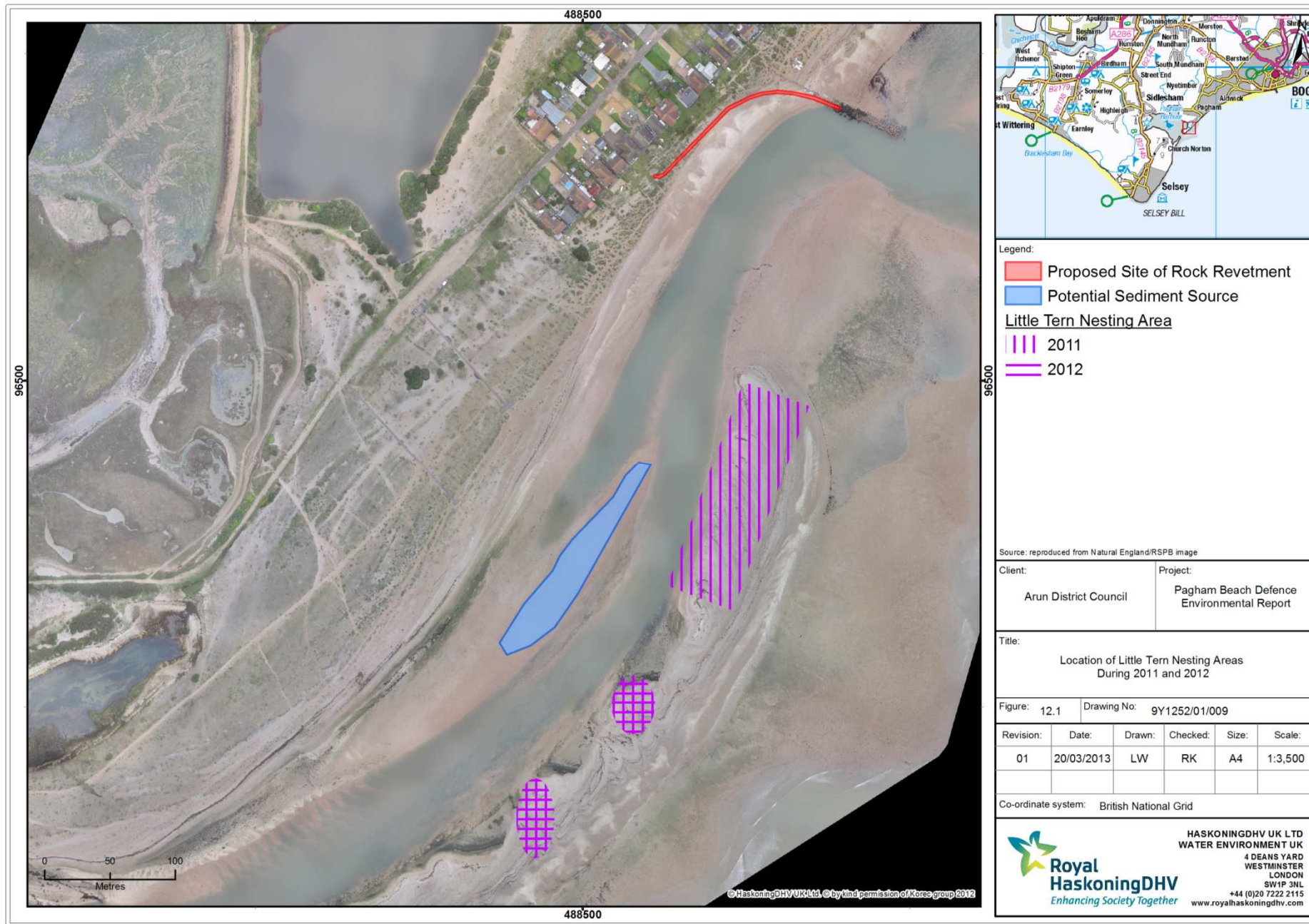
Table 12.2 provides Wetland Bird Survey (WeBS) data for the Harbour, showing the total number of waterbirds recorded on site from 2006 to 2011, and **Table 12.3** provides mean numbers (from 1997 to 2002) for important wintering bird species.

Table 12.2: Total number of waterbirds at Pagham Harbour from 2006/07 to 2010/11

Site	06/07	07/08	08/09	09/10	10/11	Average
Pagham Harbour	22,679	18,438	16,672	16,912	15,470	18,034

Table 12.3: Five year mean numbers (1997/1998 to 2001/02) of important wintering bird species

Species	Mean numbers
Pintail	768
Cormorant <i>Phalacrocorax carbo</i>	211
Dark-bellied Brent goose	2,026
Teal <i>Anas crecca</i>	1,309
Grey plover	1,053
Black-tailed godwit <i>Limosa limosa</i>	221



12.2.5 Pagham Harbour bird populations

A Coastal Defence Study undertaken in 2009 undertook an assessment of bird populations in Pagham Harbour and identified the following information on the bird species using the Harbour (Royal Haskoning, 2009a). Little ringed plover *Charadrius dubius*, little stint *Calidris minuta*, curlew sandpiper *Calidris ferruginea* and spotted redshank are rarer migrants which have been recorded in the Harbour (Royal Haskoning, 2009a). Offshore northern gannet *Morus bassanus*, tern species, Arctic skua *Stercorarius parasiticus*, great skua *Catharacta skua* and pomarine skua *Stercorarius pomarinus* were recorded.

Little gull *Larus minutus* and black tern *Chlidonias niger* are also regular visitors in the summer and numbers of yellow-legged gull *Larus michahellis* in late summer are known to be increasing (Royal Haskoning, 2009a). Raptor species such as marsh harrier *Circus aeruginosus*, honey buzzard *Pernis apivorus*, osprey *Pandion haliaetus* and northern hobby *Falco subbuteo* all use the site on passage. Hen harrier *Circus cyaneus*, merlin *Falco columbarius* and short-eared owl *Asio flammeus* are also regular visitors using the Harbour to hunt.

Passerine migrants are also varied with all of the more common species such as whinchat *Saxicola rubetra*, wheatear *Oenanthe oenanthe*, yellow wagtail *Motacilla flava* and a range of warblers being recorded. Scarcer migrants such as wryneck *Jynx torquilla*, hoopoe *Upupa epops*, black redstart *Phoenicurus ochruros*, firecrest *Regulus ignicapillus* and golden oriole *Oriolus oriolus* have also been recorded on site.

Red-breasted merganser *Mergus serrator*, scaup *Aythya marila* and common eider *Somateria mollissima* have been recorded off the Harbour at high tide. Red-necked grebe *Podiceps grisegena* and Slavonian grebe also occur offshore from the Harbour.

Consultation with Natural England has also been undertaken with regards to nesting little tern and their use of the area. Little tern typically nest on the Church Norton Spit (Natural England, pers. comms.). The location of these nesting sites is shown on **Figure 12.1**. Nesting has occurred in this area from 2008 to present day, although the exact location of nesting does vary year to year. Little terns tend to start breeding in this area from mid-April and stay on the nests until the end of July.

12.3 Potential Impacts during Construction

12.3.1 Noise and visual disturbance from the onshore construction works

The works are due to commence in September/October 2013 and last for approximately four to six weeks, resulting in the avoidance of the breeding bird season and the majority of the overwintering bird season. However, should the works be delayed, the construction works could disturb those species which have migrated over at the start of the main overwintering period and use the coastline for foraging or roosting.

The overwintering bird species for which the sites are internationally protected are typically species which use mudflat or marsh habitat for feeding and roosting. Therefore, the area of works is considered unsuitable for this species. However, there is the potential for wader species such as redshank and grey plover to use the shingle beach. Although the proposed works would occur on the shingle beach, there is

approximately 5km of shingle which extends past the proposed footprint of works towards Bognor Regis which would provide suitable habitat for feeding and roosting waders.

Given the small number of construction vehicles and staff, disturbance is likely to be limited and habituation to the regular movements of the machinery from previous recycling and renourishment activities is likely to occur. Dumper truck movements to collect the rocks would be to the north of the Harbour mouth and outside the main area of interest for bird species. In addition, the area available for use by overwintering birds is large and there is suitable habitat elsewhere for any birds disturbed by the works to move to. As a result, a **negligible** impact is predicted on overwintering bird populations.

12.3.2 Disturbance from the movements of the barge

Certain species such as Slavonian grebe, eider, scaup, red-breasted merganser and red-necked grebe are known to occur offshore from the Harbour. These species could be disturbed by the movements of the barges bringing rocks to site.

It is anticipated that there would be a maximum of two to eight barge movements to bring the necessary amount of rock to shore. Whilst the area is not currently heavily used by boats, there is commercial fishing activity in the area and therefore the presence of boats is not unusual. As a result, disturbance is unlikely to be significant and a **negligible** impact is predicted on offshore bird species.

12.3.3 Disturbance to little tern nesting grounds

Although the works would not be undertaken during the breeding bird season, there is the potential that extra fill material would be needed for the rock revetment and the source of this material is adjacent to the nesting area used by little terns (see **Figures 12.1** and **2.3**). However, the amount needed is unlikely to significantly affect the structure of the nesting area and it is anticipated that nesting would be able to occur as normal in 2014. Therefore **no impact** on little terns is predicted.

12.3.4 Direct loss of key intertidal and marine habitats

The works would result in the loss of a small area of intertidal beach habitat (primarily sand, shingle and gravel) due to the off-loading of rocks from the barge. This area would be used to off-load rocks which would then be transported to the site by dumper trucks; therefore any loss of habitat would be temporary. In addition, it is unlikely that the rocks would significantly affect the condition of the intertidal habitat and that any damage caused by movement of the dumper trucks would be reversible. Given the presence of this coarse sediment habitat elsewhere on site, it is considered that the works would have a **negligible** impact on the bird species.

There would also be a permanent change to the beach habitat as a result of construction of the rock revetment. This potential impact is detailed in **Section 12.4** below.

12.3.5 Increases in suspended sediment

There is the potential for sediments to become suspended in the water column during the delivery of rock and its subsequent movement to the area of works. However, given the location of these activities and the very small amount of sediment that could be re-suspended, smothering of areas used by roosting or foraging birds is unlikely to occur. As a result **no impact** is anticipated on the bird populations which use the Harbour.

12.4 Potential Impacts during Operation

12.4.1 Permanent changes to key intertidal and marine habitats

Whilst there is a permanent loss of shingle habitat from the construction of the rock revetment, the change is not significant in comparison to the presence of this habitat in the surrounding area. Therefore this permanent change in habitat is considered to not have an impact on bird species.

12.5 Mitigation and Residual Impacts

Given the short duration of works and their nature, no mitigation is considered to be required for the bird species which use Pagham Harbour for foraging and roosting and the impacts, where they are predicted to arise, would remain **negligible**.

13 COMMERCIAL AND RECREATIONAL NAVIGATION

13.1 Introduction

This section considers the commercial and recreational navigation movements around Pagham and along the west Sussex coast.

The study area for navigation includes the immediate area around Pagham Beach and Pagham Harbour, but also extending out to the wider area of the Solent and the English Channel.

13.2 Existing environment

13.2.1 Local area

Access to Pagham Harbour is obtained via a channel located on the south-east side of the Harbour. The Harbour is a large sheltered bay of approximately 2.8km² that fills and empties with each tide. The water is very shallow in many places in the Harbour and as a result some areas of the Harbour, such as Sidelsham Quay, are inaccessible except at the highest tide and then only by shallow draft vessels or bilge-keelers. The local boats visiting Sidelsham Quay include canoes, dinghy sailors, rigid inflatable boats, sailing catamarans up to 6m, small sea angling vessels and Environment Agency hovercrafts (Ports and Harbours of the UK, 2013).

Pagham Yacht Club currently offers recreational sailing and water sports all year round requiring access to the sea along the Pagham Beach frontage. Pagham Yacht Club has a mixed fleet, including mono and multi hull. Boats sail from March to October on Sundays, and May to August on Wednesday evenings. Races, trophy races and cruises are also organised from time to time during the year along the coast (Pagham Yacht Club, 2013).

13.2.2 Regional area

At the regional scale the study area stretches from Selsey Bill in the south-west to Bognor Regis in the north-east. There are no major port authorities in the study area. The nearest port authorities are Chichester Harbour Conservancy and Littlehampton Harbour which are mainly used by the yachting community, leisure boats and fishing vessels. Littlehampton Harbour has some commercial shipping but the activity remains quite low - there are only approximately one or two vessels entering the Harbour every week (Marine Traffic Website, 2013).

The main commercial shipping routes are located off the south-east coast of England in the English Channel. The area off the coast of Pagham Beach is mainly used by recreational vessels sailing along the coastline off Selsey and navigating in and out of Pagham Harbour. The navigation routes in the south-east of England are indicated on **Figure 13.1**.

The main marine infrastructure located near the proposed scheme are Selsey lifeboat station along the beach front on the south-west part of Selsey Bill (refer to **Plate 13.1**), approximately 4.6km from the proposed works and Bognor Regis Pier located more than 5km away to the east.

Plate 13.1: Selsey lifeboat station



Lifeguard services on the coast are only available at Littlehampton from the beginning of May to the 15th of September. Royal Life Saving Society (RLSS) lifeguards operate a safety boat and patrol the beaches during this period to ensure the safety of sea users.

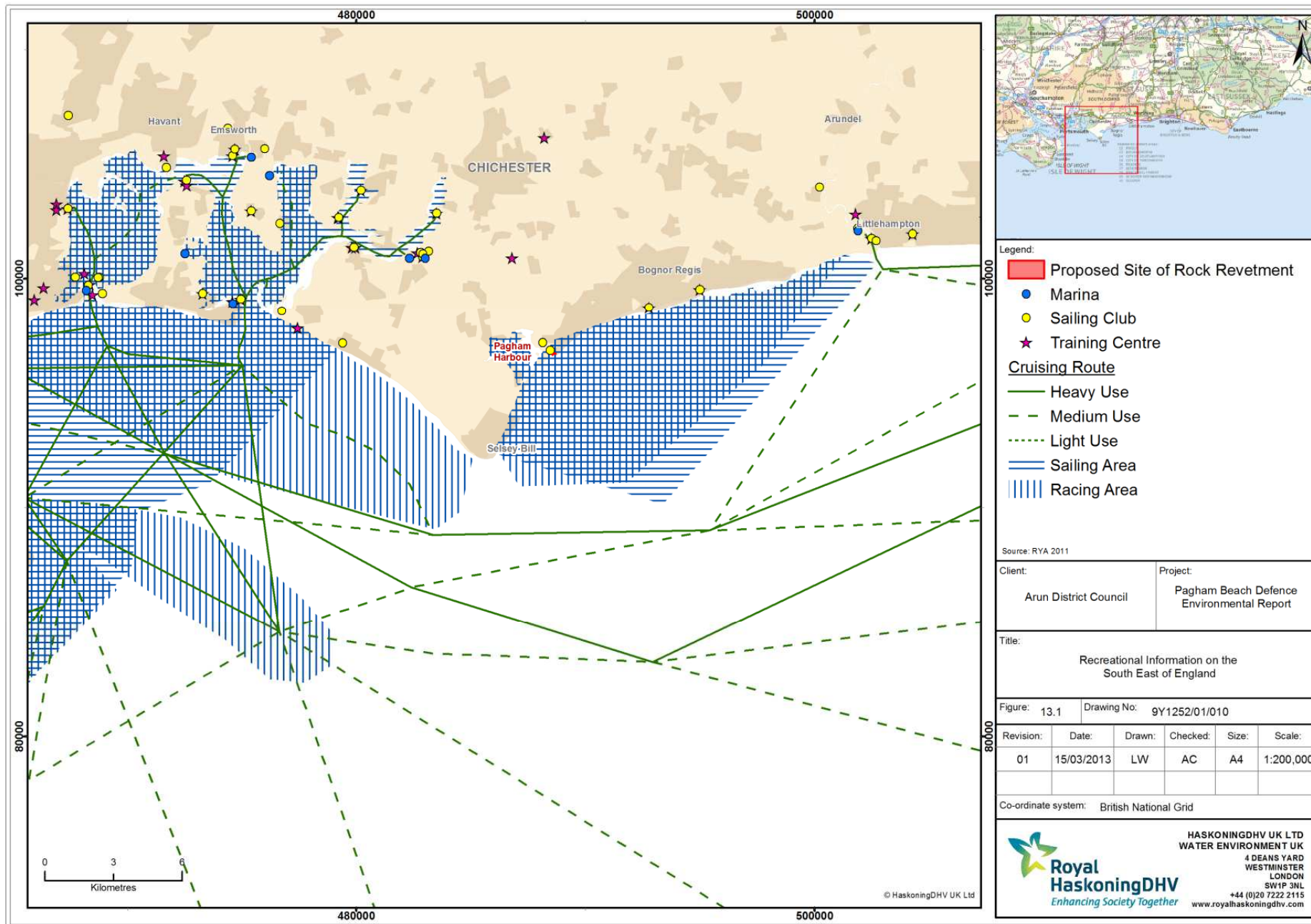
There are a number of licensed marine aggregate dredging areas to the south-east of Pagham Beach, in the Owers Bank dredge region. There is also a military practice area which lies to the south of Selsey coast. Both zones are located more than 16km away from Pagham, therefore, no military or dredging vessels are expected to navigate near Pagham Beach.

13.3 Potential Impacts during Construction

13.3.1 Restricted access to the beach and foreshore due to barges and unloading rocks

Within the proposed area of works, there are a number of small boats stored on the beach (refer to **Section 10.2.4**). These are thought to be primarily recreational fishing boats but also some recreational sailing vessels. During construction, there may be some restrictions to access along Pagham Beach during the delivery of rock on the barges. Depending on the timing of the delivery, it may be the case that the rocks are unloaded onto the intertidal and not collected by the dumper trucks for a day or so (i.e. over a Sunday when works are not occurring). The rocks could also cause an obstruction to launching of recreational boats from the beach.

There are only a limited number of boats stored on the beach, and the area of works is relatively short-term and localised. However, there is potential for a temporary, **minor adverse** impact to recreational beach users through restricted access to beach stored boats and restricted access to and from the sea for launching with these boats.



13.3.2 Potential collisions between barges and commercial fishermen

During delivery of the rocks, the barges would need to navigate into the beach area and find a suitably safe place to unload the rocks. As outlined in **Section 10.2.3**, there are a number of commercial fishing vessels which operate offshore from Pagham. There is a potential risk that the barges may collide with commercial fishing vessels in the area. This is described as a risk rather than an impact.

The number of barge movements would be limited and the window for delivery of rocks is very short-term. Additionally commercial vessels are likely to be located further offshore and therefore, it is considered that there would be a **negligible** risk to commercial fishermen through collisions with barges.

13.3.3 Potential collisions between barges and recreational boats

There are a number of recreational boats which use the Pagham area for both sailing and recreational fishing purposes. During construction there is the potential risk that these recreational vessels to collide with the barges delivering the rock to the beach. Pagham Yacht Club in particular is located very close to the area of proposed works.

The timing of the proposed works is outside of the peak summer season and there would, therefore, be reduced numbers of both recreational sailing and fishing vessels. The number of barge loads delivering rock would be limited, and only occurring over a very short period of time. It is considered, however, that there would be a **minor adverse** risk to recreational vessels due to the barges delivering the rock to the beach area.

13.3.4 Potential for boats to run aground on rocks

Once the rocks have been unloaded from the barges at Pagham Beach, as mentioned above, there is the possibility that they may remain in-situ for a short period before the dumper trucks transport the rocks along the beach. During this time, there is the potential risk that boats could run aground on these rocks resulting in damage to the boats.

It is anticipated that the rocks would only be left on the foreshore for a very short period, and would be in relatively shallow water, but there is the potential risk of collision, particularly at high tide when the rocks may be less visible. It is anticipated that there is a **minor adverse** risk to vessels as a result of the rock placement.

13.4 Potential Impacts during Operation

During operation there are not considered to be any impacts to navigation as a result of the proposed works.

13.5 Mitigation and Residual Impacts

During construction, the proposed works have been identified to result in minor adverse impact on navigation in terms of restricted access to launching boats. Risks of collisions and the risk for boats to run aground on the rocks have also been identified as minor adverse.

In order to mitigate against these impacts and manage the risks identified, it is proposed that the following mitigation is undertaken.

Mitigation
• Recreational fishermen using the beach would be given advance warning of the start of the works. • Consultation would be undertaken with the owners of beach stored boats at or within the vicinity of the proposed works to agree mitigation measures to ensure access to boats, and to and from the sea is not totally restricted during the works (e.g. temporary relocation of boats to the north-east). • Notice to Mariners would be issued prior to the start of the works informing of the proposed works and the locations and duration. • Standard safe navigation procedures would be in place including broadcasting of information through communications channels, navigation aids on seagoing vessels, and appropriate use of lights on vessels. • The local Sussex IFCA and the local MMO area officers would be advised of the works. • Notices would be erected at the entrance to the beach to advise of the proposed works, and access restrictions and the duration of the works.

Following implementation of this mitigation it is considered that the residual impacts and risks would be **negligible**.

14 SUMMARY

The proposed coastal defence works at Pagham Beach are not anticipated to result in any significant adverse impacts on the surrounding environment. Some minor adverse impacts and risk have been identified with respect to the risk of spillages and leaks, impacts on intertidal habitats through dumper truck movements, the risk of collision between barges and recreational boats, and the risks of boats running aground on rocks.

However, with the implementation of proposed mitigation and management procedures it is predicted that these impacts and risks would be reduced to a negligible level.

A summary of the proposed mitigation is outlined in **Table 14.1** below.

Table 14.1: Summary of proposed mitigation for the Pagham Beach Coastal Defence project

Parameter	Proposed mitigation
Water and Sediment Quality	• Follow best practice guidance and the Oil Care Code; • Report any pollution incidents immediately to the Environment Agency; • Ensure that the workforce is trained in pollution prevention and actions to take.
Marine Ecology	• Toolbox talk for construction workers; • Ensure work is undertaken within a defined work area; • Minimise the intertidal crossing area.
Commercial and Recreational Navigation	• Provide advance warning to beach users, fishermen and local authorities; • Issue a Notice to Mariners; • Standard use of communications and navigation aids; • Erect notices at the entrance to the beach informing of works.

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Appendix A – Water Framework Directive Compliance Assessment

APPENDIX A

WATER FRAMEWORK DIRECTIVE COMPLIANCE ASSESSMENT

(EXTRACT FROM PAGHAM COASTAL DEFENCE ENVIRONMENTAL SCOPING REPORT, APRIL 2013)

1 INTRODUCTION

In December 2003, the WFD was transposed into national law by means of the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003. These Regulations provide for the implementation of the WFD, from designation of all surface waters (rivers, lakes, transitional (estuarine) and coastal waters and ground waters) as water bodies to the requirement for achievement of good ecological status or good ecological potential by 2015.

The WFD applies to all water bodies, including those that are man-made. The consideration of the proposals under the WFD will, therefore, apply to all water bodies that have the potential to be impacted by the construction, dredging and disposal elements of this project.

Classification schemes for both estuarine and coastal waters out to one nautical mile have been developed in response to WFD. The scheme classifies the status of Transitional and Coastal Waters (TRaC) using information on the ecological, physico-chemical, chemical and hydromorphological quality of a body of water. For surface waters there are two separate classifications for water bodies; ecological and chemical. For a water body to be in overall 'good' status, both ecological and chemical status must be at least 'good'.

Ecological classification comprises:

- the condition of biological elements, for example fish;
- concentrations of supporting physico-chemical elements, for example the oxygen or ammonia levels;
- concentrations of specific pollutants, for example copper; and
- largely undisturbed hydromorphology for high status.

Ecological status is recorded on the scale of high, good, moderate, poor or bad. 'High' denotes largely undisturbed conditions and the other classes represent increasing deviation from this natural condition, otherwise described as a 'reference condition'. The ecological status classification for the water body, and the confidence in this, is determined from the worst scoring quality element.

Chemical status is assessed by compliance with environmental standards for chemicals that are listed in the EC Environmental Quality Standards Directive 2008/105/EC. These chemicals include priority substances, priority hazardous substances, and eight other pollutants carried over from the Dangerous Substance Daughter Directives. Chemical status is recorded as 'good' or 'fail'. The chemical status classification for the water body is determined by the worst scoring chemical.

For TRaC water bodies that have been designated as heavily modified (HMWB), the Environment Agency classifies according to their ecological potential rather than status. UKTAG have adopted the 'mitigation measures approach' for classifying HMWBs. This approach first assesses whether actions to mitigate the impact of physical modification are in place to the extent that could reasonably be expected. If this mitigation is in place, then the water body may be classified as achieving 'good' or 'better' ecological potential. If this level of mitigation is not in place, then the water body will be classed as 'moderate' or 'worse' ecological potential. Before an overall ecological potential classification is applied, the second step is for the results of the mitigation measures assessment to be cross-checked with data from biological and physico-chemical assessments.

Where the Environment Agency has data for biological quality elements that show signs of damage from pressures other than hydromorphological alterations, for example, if the diatom or phytoplankton status is poor because of nutrient pressures, the ecological potential will be changed. To reflect this other pressure the water body will be labelled as 'Poor Ecological Potential'. This is also true where data are available for physico-chemical quality elements.

Some areas require special protection under European legislation. The WFD therefore brings together the planning processes of a range of other European Directives, such as the revised Bathing Waters Directive (2006/44/EC) and the Habitats Directive. These Directives establish protected areas to manage water, nutrients, chemicals, economically significant species and wildlife – and where possible, have been brought in line with the planning timescales of WFD.

1.1 Environmental objectives under the WFD

Specific mitigation measures are set for water bodies to achieve the Environmental Objectives of the WFD. These are listed within the Programme of Measures for each River Basin Management Plan (RBMP). These measures are intended to mitigate impacts that have been or are being caused by human activity, such as flood and coastal defence works, with the aim of enhancing and restoring the quality of the existing environment. The default Environmental Objectives of relevance to the proposed scheme are shown in the table below.

Table 1.1 Environmental Objectives in the WFD

Objectives (taken from Article 4 of the Directive)	Reference Article
Surface water	
Member States shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water	4.1(a)(i)
Member States shall protect, enhance and restore all bodies of surface water, subject to the application of subparagraph (iii) for artificial and heavily modified bodies of water, with the aim of achieving good surface water status by 2015.	4.1(a)(ii)
Heavily Modified and Artificial Water Bodies	
Member States shall protect and enhance all artificial and heavily modified bodies of water, with the aim of achieving good ecological potential and good surface water	4.1(a)(iii)

Objectives (taken from Article 4 of the Directive)	Reference Article
chemical status by 2015.	
Progressively reduce pollution from priority substances and cease or phase out emissions, discharges and losses of priority hazardous substances.	4.1(a)(iv)
Ground water	
Prevent deterioration in status and prevent or limit input of pollutants to ground water (Daughter Directive)	Ground Water 4.1(b)(i)

1.2 Preventing deterioration in Ecological Status or Potential

A default Objective in all water bodies is to prevent deterioration in either the Ecological Status or, for Heavily Modified Water Bodies (HMWBs) or Artificial Water Bodies (AWBs), the Ecological Potential of the water body. Any activity which has the potential to have an impact on ecology (as defined by the biological, physico-chemical and hydromorphological Quality Elements listed in Annex V of the WFD) will need consideration in terms of whether it could cause deterioration in the Ecological Status or Potential of a water body.

2 THE PROPOSED SCHEME

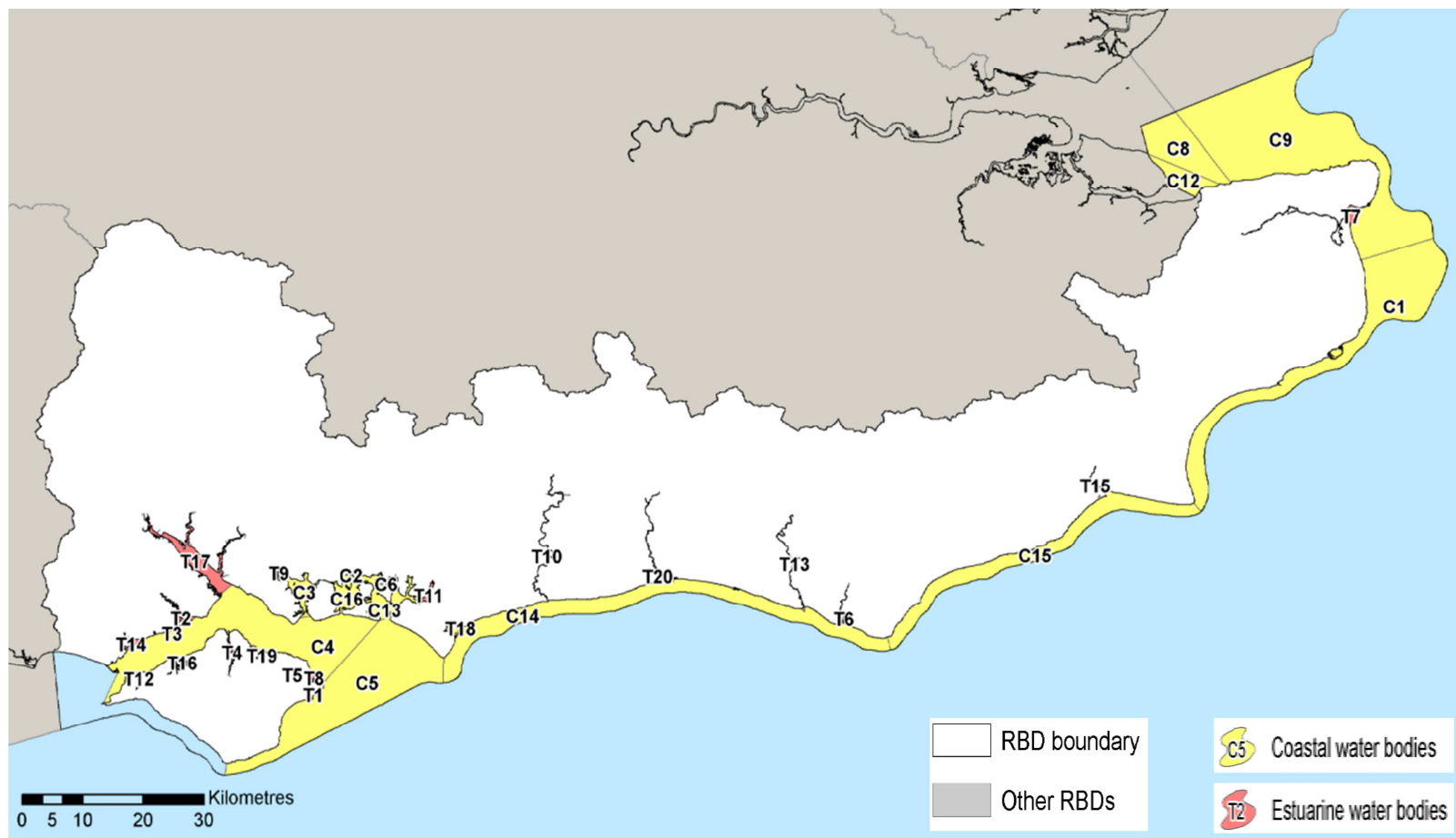
The works associated with the project are located to the east of Pagham Harbour and lie within the WFD coastal water body 'Sussex'. The proposed source material and stockpile areas fall within the same water body. **Figure 2.1** provides an overview of water bodies on the south coast of the UK and **Figure 2.2** provides specific water body locations relevant to this study.

Given the location of the proposed construction site, it is recognised that the proposals may have the potential to affect these water bodies and others that it may be adjacent to and, therefore, a WFD compliance assessment is required.

2.1 Information available

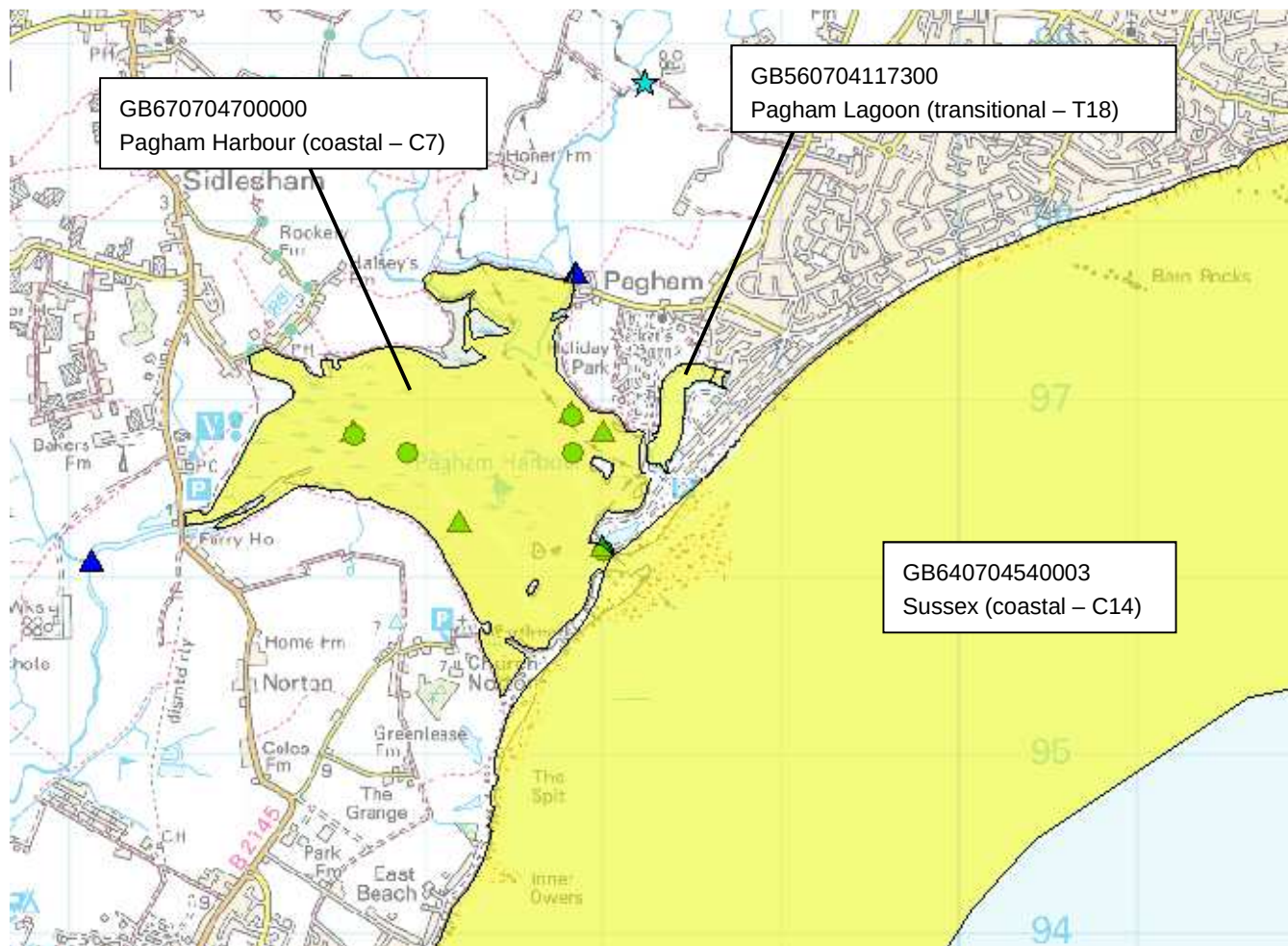
This WFD compliance assessment has been carried out as part of the wider scoping assessment of the scheme and based on historical data from the Pagham Beach Coastal Defence Environmental Statement (Royal Haskoning, 2009b, Environment Agency, 2011b). The information available for the WFD assessment is, therefore, comprehensive and includes data reviews and historical data sources, supplemented by historic ecological surveys.

Figure 2.1 Overview of WFD water bodies in southern England: South East River Basin Management Plan



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Figure 2.2 **Map of water bodies relevant to this study**



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3 THE REQUIREMENT TO CARRY OUT A WFD COMPLIANCE ASSESSMENT

The Environment Agency requires an assessment to be carried out with regard to the WFD for projects that could have a non-temporary effect on the status of a water body. The assessment for this project has progressed through Stage 1 (screening) and Stage 2 (scoping) and is detailed below.

4 THE WFD ASSESSMENT PROCESS

The Environment Agency has not yet issued external guidance for this type of WFD compliance assessment. This assessment has, therefore, followed the Environment Agency's step-wise approach used for its own projects, which are set out in National Environmental Assessment Service (NEAS) Supplementary Guidance 488_10_SD01 (2013b). The assessment, therefore, consists of the following steps:

- Step 1: Collect water body baseline data.
- Step 2: Collect proposed scheme baseline data.
- Step 3: Preliminary assessment to identify whether the project could cause deterioration in status or failure to meet Good Ecological Status (GES) or Good Ecological Potential (GEP).

5 RELEVANT WATER BODIES IN THE PAGHAM AREA

5.1 Water body status

Water bodies to be considered have been selected on the basis of the following criteria:

- All surface water bodies that could potentially be directly impacted by the proposals (i.e. those within the footprint of the proposals).
- Any surface water bodies that have direct connectivity and could potentially be affected by the proposed dredge and disposal activities.

The following water bodies have been identified as potentially relevant in geographical and hydrological terms to take through the WFD assessment process. These water bodies were identified by examining the extent to which the works could affect the coastal processes. Water bodies identified with respect to the proposed works were:

- Sussex (coastal water body - C14) ID GB640704540003;
- Pagham Harbour (coastal water body – C7) ID GB670704700000; and
- Pagham Lagoon (transitional water body - T18) ID GB560704117300.

Table 5.1 and **Table 5.2** summarise the information available for the status of these water bodies. All other water bodies have been scoped out on the basis that an impact (either direct or indirect) is unlikely.

5.2 Preliminary assessment

Step 3 aims to screen out projects from further assessment that are unlikely to have an impact on WFD objectives. In order for this scheme to be 'scoped out' from further WFD

assessment there should be no anticipated deterioration across any of the WFD quality elements and the scheme should not prevent the relevant water bodies from meeting their status or potential objectives. This step should be a rapid screening step which identifies potential impacts and establishes whether further more detailed assessment is required. The possibility for a scheme to avoid further assessment needs to be clearly established and any uncertainty should send the assessment to the next step. The preliminary assessment for the Pagham Beach coastal defence works is presented within **Table 5.3**.

Table 5.1 **General water body information**

Water body name and reference	Water body area (km)	Transitional or coastal	Current status	Record objective	If not at good status record all WFD parameters at moderate status or below	Is the water body designated as heavily modified or artificial? If so record reason
Sussex (C14) ID GB640704540003	190.60	Coastal	Moderate	Good by 2027	Mitigation Measures Assessment	Heavily modified (coastal protection, flood protection, fin fisheries)
Pagham Harbour (C7) ID GB670704700000	2.57	Coastal	Moderate (uncertain)	Good by 2027	Macroalgae – moderate (uncertain) Dissolved inorganic nitrogen – moderate (uncertain)	Artificial (no reason listed)
Pagham Lagoon (T18) ID GB560704117300	0.10	Transitional	Moderate (uncertain)	Good by 2027	None (current status and status objectives for this water body are based on expert judgement)	Artificial (no reason listed)

Table 5.2 Mitigation measures per water body

Water body name and reference	Mitigation measures	In place? ✓/x	Protected areas within water body
Sussex (C14) ID GB640704540003	Manage disturbance Site selection (dredged material disposal) (e.g. avoid sensitive sites) Sediment management Operational and structural changes to locks, sluices, weirs, beach control, etc. Preserve and where possible enhance ecological value of marginal aquatic habitat, banks and riparian zone Managed realignment of flood defence Bank rehabilitation / re-profiling Preserve and, where possible, restore historic aquatic habitats Removal of hard bank reinforcement / revetment, or replacement with soft engineering solution	x x x x x x x x x	Bathing Water Directive, Natura 2000 (Habitats and/or Birds Directive), Nitrates Directive
Pagham Harbour (C7) ID GB670704700000	None		Natura 2000 (Habitats and/or Birds Directive), Nitrates Directive, Urban Waste Water Treatment Directive
Pagham Lagoon (T18) ID GB560704117300	None		Natura 2000 (Habitats and/or Birds Directive)

Table 5.3 Preliminary assessment of the impacts of the proposed scheme on the Sussex coastal water body

Scheme element	Potential water bodies that could be affected	Potential hydromorphological consequences	Impacts on hydromorphological quality elements	Impacts on biological quality elements	Will any critical or sensitive habitats be adversely affected?	Will any of the water body mitigation measures be adversely affected?	Can any mitigation measures be included in the scheme?	Potential for cumulative effects	Objective 1 met?	Objective 2 met?	Objective 3 met?
Potential excavation for construction activities (site preparation)	Sussex	No potential hydro-morphological consequences identified by EA's own guidance	Excavation for the rock revetment would result in a change in hydromorphological regime (reduction in wave energy and sediment would remain in situ). This represents less than 0.1% of the water body and is not sufficient to cause any deterioration in status.	Invertebrates – Good	No	None currently implemented	None	None	✓	✓	✓
Installation of rock revetment	Sussex	Reduction in wave energy allowing sediments to remain in-situ	Installation of the rock revetment would reduce wave energy and sediment would remain in-situ	Invertebrates – Good Re-suspension of sediment would occur on a localised scale and due to the nature of the area would be	No	None currently implemented	Potential to implement 'Operational and structural changes to locks, sluices, weirs, beach	None	✓	✓	✓

Scheme element	Potential water bodies that could be affected	Potential hydromorphological consequences	Impacts on hydromorphological quality elements	Impacts on biological quality elements	Will any critical or sensitive habitats be adversely affected?	Will any of the water body mitigation measures be adversely affected?	Can any mitigation measures be included in the scheme?	Potential for cumulative effects	Objective 1 met?	Objective 2 met?	Objective 3 met?
			Revetment footprint is estimated to be approximately 1,500m ² . This represents less than 0.1% of the water body and is not sufficient to cause any deterioration in status	re-deposited very close to the area of the works. The levels of contaminants within the sediment in this area have not yet been recorded Invertebrates are not expected to be permanently affected by this highly localised work.			control, etc' and 'Removal of hard bank reinforcement / revetment, or replacement with soft engineering solution' are unfeasible due to aims and design of the scheme (protection of human life and property)				
Beach refill behind the rock revetment	Sussex	No potential hydro-morphological consequences identified by EA's own guidance.	None as works would be on the landside and not come in contact with the marine environment	Invertebrates – Good	No	None currently implemented	None	None	✓	✓	✓

5.3 Summary of preliminary assessment

Table .3 summarises the main points of the preliminary assessment. Small localised changes to the hydromorphological regime would occur upon the installation of the rock revetment, but this effect would be highly localised. It is unlikely that the status of the hydromorphological quality elements would be affected by the scheme.

The Biological Quality Elements (BQEs) for the Sussex water body would not be directly affected by the highly localised disturbance. As no significant hydromorphological change is predicted, the BQEs would also remain unaffected by indirect change, and there would be no deterioration in their status.

No mitigation measures are currently in place.

No cumulative effects are predicted.

5.4 Detailed assessment

Due to the highly localised nature of the works and the fact that no significant hydromorphological change is anticipated outside of the immediate vicinity of the rock revetment, no further assessment work in the context of the WFD is suggested for the scheme.

6 RECORDING THE OUTCOME OF THE WFD ASSESSMENT

From the assessment carried out in herein with regard to the WFD it is concluded that the relevant Environmental Objectives would be met by the scheme and there would be no deterioration of status of any associated water bodies. No further work regarding WFD assessment is therefore anticipated.